NATIONAL MARINE FISHERIES SERVICE
ENDANGERED SPECIES ACT SECTION 7
BIOLOGICAL AND CONFERENCE OPINION

Title:	Biological and Conference Opinion on the National Science Foundation's Low-Energy and High-Energy Marine Geophysical Survey by the Research Vessel *Sikuliaq* in the Arctic Ocean 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
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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 concurs with that determination for species under NMFS jurisdiction, consultation concludes informally (50 C.F.R. §402.14(b)).

The Federal action agency shall confer with the NMFS for species under NMFS jurisdiction on any action which is likely to jeopardize the continued existence of any species proposed to be ESA-listed or result in the destruction or adverse modification of proposed critical habitat (50 C.F.R. §402.10). If requested by the Federal agency and deemed appropriate, the conference may be conducted in accordance with the procedures for formal consultation in 50 C.F.R. §402.14.

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

The Federal action agencies for this consultation are the National Science Foundation and the NMFS, Office of Protected Resources, Permits and Conservation Division. Two Federal actions are considered in this biological and conference opinion (opinion). The first is the National Science Foundation's proposal to sponsor (fund) and conduct a marine geophysical (seismic) survey in the Arctic Ocean in summer (August through September) 2021. The second is 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 seismic survey, pursuant to section 101(a)(5)(D) of the MMPA 16 U.S.C. 1371(a)(5)(D).

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, and agency policy and guidance.

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

1.1 Background

The National Science Foundation is proposing to sponsor and conduct a low-energy and high-energy marine seismic survey for scientific research purposes and data collection in the Arctic Ocean in summer (August through September) 2021. In conjunction with this action, the NMFS Permits and Conservation Division proposes to 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 and high-energy seismic survey. Both the National Science Foundation and the NMFS Permits and Conservation Division have conducted similar actions in the past that have been the subject of ESA section 7 consultations that addressed 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), Namibia (2019), Amundsen Sea (2020), Aleutian Arc (2020), Cascadia Subduction Zone (2021), and Queen Charlotte Fault (2021) and the issuance of an incidental harassment authorization by the NMFS Permits and Conservation

Division determined that the authorized activities are not likely to jeopardize the continued existence of proposed or ESA-listed species, or the destruction or adverse modification of proposed or designated critical habitat.

1.2 Consultation History

This opinion is based on information provided in the National Science Foundation's draft environmental assessment/analysis, MMPA incidental harassment authorization application, the public notice for the proposed incidental harassment authorization prepared pursuant to the requirements of 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 peer-reviewed literature, 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 October 8, 2020, the National Science Foundation requested a list of ESA-listed species and proposed or designated critical habitat that may occur in the action area in the Arctic Ocean as well as recommended data sources for marine mammal abundances and densities in the action area.
- On November 23, 2020, we responded to the National Science Foundation request and provided a list of ESA-listed species and proposed or designated critical habitat that may occur in the action area in the Arctic Ocean, as well as recommended data sources for marine mammal abundances and densities in the action area.
- On February 12, 2021, the University of Alaska Fairbanks 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 April 6, 2021.
- On February 12, 2021, we received a request from the National Science Foundation for ESA section 7 consultation for a proposed low-energy and high-energy seismic survey to be undertaken in the Arctic Ocean in summer (August through September) of 2021. The National Science Foundation provided a letter and draft environmental assessment/analysis, in support of the request. The National Science Foundation requested the biological opinion be completed by June 27, 2021, to allow sufficient time for conclusion of the entire environmental compliance process by the commencement date of August 17, 2021 for the low-energy and high-energy seismic survey.
- On March 24, 2021, we provided the National Science Foundation with questions on their draft environmental assessment/analysis and incidental harassment authorization application. The National Science Foundation responded to the questions on April 8, 2021 and April 27, 2021.
- On March 29, 2021, we participated in the NMFS Permits and Conservation Division's Early Review Team meeting to discuss the National Science Foundation's low-energy

and high-energy seismic survey on the Research Vessel (R/V) *Sikuliaq* in the Arctic Ocean.

- On April 8, 2021, we determined there was sufficient information to initiate formal consultation. We provided the National Science Foundation with an initiation letter on May 14, 2021.
- On May 28, 2021, NMFS Permits and Conservation Division published a notice of a proposed incidental harassment authorization and request for comments on proposed authorization and possible renewal in the *Federal Register* soliciting public comment on their intent to issue an incidental harassment authorization for National Science Foundation's low-energy and high-energy marine seismic survey on the R/V *Sikuliaq* in the Arctic Ocean.
- On June 2, 2021, 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 and high-energy seismic survey on the R/V *Sikuliaq* in the Arctic Ocean. The consultation request package included an initiation memorandum, incidental harassment authorization application, *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 June 2, 2021, we determined there was sufficient information to initiate formal consultation. We provided NMFS Permits and Conservation Division with an initiation letter on June 8, 2021.
- On June 28, 2021, 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 a public comment from the Alaska Eskimo Whaling Commission regarding their decision to not conduct a peer review.
- On July 1, 2021, we provided the NMFS Permits and Conservation Division with questions on their *Federal Register* notice of proposed incidental harassment authorization and request for comments on proposed incidental harassment authorization and possible renewal. The NMFS Permits and Conservation Division responded to the questions on July 1, 2021.
- On July 2 and July 6, 2021, we provided the National Science Foundation with additional questions on their draft environmental assessment/analysis and incidental harassment authorization application. The National Science Foundation responded to the questions on July 7, July 12, and July 13, 2021.

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 (50 C.F.R. §402.02).

The final designations of critical habitat for green, leatherback, and loggerhead turtles used the term primary constituent element or essential features. The new critical habitat regulations (81 FR 7414; February 11, 2016) replace this term with physical and biological features. The shift in terminology does not change the approach used in conducting a "destruction or adverse modification" analysis, which is the same regardless of whether the original designation identified primary constituent elements, physical or biological features, or essential features. In this opinion, we use the term physical or biological features to mean primary constituent elements or essential features, as appropriate for the specific designated critical habitat.

An ESA section 7 assessment involves the following steps:

Description of the Proposed Actions (Section 3): We describe the proposed actions and those aspects (or stressors) of the proposed actions that may have direct or indirect effects on the physical, chemical, and biotic environment. This section also includes the avoidance and minimization measures that have been incorporated into the project to reduce the effects to ESA-listed species.

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

Endangered Species Act-Listed Species and Proposed or Designated Critical Habitat Present in the Action Area (Section 5): We identify the ESA-listed species and proposed or designated critical habitat that are subject this consultation because they co-occur with the stressors produced by the proposed action in space and time.

Potential Stressors (Section 6): We identify and describe the stressors that could occur as a result of the proposed actions and affect ESA-listed species and designated critical habitat.

Species and Critical Habitat Not Likely to be Adversely Affected (Section 7): We identify the ESA-listed species and proposed or designated critical habitat that are not likely to be adversely affected by the stressors produced by the proposed action.

Species and Critical Habitat Likely to be Adversely Affected (Section 8): During the ESA section 7 consultation process, we identify the ESA-listed species and proposed or designated critical habitat that are likely be adversely affected and detail our effects analysis for these species and critical habitats. We examine the status of ESA-listed species that may be adversely affected by the proposed actions throughout the action area in the *Status of the Species Likely to be Adversely Affected* (Section 8.1).

*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, 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 Actions (Section 10): Effects of the action are 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 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. These are broken into analyses of exposure, response, and risk. To characterize exposure, we identify the number, age (or life stage), and gender of ESA-listed individuals that are likely to be exposed to the stressors and the populations or sub-populations to which those individuals belong. We also consider whether the action "may affect" designated critical habitat. This is our exposure analysis. We evaluate the available evidence to determine how individuals of those ESA-listed species, and the physical and biological features of proposed or designated critical habitat that are essential to the conservation of threatened and endangered species are likely to respond given their probable exposure. This is our response analysis. We characterize risk to federally-listed species by assessing 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.

Cumulative Effects (Section 11): 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.

Integration and Synthesis (Section 12): 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.

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 physical and biological 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.

The results of our jeopardy and destruction and adverse modification analyses are summarized in the *Conclusion* (Section 13). 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), if necessary, that specifies the impact of the take, reasonable and prudent measures to minimize the impact of the take, and terms and conditions to implement the reasonable and prudent measures. ESA section 7 (b)(4); 50 C.F.R. §402.14(i). We also provide discretionary *Conservation Recommendations* that may be implemented by the action agency (Section 15) (50 C.F.R. §402.14(j)). Finally, we identify the circumstances in which *Reinitiation of Consultation* is required (Section 16) (50 C.F.R. §402.16).

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

- Information submitted by the National Science Foundation 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 proposed or designated critical habitat under NMFS' jurisdiction that may be affected by the proposed actions to draw conclusions on risks the action may pose to the continued existence of these species and the value of proposed designated critical habitat for the conservation of ESA-listed species.

3 Description of the Proposed Actions

"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 proposed actions were evaluated during consultation. The first proposed action addressed by this consultation is the National Science Foundation's proposal to sponsor and conduct a low-energy and high-energy marine seismic survey on the R/V *Sikuliaq* in the Arctic Ocean in summer (August through September) 2021. The National Science Foundation's proposed action will provide data necessary to map the northern edge of the Chukchi Borderland and the adjacent Canada Basin. The R/V *Sikuliaq*, which is owned by the National Science Foundation and is operated by the College of Fisheries and Ocean Sciences at University of Alaska Fairbanks under an existing Cooperative Agreement. The R/V *Sikuliaq*, which is not an icebreaker (but the hull is considered ice strengthened and can break low levels of ice thickness), will avoid the ice edge and stay in open water. Therefore, icebreaking activities are not expected to be required during the low-energy and high-energy seismic survey. The second proposed action addressed by this consultation is NMFS Permits and Conservation Division's proposed issuance of a proposed incidental harassment authorization authorizing non-lethal "takes" by MMPA Level B harassment and possible renewal pursuant to section 101(a)(5)(D) of the MMPA for the National Science Foundation's low-energy and high-energy marine seismic survey in the Arctic Ocean.

The National Science Foundation's proposed action includes a two-dimensional seismic survey in the United States (U.S.) Exclusive Economic Zone and International Waters in the Arctic Ocean. 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 and high-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 has been identified as a National Science Foundation program priority to meet the agency's critical need to foster an understanding of Earth processes.

The information presented here is based primarily on the draft environmental assessment/analysis, incidental harassment authorization application, and *Federal Register* notice on the request for comments on the proposed incidental harassment authorization and possible

renewal 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 proposes to fund and conduct a low-energy and high-energy seismic survey in the Arctic Ocean on the R/V *Sikuliaq*. An airgun array, sub-bottom profiler, multi-beam echosounder, and acoustic Doppler current profiler will be deployed as an energy source.

3.1.1 Seismic Survey Overview and Objectives

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

The low-energy and high-energy seismic survey is designed to collect two-dimensional seismic reflection data to document the history, structures, and stratigraphy of the Chukchi Borderland and adjacent Canada Basin, and to use ocean bottom seismometer seismic refraction data in the Canada Basin to characterize the deep crustal structure associated with an extinct mid-ocean ridge in the central basin. It will also image sites for potential future scientific ocean drilling under the International Ocean Discovery Program. The Chukchi Borderland is a block of extended continental crust embedded in the deep water Amerasia Basin. To understand the opening of this basin, it is necessary to restore the Borderland to its pre-opening position. The choice of this position distinguishes tectonic models of the basin. Better understanding the history of the Borderland and the surrounding structures would provide critical constraint on the history of the Amerasia Basin and the continents adjacent to it. In this area, three of the major structures of the Amerasia Basin intersect; the Borderland, Alpha Ridge, and Canada Basin. Dedicated seismic surveys in this region would improve our understanding of these structures and their termination or continuation below the sediment cover. The proposed seismic survey will elucidate the relations between the overtly continental, high-standing block and the surrounding crust, which may be, in part, of continental composition as well.

To achieve the goals of the project, the principal investigator proposes to utilize two-dimensional seismic reflection and ocean bottom seismometers (OBS) seismic refraction capabilities to address the following objectives:

- Reveal the crustal structure of the Northern Chukchi Borderland, an extinct mid-ocean ridge and the adjacent extended continental crust.
- Establish relations between continental Chukchi Borderland and transitional and oceanic crust in the Canada Basin.
- Identify continuation of the mid-ocean ridge.

- Link up lines collected by Canada for their Extended Continental Shelf program.
- Sample distinct pieces of seafloor that have not previously been observed.
- Image sites for proposed scientific ocean drilling.
- Gather information that could be useful for a U.S. claim of an extended continental shelf for seabed resources under Article 76 of the United Nation's Convention on the Law of the Sea.

Researchers from the University of Alaska Geophysics Institute, in collaboration with researchers from the Geological Survey of Denmark and Greenland, propose to conduct a low-energy and high-energy marine seismic survey for scientific research purposes using an airgun array and other acoustic sound sources in the waters of the Arctic Ocean in summer (August through September) 2021 (to study the origin and development of the Canada Basin which is not well known. Imaging the basin will improve the understanding of how the Arctic Ocean formed and expanded, creating the world and climate we know today. The researchers will receive funding from the National Science Foundation. The principal investigator is Dr. B. Coakley. Dr. J.R. Hopper of the Geological Survey of Denmark and Greenland will work with the principal investigator to achieve the research goals, providing assistance such as through logistical support and data acquisition, processing, and exchange. Dr. J.R. Hopper's work is not funded through the National Science Foundation. Some funding provided by the National Science Foundation will provide support for international engineer participation and equipment use.

The two-dimensional seismic survey will use a towed two or six airgun array with a maximum discharge volume of approximately 51,127.6 cubic centimeters (3,120 cubic inches) at a depth of nine meters (29.5 feet). The low-energy and high-energy seismic survey will take place in U.S. Exclusive Economic Zone and International Waters in the Arctic Ocean in (intermediate and deep) waters depths of approximately 200 to 4,000 meters (656.2 to 13,123.4 feet). The seismic survey activities will consist of a total of approximately 45 days, including approximately 30 days of airgun array operations, approximately seven days of equipment deployment and recovery (which includes contingency time [e.g., weather days, mechanical issues, etc.]), and approximately eight days of transit. It is assumed the airgun array will be active 21 hours per day, with three hours per day allotted for repair and regular maintenance. The R/V *Sikuliaq* is planning to depart from Nome, Alaska on approximately August 17, 2021, and return to Nome, Alaska on approximately September 30, 2021. The transit distance from Nome, Alaska to the seismic survey area is approximately 1,266 kilometers (683.6 nautical miles). Some minor deviation from the dates is possible, depending on logistics and weather. As the R/V *Sikuliaq* is a national asset, NSF and the University of Alaska Fairbanks strive to schedule its operations in the most efficient manner possible. Schedule efficiencies are achieved when regionally occurring research projects are scheduled consecutively and non-operational transits are minimized.

The National Science Foundation will use conventional seismic survey methodology and the procedures will be similar to those used during previous National Science Foundation-funded seismic surveys. Seismic survey protocols generally involve a predetermined set of tracklines.

The seismic data 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 (see Figure 1).

The R/V *Sikuliaq* will deploy an airgun array consisting of two to six Generator (G) airguns, with one towed hydrophone streamer behind the R/V *Sikuliaq* and OBSs to conduct the two-dimensional seismic survey. The location of the tracklines are considered representative and may shift from what is depicted in Figure 1 depending on factors such as science drivers, poor data quality, weather, ice conditions, mechanical issues with the research vessel and/or equipment, etc.

The seismic survey activities will be conducted along approximately 5,850 kilometers (3,158.7 nautical miles) of tracklines, including 5,170 kilometers (2,791.6 nautical miles) of multi-channel seismic (MCS) reflection surveys and 680 kilometers (367.2 nautical miles) of OBS refraction surveys. Most of the seismic survey activities (approximately 80 percent) will occur in deep water depths (greater than 1,000 meters [3,280.8 feet]), and the remainder (approximately 20 percent) will occur in intermediate water depths (100 to 1,000 meters [328.1 to 3,280.8 feet]). For the low-energy seismic surveys, approximately 23 percent (1,189 kilometers [642 nautical miles]) will occur in intermediate water depths (100 to 1,000 meters [328.1 to 3,280.8 feet]) and approximately 67 percent (3,981 kilometers [2,149.6 nautical miles]) will occur in deep water depths (greater than 1,000 meters [3,280.8 feet]). All high-energy seismic surveys (680 kilometers [367.1 nautical miles]) will occur in deep water depths. No seismic survey activities will occur in shallow water depths (less than 100 meters [328.1 feet]).

The MCS survey will consist of approximately 88 percent of the total trackline kilometers and OBS seismic survey will consist of approximately 12 percent of the total trackline kilometers. Some of the tracklines will be acquired twice, once for MCS reflection surveys and again for OBS refraction surveys. These MCS/OBS tracklines will take place near the end of airgun array operations in the northeastern part of the seismic survey area; however the location of these seismic surveys can shift slightly to ensure one seismic survey occurs over the extinct ridge axis and the other on hyper-extended continental crust. The nine OBSs will be deployed twice for a total of 18 deployments sites. Nine OBSs will be deployed while MCS reflection data is acquired between OBS drops, then OBS refraction data will be acquired along the same tracklines, followed by recovery of the OBSs. The R/V *Sikuliaq* will then travel to the next site to deploy all nine OBSs again.

The proposed activities will occur 24 hours per day during the proposed low-energy and high-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 for reasons such as 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); data degradation due to poor

weather; interruption due to shut-downs or ramp-ups or trackline deviation 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 MMPA Level B harassment thresholds. All planned seismic data acquisition activities will be conducted by the National Science Foundation and researchers from the University of Alaska Geophysics Institute and Geological Survey of Denmark and Greenland, 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 R/V *Sikuliaq* for the entire seismic survey. Since the low-energy and high-energy seismic survey will be conducted during the summer, seismic survey activities are anticipated to occur mostly in daylight conditions. Daylight hours at the beginning of the seismic survey activities will be approximately 19 hours per day, and by the end of September the daylight hours will be approximately 11 hours per day. Daylight will decrease between nine to ten minutes each day, which results in more than an hour of daylight each week. The National Science Foundation's draft environmental assessment/analysis and incidental harassment authorization application present more detailed information on the project.

3.1.2 Source Vessel Specifications

The low-energy and high-energy seismic survey will involve one source vessel, the U.S.-flagged R/V *Sikuliaq*. The R/V *Sikuliaq* is owned by the National Science Foundation and operated by the University of Alaska Fairbanks under an existing Cooperative Agreement. The R/V *Sikuliaq* will tow a source airgun array as a sound source along predetermined lines. The R/V *Sikuliaq* has a length of 80 meters (262.5 feet), a beam of 16 meters (52.5 feet), and a design draft of 6 meters (19.7 feet). It has a diesel-electric powertrain in which the main diesel generators produce power for electric motors coupled to the propellers. It is powered by two 1,800 kiloWatt (2,400 horsepower) and two 1,310 kiloWatt (1,760 horsepower) 12 cylinder MTU 4,000 series high speed diesel engines. The research vessel has a diesel-electric engine with 5,750 brake horsepower, and can break through ice up to 1 meter (3.3 feet) thick. When not towing seismic survey gear, the R/V *Sikuliaq* typically cruises at 18.5 kilometers per hour (10 knots). The maximum speeds is approximately 23 kilometers per hour (12.5 knots). During the two-dimensional low-energy and high-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 33,336 kilometers (18,000 nautical miles), which translates to an operating period (i.e., endurance) of approximately 45 days. No chase vessel will be used during seismic survey activities. The R/V *Sikuliaq* 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 R/V *Sikuliaq*.

Table 1. Additional details of the Research Vessel *Sikuliaq*.

Research Vessel *Sikuliaq* Specifications	
Owner	National Science Foundation
Operator	College of Fisheries and Ocean Sciences at University of Alaska Fairbanks
Flag	United States of America
Date Built	2014
Gross Tonnage	3,429 metric tons
Accommodation Capacity	46 including approximately 22 Crew and 24 Scientists/Researchers

3.1.3 Airgun Array and Acoustic Receivers Description

The energy source for the low-energy and high-energy seismic survey was chosen by the National Science Foundation to be the lowest practical to meet the scientific objectives. During the low-energy and high-energy seismic survey, marine technicians on the R/V *Sikuliaq* 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 and high-energy seismic survey will consist of up to six G airguns (each airgun is 520 cubic inches) with varying displacement volumes (Table 2). The total maximum discharge volume for the largest, six airgun array will be 51,127.6 cubic centimeters (3,120 cubic inches). During low-energy, MCS reflection surveys, two G airguns with a total discharge volume of 17,042.6 cubic centimeters (1,040 cubic inch) will be used. During OBS refraction seismic surveys, six G airguns with a total discharge volume of 51,127.6 cubic centimeters (3,120 cubic inches) will be used. All airguns in the array will be fired simultaneously. The airgun array will be towed behind the R/V *Sikuliaq*. The shot interval will be approximately 15 seconds (approximately 35 meters [114.8 feet] per second) during the MCS reflection surveys and approximately 60 seconds (approximately 139 meters [456 feet] per second) during the OBS refraction surveys for the two-dimensional low-energy and high-energy seismic survey. The firing pressure of the airgun array will be approximately 2,540 pounds per square inch (psi). The airgun array will be towed approximately 40 meters (131.2 feet) behind

the research vessel (depending on Beaufort sea state) at a tow depth of nine meters (29.5 feet) and spaced approximately 1.05 meters (3.4 feet) apart for the low-energy seismic survey (one cluster). For the high-energy seismic survey, the airgun array will consist of three clusters (each cluster includes two G airguns separated approximately 1.05 meters [3.4 feet] apart), and the clusters spaces approximately 5 meters (16.4 feet) apart. Weather conditions permitting, it is anticipated that seismic survey activities will not exceed approximately 700 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 R/V *Sikuliaq*'s airgun array configurations, source output, position, tow depths, air discharge volume, dominant frequency components, pulse duration, and shot interval associated with the low-energy and high-energy seismic survey in the Arctic Ocean.

Table 2. Specifications of the source airgun array to be used by the Research Vessel *Sikuliaq* during the proposed low-energy and high-energy seismic survey in the Arctic Ocean.

Source Airgun Array Specifications	
Energy Source – Number of Airguns	2 G Airguns (520 in^3 each for 1,040 in^3 total) (2,540 psi) for MCS reflection or 6 G airguns (520 in^3 each for 3,120 in^3) (2,540 psi) for OBS refraction
Source Output (Downward) of 2 Airgun Array Source Output (Downward) of 6 Airgun Array	Peak-to-Peak = 245.13 dB re: 1 μPa (rms) 0-to-Peak = 239.25 dB re: 1 μPa (rms) Peak-to-Peak = 254.68 dB re: 1 μPa (rms) 0-to-Peak = 248.79 dB re: 1 μPa (rms)
Position	2 G Airgun Array – 1 Cluster Approximately 1.05 m (3.4 ft) Apart 6 G Airgun Array – 3 Clusters Approximately 1.05 m (3.4 ft) Apart
Tow Depth	9 m (29.5 ft)
Air Discharge Volume of 2 G Airgun Array Air Discharge Volume of 6 G Airgun Array	Approximately 1,040 in^3 Approximately 3,120 in^3
Dominant Frequency Components	6 to 20 Hz (2 G Airgun Array) 5 to 20 Hz (6 G Airgun Array)
Pulse Duration	Approximately 0.178 Seconds (2 G Airgun Array) Approximately 0.183 Seconds (6 G Airgun Array)

Source Airgun Array Specifications	
Shot Interval	Approximately 15 Seconds (MCS) Approximately 60 Seconds (OBS)

in^3=cubic inches, GI=generator injector, psi=pounds per square inch, NA=not available, dB=decibel, μPa=micro Pascal, rms=root mean square, m=meters, ft=feet, Hz=Hertz, MCS=multi-channel seismic, OBS=ocean bottom seismometer

The receiving systems will consist of a one to three kilometer (0.5 to 1.6 nautical mile; depending on ice conditions) long towed hydrophone streamer during low-energy, MCS reflection surveys and OBSs during high-energy, refraction seismic surveys. The towed hydrophone streamer is filled with silicone. As the airgun array is towed along the tracklines, the towed hydrophone streamer will receive the returning acoustic signals and transfer the data to the onboard processing system and the OBSs will receive and store the returning acoustic signals internally for later analysis. The turning rate of the R/V *Sikuliaq* with the airgun array and towed hydrophone streamer deployed is slow and the maneuverability of the research vessel will be limited during seismic survey activities.

Researchers will deploy nine OBSs made by Sercel MicrOBS at two sites within the Canada Basin in the northeastern portion of the seismic survey area (Figure 1). The OBSs will be deployed 25 kilometers (13.5 nautical miles) apart along two tracklines; after seismic data acquisition at the first site, they will be retrieved and redeployed at the second site. The OBSs have a height and diameter of approximately 1 meter (3.3 feet) and an anchor (made of black steel) weighing approximately 80 kilograms (176.4 pounds). All OBSs will be recovered upon conclusion of the seismic survey. To retrieve OBSs placed on the seafloor, an acoustic release transponder (pinger) is used to interrogate the instrument and transmits a signal at a frequency of 10 to 11 kiloHertz, and a response is received at a frequency of 11.5 to 13 kiloHertz (operator selectable) to activate and release the instrument. The transponder will trigger the burn-wire release assembly is then activated and releases the instrument from the anchor on the seafloor and floats to the surface. The anchor for the OBS is scuttled and left on the seafloor, not to be retrieved. In general, the airgun array and towed hydrophone streamer can be safely and efficiently deployed and retrieved in approximately one hour and 45 minutes.

3.1.4 Sub-Bottom Profiler, Multi-Beam Echosounder, Acoustic Doppler Current Profiler, and Acoustic Release Transponder

Along with operations of the airgun array, three additional acoustical data acquisition systems will operate during the low-energy and high-frequency seismic survey from the R/V *Sikuliaq*. The Kongsberg TOPAS PS-18 sub-bottom profiler at 0.5 to 6 kiloHertz, and Kongsberg EM 302 multi-beam echosounder at 30 kiloHertz will map the ocean floor during the low-energy and high-energy seismic survey. The Teledyne RDI OS acoustic Doppler current profiler at 75 to 150 kiloHertz will measure water current velocities. The sub-bottom profiler, multi-beam echosounder, and acoustic Doppler current profiler sound sources will operate continuously from the R/V *Sikuliaq*, including simultaneously with the airgun array, but not during transit to and

from the seismic survey area. Also, the acoustic release transponder (pinger) will be used to communicate and recover the deployed OBSs.

3.1.4.1 Sub-Bottom Profiler

The ocean floor will be mapped with an Kongsberg TOPAS PS-18 sub-bottom profiler. The sub-bottom profiler is a hull-mounted sonar system that will be operated continuously during the seismic survey activities. The instrument is operated at 0.6 to 6 kiloHertz and emits a 3.5 to 4.5 degree beam. The instrument has a sound source level of 209 dB re: 1 μPa (rms). The sub-bottom profiler emits a series of ten to 40 consecutive 15 millisecond pulses with a variable ping rate. A sub-bottom profiler will be operated continuously during the seismic survey activities.

3.1.4.2 Multi-Beam Echosounder

The ocean floor will be mapped with the KongsbergEM 302 multi-beam echosounder. The multi-beam echosounder is a hull-mounted system operating at 30 kiloHertz. The transmitting beamwidth is very narrow, 0 to 75 degrees. The maximum sound source level is 241 dB re: 1 μPa at 1 meter (rms). The multi-beam echosounder emits a series of 0.7 to 200 millisecond pulses. A multi-beam echosounder will be operated continuously during the seismic survey activities.

3.1.4.3 Acoustic Doppler Current Profiler

The Teledyne RDI OS acoustic Doppler current profilers will be mounted on the hull of the R/V *Sikuliaq* to measure the speed of the water currents. The Teledyne RDI OS acoustic Doppler current profiler will operate at a frequency of 75 and 150 kiloHertz and a maximum sound source level of 211 to 227 dB re: 1 μPa at 1 meter (rms) over a conically-shaped 30 degree beam. The transmitting beamwidth is 30 degrees. The acoustic Doppler current profiler emits a series of 11 to 37 millisecond pulses and has a ping rate is 0.7 seconds. An acoustic Doppler current profiler will be operated continuously during the seismic survey activities.

3.1.4.4 Acoustic Release Transponder

To recover OBSs, an acoustic release transponder (pinger) will be used to interrogate the instrument on the ocean seafloor at a frequency of 10 to 11 kiloHertz, and a response is received at a frequency of 11.5 to 13 kiloHertz. The transmitting beam pattern is 55 degrees. The sound source level is approximately 93 dB re: 1 μPa at 1 meter (rms). The pulse duration is 2 milliseconds (±10 percent) and the pulse repetition rate is one per second (±50 microseconds).

3.1.5 Mitigation, Monitoring, and Reporting

The National Science Foundation (and University of Alaska Geophysics Institute) must implement mitigation measures (pre-planning and during seismic survey activities), monitoring, and reporting 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 proposed or 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.

Under the MMPA, the NMFS Permits and Conservation Division requires mitigation, monitoring, and reporting measures that the National Science Foundation will implement during the low-energy and high-energy seismic survey, which are listed below. Additional detail for each mitigation and monitoring measure is described in subsequent sections of this opinion:

- Proposed exclusion and buffer zones;
- Shut-down procedures;
- Pre-clearance and ramp-up procedures;
- Vessel-based visual monitoring by NMFS-approved protected species observers;
- Passive acoustic monitoring;
- Vessel strike avoidance measures;
- Additional mitigation measures considered; and
- Reporting.

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 (86 FR 28787 to 28809) and *Appendix A* (Section 18).

3.1.5.1 Proposed Exclusion and Buffer Zones – Ensonified Area

The NMFS Permits and Conservation Division will require, and the National Science Foundation will implement, exclusion and buffer zones around the R/V *Sikuliaq* 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 R/V *Sikuliaq*, and correspond to the respective species sound threshold for ESA harm (e.g., injury) and harassment. 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.

Ensonified Area

When the NMFS *Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing* (NOAA 2016) and *NOAA 2018 Revision to Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing* (NOAA 2018) were 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 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, the user spreadsheet predicts the closest distance at which a stationary animal will not incur permanent threshold shift (PTS) if the sound source traveled by the animal in a straight line at a constant speed. Inputs used in the user spreadsheet and the resulting isopleths are described further in the National Science Foundation's environmental assessment/analysis and incidental harassment authorization application and NMFS Permits and Conservation Division's proposed incidental harassment authorization (86 FR 28787 to 28809).

The Lamont-Doherty Earth Observatory of Columbia University (L-DEO) conducted modeling on behalf of the National Science Foundation and University of Alaska Geophysics Institute. The L-DEO model results are used to determine the 160 dB re: 1 μPa (rms) radius for the two to six G-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 L-DEO's model (Diebold et al. 2010), which uses ray tracing for the direct wave traveling from the airgun array to the receiver and its associated source ghost (i.e., reflection at the air-water interface in the vicinity of the airgun array), in a constant-velocity half-space (infinite homogeneous ocean layer, unbounded by a seafloor). In 2003, empirical data concerning 190, 180, and 160 dB re: 1 μPa (rms) distances were acquired 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 (9 meters [29.5 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 depths, the field measurements in the Gulf of Mexico cannot be used readily to derive ESA harm and 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) (Costa and Williams 1999). 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 L-DEO model, although they may be imperfectly sampled by measurements recorded at a single depth. At greater distances, the calibration data show that seafloor-reflected and sub-seafloor-refracted arrivals dominate, whereas the direct arrivals become weak and/or incoherent. Aside from local topography effects, the region around the critical distance is where the observed levels rise closest to the model curve. However, the observed sound levels are found to fall almost entirely below the model curve. Thus, analysis of the Gulf of Mexico calibration measurements demonstrates that although simple, the L-DEO model is a robust tool for conservatively estimating isopleths. For deep water depths (greater than 1,000 meters [3,280.8 feet]), L-DEO 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 model curve. No seismic survey activities will occur in water depths less than 100 meters (328.1 feet); therefore, no shallow water radii were obtained. 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 μPa (rms) isopleths for the two to six G airgun array in each water depth category are in Table 4.

The sound source levels (values for cumulative sound exposure level [SEL_{cum}] and peak sound pressure level [SPL]) were derived from calculating the modeled farfield signature. The farfield signature is often used as a theoretical representation of the source level. To compute the farfield signature, the source level is estimated at a large distance below the airgun array and this source level is back projected mathematically to a notional distance of 1 meter (3.3 feet) from the airgun arrays geometrical center. However, when the sound source is an airgun array of multiple airguns separated in space, the source level from the theoretical farfield signature is not necessarily the best measurement of the source level that is physically achieved at the sound source (Tolstoy et al. 2009). Near the sound source (at short ranges, distances less than 1 kilometer [0.54 nautical miles]), the pulses of sound pressure from each individual airgun in the airgun array of the sound source do not stack constructively, as they do for the theoretical farfield signature. The pulses

from the different airguns spread out in time such that the sound source levels observed or modeled are the result of the summation of pulses from a few airguns, not the full airgun array (Tolstoy et al. 2009). At larger distances, away from the center of the airgun array, sound pressure of all the airguns in the airgun array stack coherently, but not within one time sample, resulting in smaller sound source levels (a few dB) than the sound source level derived from the farfield signature. Because the farfield signature does not take into account the large airgun array effect near the sound source and is calculated as a point source, the modified farfield signature is a more appropriate measure of the sound source level for distributed sound sources, such as airgun arrays. The acoustic modeling methodology as used for estimating the 160 dB re: 1 μPa (rms) isopleths with a small grid step of 1 meters (3.3 feet) in both the inline and depth directions. The propagation modeling takes into account all airgun array interactions at short distances from the sound source, including interactions between subarrays, which are modeled using NUCLEUS software to estimate the notional signature and MATLAB software to calculate the pressure signal at each mesh point of the grid.

In order to more realistically incorporate the NMFS' technical guidance for auditory injury of marine mammals (NOAA 2018) weighting functions over the airgun array's full acoustic band, unweighted spectrum data (modeled in 1 Hertz bands) were used to make adjustments (dB) to unweighted spectrum levels, by frequency, according to the weighting functions for each relevant marine mammal hearing group. These adjusted and weighted spectrum levels were then converted to pressures (μPa) in order to integrate them over the entire broadband spectrum, resulting in broadband weighted sound source levels by hearing group that can be directly incorporated within the user spreadsheet (i.e., to override the user spreadsheet's more simple weighting factor adjustment). Using the user spreadsheet's "safe distance" methodology for mobile sound sources (Sivle et al. 2014) with the hearing group-specific weighted sound source levels, and inputs assuming spherical spreading propagation and sound source velocities and shot intervals specific to the planned seismic survey activities, potential radial distances to auditory injury isopleths were then calculated for SEL_{cum} thresholds. The estimated distances to the isopleths for ESA harm for the two to six G airgun array in each water depth category are in Table 3. More details of the modeling methodology and inputs to the user spreadsheet are in Appendix A of the National Science Foundation's incidental harassment authorization application.

Note that because of some of the assumptions included in the methods used (e.g., stationary receiver with no vertical or horizontal movement in response to the sound source), isopleths produced may be overestimates to some degree, which will ultimately result in some degree of overestimation of adverse effects. However, these tools offer the best way to predict appropriate isopleths when more sophisticated modeling methods are not available. NMFS continues to develop ways to quantitatively refine these tools and will qualitatively address the output where appropriate. For mobile sound sources, such as the seismic survey activities, the 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.

Auditory injury is unlikely to occur for low-frequency cetaceans given very small modeled isopleths of injury for those species (up to a maximum of 17.2 meters [56.4 feet] for low-frequency cetaceans and 11.6 meters [38.1 feet] for phocid pinnipeds for the two G airgun array; up to a maximum of 50.6 meters [166 feet] for low-frequency cetaceans and 33.6 meters [110.2 feet] for phocid pinnipeds for the six G airgun array), in context of distributed sound source dynamics. The sound source level of the airgun array is a theoretical definition assuming a point source and measurement in the farfield of the sound source (MacGillivray 2006). As described by Caldwell and Dragoset (2000b), an airgun array is not a point source, but one that spans a small area. In the farfield, individual elements in airgun arrays will effectively work as one sound source because individual pressure peaks will have coalesced into one relatively broad pulse. The airgun array can then be considered a “point source.” For distances within the nearfield, i.e., approximately two to three times the airgun array dimensions, pressure peaks from individual elements do not arrive simultaneously because the observation point is not equidistant from each element. The effect is destructive interference of the outputs of each element, so that peak pressures in the nearfield will be significantly lower than the output of the largest individual element. Here, the estimated MMPA Level A harassment isopleth distances will in all cases be expected to be within the nearfield of the airgun array where the definition of sound source level breaks down. Therefore, actual locations within this distance of the center of the airgun array where the sound level exceeds relevant criteria for MMPA Level B harassment will not necessarily exist. The NMFS Permits and Conservation Division do not propose to authorize any MMPA Level A harassment for these species.

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 or behavioral patterns). Protected species observers will establish a default (minimum) exclusion zone with a 100 meter (328.1 feet) or 500 meter (1,640.4 feet) radius for visual monitoring for the two or six airgun arrays during the low-energy seismic survey and high-energy seismic survey, respectively (except for bowhead whales). The exclusion zones 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 research vessel itself).

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. Protected species observers will also establish and monitor a 200 meter (656.2 feet) buffer zone for the low-energy seismic survey and 1,000 meter (3,280.8 feet) buffer zone for the high-energy seismic survey. 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.

The 100 meter (328.1 feet) and 500 meter (1,640.4 feet) exclusion zones are 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. Additionally, the exclusion zones are expected to minimize the likelihood that marine mammals will be exposed to sound levels likely to result in more severe behavioral responses. Although significantly greater distances may be observed from an elevated platform under good conditions, we believe that these distances are regularly attainable for protected species observers using the naked eye during typical conditions. In this case, the 100 meter (328.1 feet) and 500 meter (1,640.4 feet) radial distances will also be expected to contain sound levels that will exceed the ESA harm 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 zones 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.

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 and six G airgun array during the proposed low-energy and high-energy seismic survey in the Arctic Ocean.

Threshold	Low Frequency Cetaceans (m)	Phocid Pinnipeds (m)
Source – 2 G Airgun Array		
SEL_{cum}	17.2	0.2
Peak SPL_{flat}	10.3	11.6
Source – 6 G Airgun Array		
SEL_{cum}	50.6	0.4
Peak SPL_{flat}	29.8	33.6

m=meters, SEL_{cum}=cumulative sound exposure level, SPL=sound pressure level

The National Science Foundation's draft environmental assessment/analysis and incidental harassment authorization application have a detailed description of the modeling for the R/V *Sikuliaq*'s airgun arrays as well as the resulting isopleths to thresholds for the various marine mammal hearing groups (Table 4). Predicted distances to MMPA Level A harassment isopleths, which vary based on marine mammal hearing groups, were calculated based on modeling performed by L-DEO using the NUCLEUS source modeling software program and the NMFS user spreadsheet (https://www.fisheries.noaa.gov/action/user-manual-optional-spreadsheet-tool-2018-acoustic-technical-guidance). The largest distance of the dual criteria (SEL_{cum} or Peak SPL_{flat}) was used to calculate MMPA Level A harassment and threshold distances for marine mammals. The 160 dB re: 1 µPa (rms) isopleth is the distance at which MMPA Level B harassment is expected to occur (see Table 4).

Table 4. Predicted distances to which sound levels of 160 re: 1 μPa (rms) for harassment (Marine Mammal Protection Act Level B harassment) for impulsive sound sources will be received from the two and six G airgun arrays in intermediate and deep water depths for marine mammals during the proposed low-energy and high-energy seismic survey in the Arctic Ocean.

Source	Volume (in^3)	Tow Depth (m)	Water Depth (m)	Predicted Distance to Threshold (160 dB re: 1 μPa [rms]) (m)
2 (520 in^3) G Airgun Array	1,040	9	100 to 1,000	2,406
2 (520 in^3) G Airgun Array	1,040	9	Greater than 1,000	1,604
6 (520 in^3) G Airgun Array	3,120	9	100 to 1,000	6,960
6 (520 in^3) G Airgun Array	3,120	9	Greater than 1,000	4,640

in^3=cubic inches, m=meters

An extended exclusion zone of 500 meters (1,640.4 feet) and 1,500 meters (4,921.3 feet) for the low-energy and high-energy seismic survey, respectively, will be implemented for bowhead whales, because of their importance to subsistence hunters and protected status. No buffer of this extended exclusion zone is required. An exclusion zone at any distance will also be used for aggregations of six or more large whales (i.e., any baleen whale) and/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).

A recent retrospective analysis of acoustic propagation of the sound sources on the R/V *Marcus G. Langseth* in a coastal/continental shelf environment from the Cascadia Margin off

Washington suggests that predicted (modeled) isopleths were two to three times larger than measured in shallow water, so they are expected to be very conservative (Carton et al. 2014). Similarly, data collected by Crone et al. (2017) during a high-energy seismic survey off New Jersey in 2014 and 2015 confirmed that in situ measurements and estimates of the 160 dB re: 1 μPa (rms) distances collected by the towed hydrophone streamer on the R/V *Marcus G. Langseth* were two to three times smaller than the predicted isopleths. These comparisons of the modeling done by L-DEO with in situ received sound levels have confirmed that the isopleths generated for this low-energy and high-energy seismic survey are conservative and likely larger (more protective) than those described in the NMFS *Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing* (NOAA 2016) and *NOAA 2018 Revision to Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing* (NOAA 2018).

3.1.5.2 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 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 exclusion zone (i.e., low-energy seismic survey – 100 meters [328.1 feet] for all marine mammals/500 meters [1,640.4 feet] for bowhead whales; high-energy seismic survey – 500 meters [1,640.4 feet]/1,500 meters [4,921.3 for bowhead whales). The animal will be considered to have cleared the exclusion zone if it is visually observed to have departed the exclusion zone, or if it has not been seen within the 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 beluga whales and killer whales.

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 beluga whales and killer 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 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 be shut-down at any distance:

- Any large whale (defined as 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); and/or
- An aggregation of six or more large whales is observed.

More details on shut-down procedures can be found in *Appendix A*, which contains the NMFS Permits and Conservation Division's proposed incidental harassment authorization and possible renewal, (Section 18) of this consultation.

3.1.5.3 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 of the smallest volume, followed by doubling the number of active elements in stages until the full complement of airgun arrays are active (e.g., for the low-energy seismic survey, the second airgun will be activated after five minutes). Each stage shall be approximately the same duration, and the total duration should not be less than approximately 20 minutes for the airgun array for the high-energy seismic survey. Ramp-up for the airgun array for the low-energy seismic survey, which includes only two elements, may be shorter. 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. All operators must adhere to the following pre-clearance and ramp-up requirements:

- 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; the notification time shall not be less than 60 minutes prior to the planned ramp-up in order to allow the protected species observers time to monitor the exclusion zone and buffer zone for 30 minutes prior to the initiation of ramp-up (pre-clearance);

- Ramp-ups shall be scheduled so as to minimize the time spent with the airgun array activated prior to reaching the designated run-in;
- 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 zone or buffer zone. If a marine mammal is observed within the applicable exclusion zone or the buffer zone during the 30 minute pre-clearance period. 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 mysticetes and large odontocetes [including large delphinids, such as beluga whales and killer whales]).
- Ramp-up will begin by activating a single airgun of the smallest volume in the airgun array and will continue in stages by doubling the number of active elements at the commencement of each stage, with each stage of approximately the same duration. Duration will not be more than 20 minutes for low-energy airgun arrays. Duration will not be less than 20 minutes for high-energy airgun arrays. The operator must provide information to the protected species observer documenting that appropriate procedures were followed;
- 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 detection of a marine mammals within the applicable exclusion zone. Once ramp-up has begun, detections of marine mammals within the buffer zone do not require shut-down, but such observation will be communicated to the operator to prepare for the potential shut-down;
- Ramp-up may occur at times of poor visibility, including nighttime, if PAM has occurred with no detections in 30 minutes prior to beginning ramp-up. Acoustic source activation may only occur at times of poor visibility where operational planning cannot reasonably avoid such circumstances;
- 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 exclusion zone. For any longer shut-down, pre-clearance observation and ramp-up are required. For any shut-down at night or in periods of poor visibility (e.g., Beaufort sea state four or greater), ramp-up is required, but if the shut-down period was brief and constant observation was maintained, pre-clearance watch of 30 minutes is not required; 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 *Appendix A*, which contains the NMFS Permits and Conservation Division's proposed incidental harassment authorization and possible renewal (Section 18), of this consultation.

3.1.5.4 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 protected species (e.g., marine mammals, sea turtles, and fish). The area to be scanned visually includes primarily the exclusion zone, within which observation of certain protected species requires shut-down of the airgun array, 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 standard exclusion zone is 100 meters (328.1 feet) for low-energy seismic surveys and 500 meters (1,640.4 feet) for high-energy seismic surveys from the edges of the airgun array. For low-energy seismic surveys, the buffer zone encompasses the area at and below the sea surface from the edge of the 0 to 100 meter (0 to 328.1 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]). For high-energy seismic surveys, the buffer zone encompasses the area at and below the sea surface from the edge of the 0 to 500 meter (0 to 1,640.4 feet) exclusion zone, out to a radius of 1,000 meters (3,280.8 feet) from the edges of the airgun array (500 to 1,000 meters [1,640.4 to 3,280.8 feet]).

Visual monitoring of the exclusion zones and adjacent waters (buffer zones) 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 closer to the research 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 five dedicated, trained, NMFS-approved protected species observers aboard the R/V *Sikuliaq*. Two protected species observers will be on visual watch at all times during daytime hours. The operator will work with the selected third-party protected species observer provider to ensure the protected species observers have all the equipment (including backup equipment) needed to adequately perform necessary tasks, including accurate determination of distance and bearing to observed marine mammals.

Protected species observers must have the following requirements and qualifications:

- Protected species observers shall be independent, dedicated, trained visual and acoustic protected species observers and must be employed by a third-party observer provider;
- Protected species observers shall have no tasks other than to conduct observational effort, record observation data, and communicate with and instruct relevant vessel crew with regard to the presence of protected species and mitigation requirements (including brief alerts regarding maritime hazards);
- Protected species observer shall have successfully completed an approved protected species observer training course;
- NMFS must review and approve protected species observer resumes accompanied by a relevant training course information packet that includes the name and qualifications (i.e., experience, training completed, or educational background) of the instructor(s), the course outline or syllabus, and course reference material as well as a document stating successful completion of the course;
- NMFS shall have one week to approve protected species observers from the time that the necessary information is submitted, after which protected species observers meeting the minimum requirements shall automatically be considered approved;
- Protected species observers must successfully complete relevant training, including completion of all required coursework and passing (80 percent or greater) a written and/or oral examination developed for the training program;
- Protected species observers must have successfully attained a bachelor's degree from an accredited college or university with a major in one of the natural sciences, a minimum of 30 semester hours or equivalent in the biological sciences, and at least one undergraduate courses in math or statistics; and
- The educational requirements may be waived if the protected species observer has acquired the relevant skills through alternate experience. Requests for such a waiver shall be submitted to NMFS and must include written justification. Requests shall be granted or denied (with justification) by NMFS within one week of receipt of submitted information. Alternate experience that may be considered includes, but is not limited to (1) secondary education and/or experience comparable to protected species observer duties; (2) previous work experience conducting academic, commercial, or government-sponsored, protected species surveys; or (3) previous work experience as a protected species observer; the protected species observer shall demonstrate good standing and consistently good performance of protected species observer duties. Traditional ecological knowledge is also a relevant consideration.

At least one of the visual protected species observers aboard the research vessel must have a minimum of 90 days at-sea experience working in that role during seismic surveys, 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 two 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). 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 research 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 research 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), detections 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 towed hydrophone 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.

Visual protected species observers may be on watch for a general limit of two consecutive hours (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 for any individual protected species observer. When visual protected species observers are stationed on the bridge of the R/V *Sikuliaq*, eye level will be approximately 15.5 meters (51 feet) above sea level, and the position provides an approximate 345 degree view around the research vessel. Visual protected species observers will systematically scan around the research vessel with handheld reticle binoculars and with the naked eye. The National Science Foundation will not have Big-

Eye binoculars on the R/V *Sikuliaq* and NMFS Permits and Conservation Division will remove the requirement from the final incidental harassment authorization. Protected species observers will also have night vision devices (ITT F500 Series Generation 3 binocular-image intensifier or equivalent) during darkness, if necessary. At least one protected species observer will conduct visual monitoring at all times during daytime periods when the R/V *Sikuliaq* is underway when not conducting seismic survey activities, such as during transits.

For data collection purposes, protected species observers shall use standardized data collection forms, whether hard copy or electronic. Protected species observers shall record detailed information about any implementation of mitigation requirements, including the distance of animals to the sound 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 shut-down was implemented, the length of time before any subsequent ramp-up of the airgun array. If required mitigation was not implemented, protected species observer shall record a description of the circumstances. At a minimum, the following information must be recorded:

- Vessel names (source vessel and other vessels associated with survey) and call signs;
- Protected species observer names and affiliations;
- Dates of departures and returns to port with port name;
- Date and participants of protected species observer briefings;
- Dates and times (Greenwich Mean Time) of survey effort and times corresponding with protected species observer effort;
- Vessel location (latitude/longitude) when survey effort began and ended and vessel location at beginning and end of visual protected species observer duty shifts;
- Vessel heading and speed at beginning and end of visual protected species observer duty shifts and upon any line change;
- Environmental conditions while on visual survey (at beginning and end of protected species observer shift and whenever conditions changed significantly), including Beaufort Sea State and any other relevant weather conditions including cloud cover, fog, sun glare, and overall visibility to the horizon;
- Factors that may have contributed to impaired observations during each protected species observer shift change or as needed as environmental conditions changed (e.g., vessel traffic, equipment malfunctions); and
- Survey activity information, such as sound source power output while in operation, number and volume of airguns operating in the airgun array, tow depth of the airgun array, and any other notes of significance (i.e., pre-clearance, ramp-up, shut-down, testing, shooting, ramp-up completion, end of operations, streamers, etc.).

The following information shall be recorded upon visual observation of any protected species:

- Watch status (sighting made by protected species observer on/off effort, opportunistic, crew, alternate vessel/platform);

- Protected species observer who sighted the animal;
- Time of sighting;
- Vessel location at time of sighting;
- Water depth;
- Direction of vessel's travel (compass direction);
- Direction of animal's travel relative to the vessel;
- Pace of the animal;
- Estimated distance to the animal and its heading relative to vessel at initial sighting;
- Identification of the animal (e.g., genus/species, lowest possible taxonomic level, or unidentified) and the composition of the group if there is a mix of species;
- Estimated number of animals (high/low/best);
- Estimated number of animals by cohort (adults, yearlings, juveniles, calves, group composition, etc.);
- 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);
- Detailed behavior observations (e.g., number of blows/breaths, number of surfaces, breaching, spyhopping, diving, feeding, traveling; as explicit and detailed as possible; note any observed changes in behavior);
- Animal's closest point of approach and/or closest distance from any element of the sound source;
- Platform activity at time of sighting (e.g., deploying, recovering, testing, shooting, data acquisition, other); and
- Description of any actions implemented in response to the sighting (e.g., delays, shut-down, ramp-up) and time and location of the action.

More details on monitoring can be found in *Appendix A*, which contains NMFS Permits and Conservation Division's proposed incidental harassment authorization and possible renewal (Section 18), of this consultation.

3.1.5.5 Passive Acoustic Monitoring

Passive acoustic monitoring (PAM) was proposed by the National Science Foundation to complement the vessel-based visual mitigation monitoring as part of the high-energy seismic survey early in the consultation. NMFS Permits and Conservation Division does not propose to require the use of PAM for the proposed actions. NMFS Permits and Conservation Division typically recommends use of PAM as part of prescribed mitigation requirements for high-energy seismic surveys, but not for low-energy seismic surveys. For the National Science Foundation's proposed seismic survey activities, the low-energy seismic survey comprises 88 percent and the high-energy seismic survey comprises 12 percent. Therefore, PAM would only be applicable to the small portion of the seismic survey activities. In addition, the use of towed PAM is not

generally expected to be effective at detecting mysticetes, due to overlap in the frequencies of mysticete vocalizations with the noise from the airgun array as well as the research vessel and flow noise from the towed PAM receiver. Marine mammal species that are of greatest interest in prescribing use of towed PAM (e.g., sperm whales [*Physeter macrocephalus*] and beaked whales) are not present in the seismic survey area. Further, the National Science Foundation and University of Alaska Geophysics Institute have indicated it will not be practicable to carry the additional personnel to monitor and implement the towed PAM. The R/V *Sikuliaq* is a smaller research vessel with limited space for equipment and personnel.

3.1.5.6 Vessel Strike Avoidance Measures

Vessel strike avoidance measures are intended to minimize the potential for collisions with marine mammals. These vessel strike avoidance measures include the following:

- The vessel operator (R/V *Sikuliaq*) and crew will maintain a vigilant watch for all protected species and slow down or stop or alter course of the vessel, as appropriate and regardless of vessel size, to avoid striking any protected species during seismic survey activities as well as transits. 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 cetaceans are observed near the vessel.
- The vessel (R/V *Sikuliaq*) will maintain a minimum separation distance of 500 meters (1,640.2 feet) from bowhead whales. If a whale is observed but cannot be confirmed as a species other than a bowhead whale, the vessel operator must assume that it is a bowhead whale and take appropriate action.
  The vessel (R/V *Sikuliaq*) will maintain a minimum separation distance of 100 meters (328.1 feet) from large whales (i.e., all baleen whales and sperm whales).
- The vessel will maintain a minimum separation distance of 50 meters (164 feet) from all other marine mammals, with an understanding that at times this may not be possible (e.g., 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 protected species 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 or any vessel that is navigationally constrained.

- 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.
- 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.

3.1.5.7 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 consultation.

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 and high-energy seismic survey. The National Science Foundation determined that the sound sources proposed already are relatively small (most of the data acquisition will use a two G airgun array), and scientific objectives for the proposed low-energy seismic survey could not be met using smaller sound sources. The two G airgun array will need to penetrate substantial thickness of sediment expected to be encountered in the Canada Basin. Recognizing the structures associated with the extinct mid-ocean ridge and adjacent possible hyper-extended continental crust in the Canada Basin is also an important objective. On the Chukchi Borderland, there appear to be substantial basement structures beneath the sediment cover. Imaging these structures is critical to understanding the pre-extension history of the Chukchi Borderland. The six G airgun array will be needed to collect seismic refraction data in the Canada Basin to characterize the deep crustal structure associated with an extinct mid-ocean ridge in the central basin. The airgun arrays being used for the proposed action is one of the smaller sound sources used by the U.S. academic research community to conduct research during seismic survey activities. Based on experience, the principal investigator has found that this sound source (two G-airgun array) is considered the minimum that will provide sufficient energy to image the stratigraphy and underlying structure.

Speed or Course Alteration

The National Science Foundation will alter the R/V *Sikuliaq*'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] or 500 meters [1,640.4 feet]). Speed and course alteration will be implemented if operationally practicable while minimizing the effect on the planned scientific objectives. 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] or 500 meters [1,640.4 feet]), further mitigation measures (such as shut-down procedures) will be taken. Typically, during seismic survey

activities, the R/V *Sikuliaq* is unable to change speed and course and one or more alternative mitigation measures will need to be implemented.

Location and Timing

The principal investigator worked with the National Science Foundation and its contractors to identify potential times to carry out the low-energy and high-energy seismic survey, taking into consideration key factors such as environmental conditions (e.g., ice cover, seasonal presence of marine mammals and seabirds), subsistence activities, weather conditions, equipment, and optimal timing for other proposed research cruises using the R/V *Sikuliaq*, as well as coordination with the Geological Survey of Denmark and Greenland. The summer schedule (August through September) is proposed because sea ice cover is typically at a minimum during this time of year. The schedule is mainly constrained by the ice-minimum (approximately September 15) and consideration of subsistence activities in the region (i.e., seismic surveys will occur greater than or equal to 300 kilometers [162 nautical miles] north of Utqiagvik, Alaska [formerly Barrow]). Acquiring data from the airgun array, sub-bottom profiler, multi-beam echosounder, and acoustic Doppler current profiler in ice covered seas creates a risk such as damage and/or loss to the sound source and acoustic receivers that are deployed behind the R/V *Sikuliaq*. Working north of the Chukchi Borderland around the time of the ice-minimum enables the longer tracklines to be acquired. The R/V *Sikuliaq* is expected to encounter only limited ice in the marginal ice zone during this seismic survey. Arriving earlier risks heavier residual ice from the previous season, whereas arriving later risks encountering fresh annual ice that can impair operations. The plan is to have all the seismic survey equipment on board and be heading southbound to Nome, Alaska prior to the beginning of fall whaling in Utqiagvik. Therefore, summer is the most practical season for the proposed seismic survey. A higher density of cetacean species, in particular baleen whales, are expected to occur in the action area during the summer. Pinnipeds inhabit the action area year-round.

3.1.5.8 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 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 and high-energy seismic survey. The report will describe the seismic survey activities that were conducted and sightings of marine mammals near the proposed actions. 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 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. A final report must be submitted within 30 days following resolution of any comments on the draft report.

More details on reporting (e.g., reporting injured or dead marine mammals) can be found in *Appendix A*, which contains NMFS Permits and Conservation Division's proposed incidental harassment authorization and possible renewal (Section 18), of this consultation.

3.2 National Marine Fisheries Service's Proposed Action

On February 12, 2021, NMFS Permits and Conservation Division received a request from the National Science Foundation and University of Alaska Geophysics Institute for an incidental harassment authorization to take marine mammals incidental to conducting a low-energy and high-energy marine seismic survey in the Arctic Ocean. On April 6, 2021, NMFS Permits and Conservation Division deemed the National Science Foundation and University of Alaska Geophysics Institute's application for an incidental harassment authorization to be adequate and complete. The National Science Foundation and University of Alaska Geophysics Institute's request is for take of a small number of 13 species of marine mammals by MMPA Level B harassment. Neither the National Science Foundation and University of Alaska Geophysics Institute, 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 and high-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 August 1, 2021 through August 1, 2022. The NMFS Permits and Conservation Division proposes to issue the incidental harassment authorization by July 23, 2021, so that the National Science Foundation and University of Alaska Geophysics Institute will have the incidental harassment authorization prior to the start of the proposed low-energy and high-energy seismic survey. Because the National Science Foundation and University of Alaska Geophysics Institute has tentatively scheduled the proposed low-energy and high-energy seismic survey to begin on August 17, 2021 and has requested that the incidental harassment authorization be issued by July 23, 2021, the NMFS Permits and Conservation Division has requested the consultation be completed by July 2, 2021.

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 and high-energy seismic survey. The incidental harassment authorization will be valid for a period of one year from August 1, 2021 through August 1, 2022. The incidental harassment authorization will authorize the incidental harassment of the following threatened and endangered species: bowhead whale (*Balaena mysticetus*), fin whale (*Balaenoptera physalus*), Mexico DPS and Western North Pacific DPS of humpback whale (*Megaptera novaeangliae*), Beringia DPS of bearded seal (*Erignathus barbatus*), and Arctic subspecies of ringed seal (*Phoca hispida hispida*). The proposed incidental harassment authorization identifies requirements that the National Science Foundation and University of Alaska Geophysics Institute must comply with as part of its authorization. The NMFS Permits and Conservation Division does not expect the National Science Foundation and University of Alaska Geophysics Institute's planned low-energy and high-energy seismic survey to exceed one

year and do not expect subsequent MMPA incidental harassment authorizations will be issued for this particular specified activity. Nevertheless, NMFS Permits and Conservation Division recognizes that delays to the 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-time, one-year incidental harassment authorization renewal with an expedited 15-day public comment period when (1) up to 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 (renewal) 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 the needed renewal incidental harassment authorization effective date (recognizing that the renewal incidental harassment authorization expiration date cannot extend beyond one year from the expiration of the initial incidental harassment authorization;
- The request for renewal must include the following: (1) an explanation that the activities to be conducted under the proposed renewal incidental harassment authorization 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); 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 May 28, 2021, NMFS Permits and Conservation Division published a notice of proposed incidental harassment authorization and request for comments on proposed incidental harassment authorization and possible renewal in the *Federal Register* (86 FR 28787 to 28809). The public comment period closed on June 28, 2021. The NMFS Permits and Conservation Division received a late public comment from the Alaska Eskimo Whaling Commission regarding their decision to not conduct a peer review. *Appendix A* (see Section 18) contains the NMFS Permits and Conservation Division's proposed incidental harassment authorization and possible renewal. The text in *Appendix A* (see Section 18) was taken directly from the proposed incidental harassment authorization and possible renewal provided to us in the consultation initiation package.

3.2.2 Revision to Proposed Incidental Harassment Authorization

The NMFS Permits and Conservation Division has made revisions to the proposed incidental harassment authorization since the notice was published in the *Federal Register* on May 28, 2021 (86 FR 28787 to 28809). The revisions are based on a conversion error for the average density of several species of baleen whales as well as a calculation error for phocid pinnipeds used in the exposure analysis. The revisions to the proposed incidental harassment authorization include modifications to the incidental take estimates of marine mammals (bowhead whales, Beringia DPS of bearded seals, and Arctic subspecies of ringed seals). Also, the NMFS Permits and Conservation Division will remove the requirement for Big-Eye binoculars from the final incidental harassment authorization because the National Science Foundation will not have them on the R/V *Sikuliaq*.

3.2.3 Overview of Proposed Mitigation, Monitoring, and Reporting in the Incidental Harassment Authorization

In order to issue an incidental harassment authorization under section 101(a)(5)(D) of the MMPA, NMFS Permits and Conservation Division must set forth permissible methods of taking pursuant to the activity, and other means of effecting the least practicable impact on the species or stock and its habitat, paying particular attention to rookeries, mating grounds, and areas of similar significance, and on the availability of the species or stock for taking for certain subsistence uses. NMFS Permits and Conservation Division regulations require applicants for incidental take authorizations to include information about the availability and feasibility (economic and technological) of equipment, methods, and manner of conducting the activity or other means of effecting the least practicable adverse impact upon the affected species or stocks and their habitat (50 C.F.R. §216.104(a)(11)).

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

- The manner in which, and the degree to which, the successful implementation of the measure(s) is expected to reduce impacts to marine mammals, marine mammal species or stocks, and their habitat, as well as subsistence uses. This considers the nature of the potential adverse impact being mitigated (likelihood, scope, range). It further considers the likelihood that the measure will be effective if implemented (probability of accomplishing the mitigating result if implemented as planned), the likelihood of effective implementation (probability implemented as planned), and;
- The practicability of the measures for applicant implementation, which may consider such things as cost and impact on operations.

In order to satisfy the MMPA's least practicable adverse impact standard, NMFS Permits and Conservation Division has evaluated a suite of basic mitigation protocols for seismic surveys that are required regardless of the status of a stock. Additional or enhanced protections may be

required for species whose stocks are in particularly poor health and/or subject to some significant additional stressor that lessens that stock's ability to weather the effects of the specified activities without worsening its status. The NMFS Permits and Conservation Division reviewed seismic mitigation protocols required or recommended elsewhere (HESS 1999; JNCC 2017; Kyhn et al. 2011; Nowacek et al. 2013), recommendations received during public comment periods for previous actions, and the available scientific literature. The NMFS Permits and Conservation Division also considered recommendations given in a number of review articles (Compton et al. 2008; Parsons et al. 2009; Weir and Dolman 2007; Wright and Cosentino 2015). This exhaustive review and consideration of public comments regarding previous similar activities has led to development of the protocols included here.

Due to the low-energy and high-energy airgun arrays used, two separate mitigation protocols are proposed for use throughout the seismic survey activities, depending on which airgun array is in use.

Table 5. Proposed mitigation and monitoring protocols for the low-energy and high-energy airgun arrays in the National Marine Fisheries Service's proposed incidental harassment authorization and possible renewal.

Mitigation and Monitoring Protocols	Low-Energy Airgun Array (2 Airguns with 1,040 in^3 Total Discharge Volume)	High-Energy Airgun Array (6 Airguns with 3,120 in^3 Total Discharge Volume)
Vessel-Based Visual Mitigation Monitoring	Minimum of two NMFS-approved protected species observers on duty during daylight hours (30 minutes before sunrise through 30 minutes after sunset); General limit of two consecutive hours on watch followed by a break of at least one hour; Maximum of 12 hours on watch per 24-hour period.	Minimum of two NMFS-approved protected species observers on duty during daylight hours (30 minutes before sunrise through 30 minutes after sunset); General limit of two consecutive hours on watch followed by a break of at least one hour; Maximum of 12 hours on watch per 24-hour period.
Passive Acoustic Monitoring	Not required.	Not required.
Buffer Zones	200 m	1,000 m
Exclusion Zones	100 m (all marine mammals) 500 m (bowhead whales)	500 m (all marine mammals) 1,500 m (bowhead whales)
Pre-Clearance and Ramp-Up Procedures	Required; 30 minute clearance period of the following zones: 200 m (all marine mammals) 500 m (bowhead whales) Following detection within zone, animal must be observed exiting	Required; 30 minute clearance period of the following zones: 1,000 m (all marine mammals) 1,500 m (bowhead whales) Following detection within zone, animal must be observed exiting

Mitigation and Monitoring Protocols	Low-Energy Airgun Array (2 Airguns with 1,040 in^3 Total Discharge Volume)	High-Energy Airgun Array (6 Airguns with 3,120 in^3 Total Discharge Volume)
	or additional period of 15 or 30 minutes.	or additional period of 15 or 30 minutes.
Ramp-Up Procedures	Required; duration not more than 20 minutes.	Required; duration greater than or equal to 20 minutes.
Shut-Down Procedures	Shut-down required for marine mammals detected within defined exclusion zones; re-start allowed following clearance period of 15 or 30 minutes.	Shut-down required from marine mammals detected within defined exclusion zones; re-start allowed following clearance period of 15 or 30 minutes.

in^3=cubic inches; m=meters

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 actions will take place approximately 300 kilometers (162 nautical miles) from the Alaska coastline (north of Utqiagvik) in the Arctic Ocean, between approximately 73.5 to 81.0 degrees North, and 139.5 to 168 degrees West. The low-energy and high-energy seismic survey will take place in the Exclusive Economic Zone of the U.S. (a small portion) and International Waters in water depths ranging from approximately 200 to 4,000 meters (656.2 to 13,123.4 feet). Approximately four percent or 236 kilometers (127.4 nautical miles) out of a total of 5,850 kilometers (3,158.7 nautical miles) of tracklines will occur in the U.S. Exclusive Economic Zone. Representative tracklines are shown in Figure 1. The representative tracklines shown in Figure 1 have a total length of approximately 5,850 kilometers (3,158.7 nautical miles), including 5,170 kilometers (2,791.6 nautical miles) of MCS reflection surveys and 680 kilometers (367.2 nautical miles) of OBS refraction surveys. 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. The tracklines can occur anywhere within the coordinates noted in Figure 1. The action area will also include the area covered by the R/V *Sikuliaq* while transiting from its port to the seismic survey area, and its return at the conclusion of the low-energy and high-energy seismic survey. The R/V *Sikuliaq* is expected to leave from and return to the port of Nome, Alaska. The port locations may be subject to change. The action area (the study area and the transit to/from Nome, Alaska) will not extend beyond the area shown in Figure 1. We do not anticipate any effects (see Sections 6, 7, and 10) outside the area shown on the maps in Figure 1.

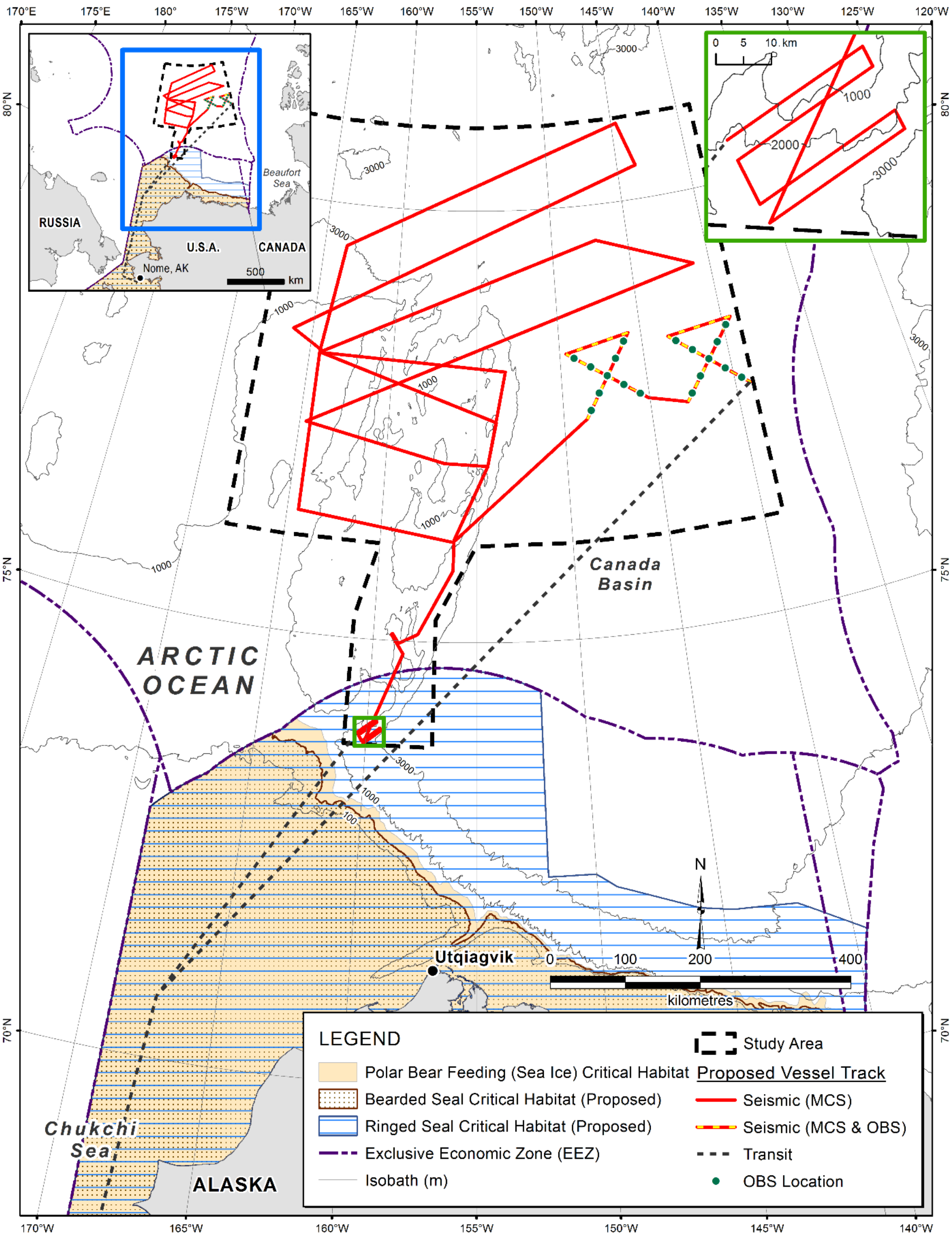

Figure 1. Map of the National Science Foundation's low-energy and high-energy seismic survey in the Arctic Ocean and National Marine Fisheries Service Permits and Conservation Division's proposed issuance of an incidental harassment authorization and possible renewal for this consultation.

5 Endangered Species Act-Listed Species and Proposed or Designated Critical Habitat Present in the Action Area

This section identifies the ESA-listed species and proposed or designated critical habitat that potentially occur within the action area (Table 6) that may be affected by the proposed actions. These ESA-listed species and proposed or designated critical habitat are subject in this consultation because they co-occur with the potential stressors produced by the proposed actions in space and time.

Table 6. Endangered Species Act-listed threatened and endangered species and proposed critical habitat potentially occurring in the action area that may be affected by the National Science Foundation's low-energy and high-energy seismic survey in the Arctic Ocean and National Marine Fisheries Service Permits and Conservation Division's proposed issuance of an incidental harassment authorization and possible renewal.

Species	ESA Status	Critical Habitat	Recovery Plan
Marine Mammals – Cetaceans			
Blue Whale (*Balaenoptera musculus*)	E – 35 FR 18319	-- --	07/1998 10/2018 - Draft
Bowhead Whale (*Balaena mysticetus*)	E – 35 FR 18319	-- --	-- --
Fin Whale (*Balaenoptera physalus*)	E – 35 FR 18319	-- --	75 FR 47538 07/2010
Gray Whale (*Eschrichtius robustus*) Western North Pacific Population	E – 35 FR 18319	-- --	-- --
Humpback Whale (*Megaptera novaeangliae*) – Mexico DPS	T – 81 FR 62259	86 FR 21082	11/1991
Humpback Whale (*Megaptera novaeangliae*) – Western North Pacific DPS	E – 81 FR 62259	86 FR 21082	11/1991
North Pacific Right Whale (*Eubalaena japonica*)	E – 73 FR 12024	73 FR 19000	78 FR 34347 06/2013
Sei Whale (*Balaenoptera borealis*)	E – 35 FR 18319	-- --	12/2011
Marine Mammals – Pinnipeds			
Bearded Seal (*Erignathus barbatus*) – Beringia DPS	T – 77 FR 76739	86 FR 1433 (Proposed)	-- --

Species	ESA Status	Critical Habitat	Recovery Plan
Ringed Seal (*Phoca hispida hispida*) – Arctic Subspecies	T – 77 FR 76706	79 FR 73010 (Proposed) 86 FR 1452 (Revised Proposed)	-- --
Steller Sea Lion (*Eumetopias jubatus*) – Western DPS	E – 55 FR 49204	58 FR 45269	73 FR 11872 2008
Proposed Critical Habitat			
Bearded Seal (*Erignathus barbatus*) – Beringia DPS	T – 77 FR 76739	86 FR 1433 (Proposed)	-- --
Ringed Seal (*Phoca hispida hispida*) – Arctic Subspecies	T – 77 FR 76706	79 FR 73010 (Proposed) 86 FR 1452 (Revised Proposed)	-- --

ESA= Endangered Species Act, FR=*Federal Register*, DPS=Distinct Population Segment, T=Threatened, E=Endangered

6 Potential Stressors

The proposed actions involve 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 proposed or designated critical habitat. During consultation, we deconstructed the proposed actions to identify stressors that are reasonably certain to occur from the proposed actions. These can be categorized as pollution (e.g., fuel, oil, trash), vessel strikes, acoustic and visual disturbance (research vessel, seismic airgun array, sub-bottom profiler, multi-beam echosounder, acoustic Doppler current profiler, acoustic release transponder), entanglement in towed seismic equipment (airgun array and hydrophone streamer). Below we provide detailed information on the effects of these potential stressors. Furthermore, the proposed actions includes several conservation (monitoring and mitigation) measures described in Section 3.1.5 that are designed to minimize effects that may result from these potential stressors. While we consider all of these 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 actions and fully consider them when evaluating the effects of the proposed actions (Sections 3.1 and 3.2).

6.1 Pollution

The operation of the R/V *Sikuliaq* 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 change (see https://www.epa.gov/ghgemissions/overview-greenhouse-gases for additional information). The release of marine debris such as paper, plastic, wood, glass, and metal associated with vessel operations can also have adverse effects on marine species most commonly through entanglement or ingestion (Gall and Thompson 2015). While lethal and non-lethal effects to air breathing marine animals such sea turtles, birds, and marine mammals are well documented, marine debris also adversely affects marine fish (Gall and Thompson 2015).

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

6.2 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 actions 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 R/V *Sikuliaq* has a length of 80 meters (262.5 feet) and the operating speed during seismic data acquisition is typically approximately 8.3 kilometers per hour (4.5 knots). When not towing seismic survey gear, the R/V *Sikuliaq* typically transits at 18.5 kilometers per hour (10 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 research vessel activity associated with the proposed actions 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 actions.

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

The proposed actions will produce a variety of different sounds including those associated with vessel operations, sub-bottom profilers, multi-beam echosounders, acoustic Doppler current profilers, acoustic release transponders, and airgun arrays that may produce an acoustic disturbance or otherwise affect ESA-listed species. It will also involve the presence of vessels (and associated equipment) that produce a visual disturbance that may affect ESA-listed marine mammals. The acoustic noise from the sub-bottom profilers, multi-beam echosounders, acoustic Doppler current profilers, and acoustic release transponders will be discussed further in Section 6.4.

The research vessel associated with the proposed actions 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, sub-bottom profilers, multi-beam echosounders, acoustic Doppler current profilers, acoustic release transponders, 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).

Several of the mitigation measures associated with the proposed actions such as ramp-up and shut-down procedures associated with the low-energy and high-energy seismic survey procedures 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 R/V *Sikuliaq* 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. 1995d). 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 μPa [rms] ± standard error) for individual vessels ranged from 158 ± 2 dB (research vessel) to 186 ± 2 dB (oil tanker). McKenna et al. (2012) documented different acoustic levels and spectral shapes observed from different modern vessel-types in a study off Southern California.

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 2002; 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 2005b; 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.

6.4 Sub-Bottom Profiler, Multi-Beam Echosounder, Acoustic Doppler Current Profiler, and Acoustic Release Transponder

The sub-bottom profiler, multi-beam echosounder, acoustic Doppler current profiler, and acoustic release transponder are four active acoustic systems that will operate during the proposed low-energy and high-energy seismic survey on the R/V *Sikuliaq*. As described above in

Section 3.1.4, a sub-bottom profiler, 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 seismic survey area. The acoustic release transponder will be used during recovery of the OBSs.

The sub-bottom profiler, multi-beam echosounder, acoustic Doppler current profiler, and acoustic release transponder (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 µPa (rms) threshold for harassment. The sub-bottom profiler, multi-beam echosounder, acoustic Doppler current profiler, and acoustic release transponder operate at a frequency of 0.5 to 6 kiloHertz, 30 kiloHertz, 75 to 150 kiloHertz, and 10 to 13 kiloHertz, respectively. These frequencies are generally higher frequencies than airgun array operations (6 to 20 Hertz for the two G airgun array, 5 to 20 Hertz for the six G airgun array). These frequencies are within the functional hearing range of baleen whales (7 Hertz to 35 kiloHertz), such a blue, bowhead, fin, gray, humpback, North Pacific right, and sei whales as well as phocid pinnipeds (50 to 86 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 µPa range, it is difficult to determine the significance of this because the sound source was a signal designed to be alarming and the sound level was well below typical ambient noise. Goldbogen et al. (2013) found blue whales to respond to 3.5 to 4 kiloHertz mid-frequency sonar at received levels below 90 dB re: 1 µPa (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 sub-bottom profiler, multi-beam echosounder, acoustic Doppler current profiler, and acoustic release transponder (Ketten 1997; Richardson et al. 1995f).

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 sub-bottom profiler, multi-beam echosounder, and acoustic Doppler current profiler since these other sound sources will drop off faster than the airgun arrays. In addition, the sub-bottom profiler, 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 PTS for an animal. Therefore, sounds from the airgun array are expected to effectively cancel out sounds produced by the sub-bottom profiler, multi-beam echosounder, and acoustic Doppler current profiler.

For the sub-bottom profiler, the instrument emits energy in a 3.5 to 4.5 degree beam from the bottom of the research vessel with a series of ten to 40 consecutive 15 millisecond pulses with a

variable ping rate. For the multi-beam echosounder, the transmitting beamwidth is very narrow, 0 to 75 degrees, and emits a series of 0.7 to 200 millisecond pulses. For the acoustic Doppler current profiler, the instrument will have a 30 degree conically-shaped beam, and emits a series of 11 to 37 millisecond pulses and has a ping rate of 0.7 seconds. For the acoustic release transponder, the instrument will have a transmitting beam patter of 55 degrees with a pulse duration of 2 milliseconds and the pulse repetition rate of one per second. Given the movement and speed of the research vessel, the intermittent and narrow downward-directed nature of the sounds emitted by the sub-bottom profiler, multi-beam echosounder, acoustic Doppler current profiler, and acoustic release transponder will result in no more than one or two brief ping exposures of any individual cetacean or pinniped, if any exposure were to occur.

The response of a blue whale to 3.5 kiloHertz sonar supports this species' ability to hear the signal from the sonar (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.

Investigations stemming from a 2008 stranding event in Madagascar indicated a 12 kiloHertz multi-beam echosounder, similar in operating characteristics as that proposed for use aboard the R/V *Sikuliaq*, suggest that this sonar played a significant role in a the mass stranding of a large group of melon-headed whales (*Peponocephala electra*) (Southall 2013). Although pathological data suggesting a direct physical effect are lacking and the authors acknowledge that while the use of this type of sonar is widespread and common place globally without noted incidents (like the Madagascar stranding), all other possibilities were either ruled out or believed to be of much lower likelihood as a cause or contributor to stranding compared to the use of the multi-beam echosounder (Southall 2013). This incident highlights the caution needed when interpreting effects that may or may not stem from anthropogenic sound sources, such as the R/V *Sikuliaq*'s sub-bottom profiler, multi-beam echosounder, acoustic Doppler current profiler, and acoustic release transponder. 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 R/V *Sikuliaq* differs

from sonars used during naval operations, which generally have a longer pulse duration and more horizontal orientation than the more downward-directed sub-bottom profiler, multi-beam echosounder, acoustic Doppler current profiler, and acoustic release transponder. The sound energy received by any individuals exposed to the sub-bottom profiler, multi-beam echosounder, acoustic Doppler current profiler, and acoustic release transponder 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 sub-bottom profiler, multi-beam echosounder, acoustic Doppler current profiler, and acoustic release transponder is also much smaller, consisting of a narrow zone close to and below the source vessel. Because of these differences, we do not expect these systems to contribute to a stranding event.

6.5 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 (*Eubalaena japonica*), 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).

Towed gear from the seismic survey activities poses a risk of entanglement to ESA-listed marine mammals. The towed hydrophone streamer could come in direct contact with ESA-listed species. 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 pinnipeds (seals) 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.

7 Species and Critical Habitat Not Likely to be Adversely Affected

This section identifies the ESA-listed species and proposed or designated critical habitat under NMFS jurisdiction that may occur within the action area that are not likely to be adversely affected by the proposed actions. This section also identifies potential stressors associated with the proposed actions that are not likely to adversely affect ESA-listed species and proposed or designated critical habitat that may occur within the action area. NMFS uses two criteria to identify the ESA-listed or 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 6 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.

Discountable effects are those that are extremely likely 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 an ESA-listed species), but it is very unlikely to occur. If the effects of an action are determined to be wholly beneficial, insignificant, or discountable, we conclude that the action is not likely to adversely affect ESA-listed species or designated critical habitat. This same decision model applies to individual stressors associated with the proposed actions, such that some stressors may be determined to be not likely to adversely affect ESA-listed species or critical habitat because any effects associated with the stressors will not rise to the level of take under the ESA.

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 actions. 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 ESA-listed species. The effects of other stressors associated with the proposed actions, which are not likely to adversely affect ESA-listed species and proposed critical habitat, are evaluated in Section 7.1. The species and proposed critical habitat potentially occurring within the action area that may be affected, but are not likely to be adversely affected, are listed in Table 6, except for the bowhead whale, Beringia DPS of bearded seal, and Arctic subspecies of ringed seal.

7.1 Potential Stressors to Endangered Species Act-Listed Cetaceans and Pinnipeds

Potential stressors that may affect, but are not likely to adversely affect ESA-listed marine mammals (cetaceans and pinnipeds; i.e., blue whales, bowhead whales, fin whales, Western North Pacific population of gray whales, Mexico DPS and Western North Pacific DPS of humpback whales, North Pacific right whales, sei whales, Beringia DPS of bearded seals, Arctic subspecies of ringed seals, and Western DPS of Steller sea lions) and proposed or designated critical habitat include pollution, vessel strike, vessel noise and visual disturbance, acoustic noise from sub-bottom profiler, multi-beam echosounder, acoustic Doppler current profiler, acoustic release transponder, and gear entanglement. The following sections describe how we reached this effects determination for these potential stressors.

7.1.1 Pollution

As stated in Section 6.1, the National Science Foundation proposes to include guidance on the handling and disposal of marine trash and debris during the low-energy and high-energy seismic survey. The research vessel used during the National Science Foundation-funded low-energy and high-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 R/V *Sikuliaq* during the proposed seismic survey 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 R/V *Sikuliaq* 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. The possibility for oil or fuel leakage is extremely unlikely to occur. Therefore, we conclude that pollution by oil or fuel leakage may affect, but is not likely to adversely affect ESA-listed species.

7.1.2 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 R/V *Sikuliaq* will be traveling at generally low 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 R/V *Sikuliaq* has traveled without a vessel strike, the general expected movement of marine mammals away from or parallel to the R/V *Sikuliaq*, as well as the generally slow movement of the R/V *Sikuliaq* during most of its travels (Hauser and Holst 2009; Holst 2010; Holst and Smultea 2008). The R/V *Sikuliaq* will have an operating speed of typically 8.3 kilometers per hour (4.5 knots) during seismic data acquisition. When not towing seismic survey gear, the R/V *Sikuliaq* typically transits at 18.5 kilometers per hour (10 knots). 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, we find that

the risk from this potential stressor on ESA-listed marine mammals in the action area is extremely unlikely to occur. Therefore, we conclude that vessel strike may affect, but is not likely to adversely affect ESA-listed species.

7.1.3 Vessel Noise and Visual Disturbance

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 2002; 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 2005b; 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 *Sikuliaq* is likely small in the overall regional sound field of the action area. The R/V *Sikuliaq*'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 *Sikuliaq* 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 may affect, but is not likely to adversely affect ESA-listed species.

7.1.4 Acoustic Noise from Sub-Bottom Profiler, Multi-Beam Echosounder, Acoustic Doppler Current Profiler, and Acoustic Release Transponder

We do not expect masking of communication will occur to an appreciable extent in blue, bowhead, fin, Western North Pacific Population of gray, Mexico DPS of humpback, Western North Pacific DPS of humpback, North Pacific right, and sei whales as well as Beringia DPS of bearded seal, Arctic subspecies of ringed seal, and Western DPS of Steller sea lion due to the sub-bottom profiler, multi-beam echosounder, acoustic Doppler current profiler, and acoustic release transponder'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 sub-bottom profiler, multi-beam echosounder, acoustic Doppler current profiler, and acoustic release transponder 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 sub-bottom profilers, multi-beam echosounders, 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 potential stressor to be extremely unlikely to occur. 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 sub-bottom profiler, multi-beam echosounder, acoustic Doppler current profiler, and acoustic release transponder. As discussed earlier, the sound levels produced by the airgun array are of primary concern in terms of exposure, due to their greater energy power, and the potential to cause injury or disrupt essential behavioral patterns. Therefore, we conclude that the sub-bottom profiler, multi-beam echosounder, acoustic Doppler current profiler, and acoustic release transponder may affect, but are not likely to adversely affect ESA-listed species.

7.1.5 Gear Entanglement

As discussed, towed seismic equipment (airgun array and towed hydrophone streamer) associated with the proposed seismic survey activities may pose a risk of entanglement to ESA-listed species. Although the airgun array and towed hydrophone streamer could come in direct contact with an ESA-listed species, entanglements are highly unlikely. The airgun array and 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 and pinnipeds considered during this consultation. For these reasons, we expect the taut cables will prevent entanglement of ESA-listed species. Furthermore, mysticetes and possibly pinnipeds 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 species 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 extremely unlikely to occur. Therefore, we conclude that gear entanglement may affect, but is not likely to adversely affect ESA-listed species.

7.2 Cetaceans

The blue whale, fin whale, Western North Pacific population of gray whale, Mexico DPS of humpback whale, Western North Pacific DPS of humpback whale, North Pacific right whale, and sei whale may occur in the action area and may be affected by the proposed actions. In addition to the potential stressors that are not likely to adversely affect ESA-listed cetaceans discussed above in Section 7.1, other stressors resulting from the proposed actions may affect, but are not likely to adverse affect specific species and critical habitat as discussed in the following subsections.

7.2.1 Blue Whale

The ESA-listed blue whale may occur in the action area and may be affected by the stressors associated with the National Science Foundation's proposed low-energy and high-energy seismic survey (see Section 6). While the blue whale can be found in coastal and pelagic habitats within the action area, it is unlikely that blue whales will be adversely affected by stressors associated with the proposed actions as they are not expected to occur in the portion of the action area where airgun array operations are expected to occur. Each of the stressors associated with the proposed actions, along with our determination on their impacts to ESA-listed marine mammals (particularly cetaceans) within the action area, are discussed below.

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

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.

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 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.

From this overview, blue whales may be found within the action area. However, the blue whale is not expected to occur in the area of the proposed seismic survey activities as the tracklines to

the proposed low-energy and high-energy seismic survey are further north (between approximately 73.5 to 81.0 degrees North, and 139.5 to 168 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 blue whales to be present, we do not expect the animals to be exposed to the potential stressors of acoustic noise from the airgun array. The potential for exposure to the potential stressors of acoustic noise from the airgun array or gear entanglement is extremely unlikely to occur. Blue whales may be exposed to the potential stressors of pollution, vessel strike, and vessel noise during the transit and port stops of the R/V *Sikuliaq*. However, we determined any effects associated with these potential stressors are insignificant or discountable (discussed further in Section 7.1). Therefore, we conclude that the National Science Foundation's proposed low-energy and high-energy seismic survey may affect, but is not likely to adversely affect ESA-listed blue whales.

7.2.2 Fin Whale

The ESA-listed fin whale may occur in the action area and may be affected by the stressors associated with the National Science Foundation's proposed low-energy and high-energy seismic survey (see Section 6). While the fin whale can be found in coastal and pelagic habitats within the action area, it is unlikely that fin whales will be adversely affected by stressors associated with the proposed actions as they are not expected to occur in the portion of the action area where airgun array operations are expected to occur. Each of the stressors associated with the proposed actions, along with our determination on their impacts to ESA-listed marine mammals (particularly cetaceans) within the action area, are discussed below.

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.

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. The availability of prey, sand lice in particular, is thought to have had a strong influence on the distribution and movements of fin whales.

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. 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. 2016).

Fin whales do not generally occur in the Chukchi and Beaufort Seas. Fin whales have rarely been observed as far north in the Arctic Ocean as the location of the seismic survey activities, but have

been sighted on rare occasions in areas with lower latitudes during aerial surveys. The action area is considered to be outside of their typical migratory patterns. Brower et al. (2018) suggest that sightings of these sub-Arctic species are increasing in the eastern Chukchi Sea as in recent years due to climate change. They have been minimally sighted in the Chukchi Sea based on aerial survey of Arctic marine mammals (ASAMM) data. In the Chukchi and Beaufort seas, recent monitoring during seismic surveys for the oil and gas industry suggest that they may be increasing in numbers in the Arctic Ocean, but are still expected to be south of the action area for the seismic survey activities (Funk et al. 2010).

From this overview, fin whales may be found within the action area. However, the fin whale is not expected to occur in the area of the proposed seismic survey activities as the tracklines to the proposed low-energy and high-energy seismic survey are further north (between approximately 73.5 to 81.0 degrees North, and 139.5 to 168 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 fin whales to be present, we do not expect the animals to be exposed to the potential stressors of acoustic noise from the airgun array. The potential for exposure to the potential stressors of acoustic noise from the airgun array or gear entanglement is extremely unlikely to occur. Fin whales may be exposed to the potential stressors of pollution, vessel strike, and vessel noise during the transit and port stops of the R/V *Sikuliaq*. However, we determined any effects associated with these potential stressors are insignificant or discountable (discussed further in Section 7.1). Therefore, we conclude that the National Science Foundation's proposed low-energy and high-energy seismic survey may affect, but is not likely to adversely affect ESA-listed fin whales.

7.2.3 Gray Whale – Western North Pacific Population

The ESA-listed Western North Pacific population of gray whale may occur in the action area and may be affected by the stressors associated with the National Science Foundation's proposed low-energy and high-energy seismic survey (see Section 6). While the Western North Pacific population of gray whale can be found in coastal and pelagic habitats within the action area, it is unlikely that Western North Pacific population of gray whales will be adversely affected by stressors associated with the proposed actions as they are not expected to occur in the portion of the action area where airgun array operations are expected to occur. Each of the stressors associated with the proposed actions, along with our determination on their impacts to ESA-listed marine mammals (particularly cetaceans) within the action area, are discussed below.

Gray whales mostly inhabit shallow coastal waters in the North Pacific Ocean. Some Western North Pacific population of gray whales winter on the west coast of North America while other migrate south to winter in waters off Japan and China, and summer in the Okhotsk Sea off northeast Sakhalin Island, Russia, and off southeastern Kamchatka in the Bering Sea (Burdin et al. 2013).

The Western North Pacific population of gray whales feeds during the summer and fall in the Okhotsk and Bering Seas off northeastern Japan and eastern Russia, respectively. The non-ESA-

listed Eastern North Pacific population of gray whales also feeds in the Bering Sea, in addition to the Beaufort Sea and Chukchi Seas and the coastal waters of western North America. This population is estimated to comprised of approximately 26,290 individuals, while the Western North Pacific population is comprised of approximately 290 individuals (reviewed in (Carretta et al. 2019). The probability of encountering gray whales from the Western North Pacific population in the Chukchi and Beaufort Seas is zero percent and 1.1 percent in the Bering Sea.

Previous studies have observed approximately 30 gray whales from the Western North Pacific population in the Western and Eastern North Pacific Ocean (including coastal waters of Canada, U.S., and Mexico), as some gray whales from the Western North Pacific population are thought to migrate to the eastern North Pacific Ocean in winter, while others from this population migrate south to waters of Japan and China (reviewed in (Carretta et al. 2019)). Genetic structure analysis of gray whales feeding off Russia show most animals are recent descendants of Eastern North Pacific Population of gray whales, with estimates that 20 to 55 percent not using wintering grounds off Mexico. A small proportion of animals from the Western North Pacific Population of gray whales remain in the Western North Pacific Ocean year-round (Lang et al. 2020).

From this overview, the Western North Pacific population of gray whales may be found within the action area. However, the Western North Pacific population of gray whale is not expected to occur in the area of the proposed seismic survey activities as the tracklines to the proposed low-energy and high-energy seismic survey are further north (between approximately 73.5 to 81.0 degrees North, and 139.5 to 168 degrees West) than their range; however, they may occur in the action area of the port stops and transit. Most animals that occur in the Bering, Chukchi, and Beaufort seas likely belong to the delisted Eastern North Pacific Population of gray whales. Since the proposed seismic survey activities will take place in a location where we do not expect Western North Pacific population of gray whales to be present, we do not expect the animals to be exposed to the potential stressors of acoustic noise from the airgun array. The potential for exposure to the potential stressors of acoustic noise from the airgun array or gear entanglement is extremely unlikely to occur. Western North Pacific population of gray whales may be exposed to the potential stressors of pollution, vessel strike, and vessel noise during the transit and port stops of the R/V *Sikuliaq*. However, we determined any effects associated with these potential stressors are insignificant or discountable (discussed further in Section 7.1). Therefore, we conclude that the National Science Foundation's proposed low-energy and high-energy seismic survey may affect, but is not likely to adversely affect ESA-listed Western North Pacific population of gray whales.

7.2.4 Humpback Whale – Mexico Distinct Population Segment and Western North Pacific Distinct Population Segment

The ESA-listed Mexico DPS and Western North Pacific DPS of humpback whale may occur in the action area and may be affected by the stressors associated with the National Science Foundation's proposed low-energy and high-energy seismic survey (see Section 6). While the Mexico DPS and Western North Pacific DPS of humpback whale can be found in coastal and

pelagic habitats within the action area, it is unlikely that Mexico DPS and Western North Pacific DPS of humpback whales will be adversely affected by stressors associated with the proposed actions as they are not expected to occur in the portion of the action area where airgun array operations are expected to occur. Each of the stressors associated with the proposed actions, along with our determination on their impacts to ESA-listed marine mammals (particularly cetaceans) within the action area, are discussed below.

The humpback whale is a widely distributed baleen whale found in all major oceans. Humpback whales mostly inhabit coastal and continental shelf waters. They winter at lower latitudes, where they calve and nurse, and summer at high latitudes, where they feed. Humpback whales exhibit a wide range of foraging behaviors and feed on a range of prey types, including: small schooling fishes, euphausiids, and other large zooplankton (Bettridge et al. 2015).

The current abundance and population growth rate of the Mexico DPS of humpback whale is unavailable. The Mexico DPS is composed of humpback whales that breed along the Pacific coast of mainland Mexico, and the Revillagigegos Islands, and transit through the Baja California Peninsula coast. This DPS feeds across a broad geographic range from California to the Aleutian Islands, with concentrations in California-Oregon, northern Washington-southern British Columbia, northern and western Gulf of Alaska, and Bering Sea feeding grounds.

The current abundance of the Western North Pacific DPS of humpback whales is 1,059 and a population growth rate is currently unavailable. The Western North Pacific DPS of humpback whales is composed of animals that breed/winter in the area of Okinawa and the Philippines, another unidentified breeding area (inferred from sightings of whales in the Aleutian Islands area feeding grounds), and those transiting from the Ogasawara area. These whales migrate to feeding grounds in the northern Pacific Ocean, primarily off the Russian coast.

Humpback whales do not generally occur in the Chukchi and Beaufort Seas. Humpback whales have rarely been observed as far north in the Arctic Ocean as the location of the seismic survey activities, but have been sighted on rare occasions in areas with lower latitudes during aerial surveys. The action area is considered to be outside of their typical migratory patterns. Brower et al. (2018) suggest that sightings of these sub-Arctic species are increasing in the eastern Chukchi Sea as of recent years due to climate change. They have been minimally sighted in the Chukchi Sea based on ASAMM data. In the Chukchi and Beaufort seas, recent monitoring during seismic surveys for the oil and gas industry suggest that they may be increasing in numbers in the Arctic Ocean, but are still expected to be south of the action area for the seismic survey activities (Funk et al. 2010). Based on Wade (2021), the probability of encountering humpback whales from the Hawaii DPS (not ESA-listed), Mexico DPS, and Western North Pacific DPS in the summer feeding areas of the Aleutian Islands, Bering Sea, Chukchi Sea, and Beaufort Sea during the summer feeding season is 91 percent, 7 percent, and 2 percent, respectively.

From this overview, the Mexico DPS and Western North Pacific DPS of humpback whales may be found within the action area. However, the Mexico DPS and Western North Pacific DPS of humpback whale are not expected to occur in the area of the proposed seismic survey activities

as the tracklines to the proposed low-energy and high-energy seismic survey are further north (between approximately 73.5 to 81.0 degrees North, and 139.5 to 168 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 Mexico DPS and Western North Pacific DPS of humpback whales to be present, we do not expect the animals to be exposed to the potential stressors of acoustic noise from the airgun array. The potential for exposure to the potential stressors of acoustic noise from the airgun array or gear entanglement is extremely unlikely to occur. Mexico DPS and Western North Pacific DPS of humpback whales may be exposed to the potential stressors of pollution, vessel strike, and vessel noise during the transit and port stops of the R/V *Sikuliaq*. However, we determined any effects associated with these potential stressors are insignificant or discountable (discussed further in Section 7.1). Therefore, we conclude that the National Science Foundation's proposed low-energy and high-energy seismic survey may affect, but is not likely to adversely affect ESA-listed Mexico DPS and Western North Pacific DPS of humpback whales.

7.2.5 North Pacific Right Whale

The ESA-listed North Pacific right whale may occur in the action area and may be affected by the stressors associated with the National Science Foundation's proposed low-energy and high-energy seismic survey (see Section 6). While the North Pacific right whale can be found in coastal and pelagic habitats within the action area, it is unlikely that North Pacific right whales will be adversely affected by stressors associated with the proposed actions as they are not expected to occur in the portion of the action area where airgun array operations are expected to occur. Each of the stressors associated with the proposed actions, along with our determination on their impacts to ESA-listed marine mammals (particularly cetaceans) within the action area, are discussed below.

North Pacific right whales are found in temperate and sub-polar waters of the North Pacific Ocean. North Pacific right whales mostly inhabit coastal and continental shelf waters. Little is known about their migration patterns, but they have been observed in lower latitudes during winter (Japan, California, and Mexico) where they likely calve and nurse. In the summer, they feed on large concentrations of copepods in Alaska waters. There are two currently recognized stocks of North Pacific right whales, a Western North Pacific stock that feeds primarily in the Sea of Okhotsk, and an Eastern North Pacific stock that feeds in eastern North Pacific Ocean waters off Alaska, Canada, and Russia.

The North Pacific right whale inhabits the Pacific Ocean, particularly between 20 and 60 degrees North latitude. Prior to exploitation by commercial whalers, concentrations of North Pacific right whales were found in the Gulf of Alaska, Aleutian Islands, south central Bering Sea, Sea of Okhotsk, and Sea of Japan. There has been little recent sighting data of North Pacific right whales occurring in the central North Pacific and Bering Sea. However, since 1996, North Pacific right whales have been consistently observed in Bristol Bay and the southeastern Bering Sea during summer months. Although North Pacific right whales are typically found in higher

latitudes, they are thought to migrate to more temperate waters during winter to reproduce, and have been sighted as far south as Hawaii and Baja California.

From this overview, the North Pacific right whales may be found within the action area. However, the North Pacific right whale is not expected to occur in the area of the proposed seismic survey activities as the tracklines to the proposed low-energy and high-energy seismic survey are further north (between approximately 73.5 to 81.0 degrees North, and 139.5 to 168 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 North Pacific 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. The potential for exposure to the potential stressors of acoustic noise from the airgun array or gear entanglement is extremely unlikely to occur. North Pacific right whales may be exposed to the potential stressors of pollution, vessel strike, and vessel noise during the transit and port stops of the R/V *Sikuliaq*. However, we determined any effects associated with these potential stressors are insignificant or discountable (discussed further in Section 7.1). Therefore, we conclude that the National Science Foundation's proposed low-energy and high-energy seismic survey may affect, but is not likely to adversely affect ESA-listed North Pacific right whales.

7.2.6 Sei Whale

The ESA-listed sei whale may occur in the action area and may be affected by the stressors associated with the National Science Foundation's proposed low-energy and high-energy seismic survey (see Section 6). While the sei whale can be found in coastal and pelagic habitats within the action area, it is unlikely that sei whales will be adversely affected by stressors associated with the proposed actions as they are not expected to occur in the portion of the action area where airgun array operations are expected to occur. Each of the stressors associated with the proposed actions, along with our determination on their impacts to ESA-listed marine mammals (particularly cetaceans) within the action area, are discussed below.

The sei whale is a widely distributed baleen whale found in all major oceans (North Atlantic Ocean, North Pacific Ocean, and Southern Hemisphere). 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.

Two sub-species of sei whale are recognized, *B. b. borealis* in the Northern Hemisphere and *B. b. schlegellii* in the Southern Hemisphere. Models indicate that total abundance declined from 42,000 to 8,600 individuals between 1963 and 1974 in the North Pacific Ocean. More recently, the North Pacific Ocean population was estimated to be 29,632 (95 percent confidence intervals 18,576 to 47,267) between 2010 and 2012 (IWC 2016; Thomas et al. 2016). 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.

One sei whale was sighted during U.S. Navy research activities on September 9, 2019 just south of the seismic survey area at 74.1 degrees North 166.5 degrees West.

From this overview, the sei whale may be found within the action area. However, the sei whale is not expected to occur in the area of the proposed seismic survey activities as the tracklines to the proposed low-energy and high-energy seismic survey are further north (between approximately 73.5 to 81.0 degrees North, and 139.5 to 168 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 sei whales to be present, we do not expect the animals to be exposed to the potential stressors of acoustic noise from the airgun array. The potential for exposure to the potential stressors of acoustic noise from the airgun array or gear entanglement is extremely unlikely to occur. Sei whales may be exposed to the potential stressors of pollution, vessel strike, and vessel noise during the transit and port stops of the R/V *Sikuliaq*. However, we determined any effects associated with these potential stressors are insignificant or discountable (discussed further in Section 7.1). Therefore, we conclude that the National Science Foundation's proposed low-energy and high-energy seismic survey may affect, but is not likely to adversely affect ESA-listed sei whales.

7.3 Pinnipeds

The Western DPS of Steller sea lion may occur in the action area and may be affected by the proposed actions. The potential stressors that may affect, but are not likely to adversely affect ESA-listed pinnipeds are discussed further in Section 7.1.

7.3.1 Steller Sea Lion – Western Distinct Population Segment

The ESA-listed Western DPS of Steller sea lion may occur in the vessel transit portion of the action area and may be affected by the stressors associated with the National Science Foundation's proposed low-energy and high-energy seismic survey (see Section 6). While the Western DPS of Steller sea lion can be found in coastal and pelagic habitats within the action area, it is unlikely that Western DPS of Steller sea lion will be adversely affected by stressors associated with the proposed actions as they are not expected to occur in the portion of the action area where airgun array operations are expected to occur. Each of the stressors associated with the proposed actions, along with our determination on their impacts to ESA-listed marine mammals within the action area, are discussed below.

The Steller sea lion ranges from Japan, through the Okhotsk and Bering Seas, to central California. It consists of two morphologically, ecologically, and behaviorally separate DPSs: the Eastern, which includes sea lions in Southeast Alaska, British Columbia, Washington, Oregon, and California; and the Western, which includes sea lions in all other regions of Alaska, as well as Russia and Japan.

Their large aquatic ranges are used for foraging, resting, and traveling. Steller sea lions forage on a wide variety of demersal, semi-demersal, and pelagic prey, including fishes and cephalopods.

Some prey species form large seasonal aggregations, including endangered salmon and eulachon species. Others are available year round.

As of 2017, the best estimate of abundance of the Western DPS of Steller sea lion in Alaska was 11,952 pups and 42,315 for non-pups (total N_{min}=54,267) (Muto et al. 2018). This represents a large decline since counts in the 1950s (N=140,000) and 1970s (N=110,000).

Using data collected from 1978 through 2017, there is strong evidence that pup and non-pup counts of western stock Steller sea lions in Alaska were at their lowest levels in 2002 and 2003, respectively, and have increased at 1.78 percent and 2.14 percent, respectively, between 2002 and 2017 (Sweeney et al. 2017). Western DPS of Steller sea lion site counts decreased 40 percent from 1991 through 2000, an average annual decline of 5.4 percent; however, counts increased three percent between 2004 through 2008, the first recorded population increase since the 1970s (NMFS 2008). Overall, there are strong regional differences across the range in Alaska, with positive trends in the Gulf of Alaska and eastern Bering Sea east of Samalga Pass (approximately 170 degrees West) and generally negative trends to the west in the Aleutian Islands. Non-pup trends in 2002 through 2017 in Alaska have a longitudinal gradient with highest rates of increase generally in the east (eastern Gulf of Alaska) and steadily decreasing rates to the west.

Based on the results of genetic studies, the Steller sea lion population was reclassified into two DPSs: Western and Eastern. The data which came out of these studies indicated that the two populations had been separate since the last ice age (Bickham et al. 1998). Further examination of the Steller sea lions from the Gulf of Alaska (i.e., the Western DPS) revealed a high level of haplotype diversity, indicating that genetic diversity had been retained despite the decline in abundance (Bickham et al. 1998). There is an exchange of sea lions across the stock boundary, especially due to the wide-ranging seasonal movements of juveniles and adult males (Jemison et al. 2013). During the breeding season, sea lions, especially adult females, typically return to their natal rookery, or a nearby breeding rookery to breed and pup (Hastings et al. 2017). However, mixing of mostly breeding females from Prince William Sound to Southeast Alaska began in the 1990s and two new, mixed-stock rookeries were established (Jemison et al. 2013; O'corry-Crowe et al. 2011).

Steller sea lions are distributed mainly around the coasts to the other continental shelf along the North Pacific Ocean rim from northern Hokkaido, Japan through the Kuril Islands and Okhotsk Sea, Aleutian Islands and central Bering Sea south of the Bering Strait, southern coast of Alaska and south to California. The Western DPS includes Steller sea lions that reside in the central and western Gulf of Alaska, Aleutian Islands, as well as those that inhabit the coastal waters and breed in Asia (e.g., Japan and Russia).

From this overview, the Western DPS of Steller sea lion may be found within the action area. However, the Western DPS of Steller sea lion is not expected to occur in the area of the proposed seismic survey activities as the tracklines to the proposed low-energy and high-energy seismic survey are further north (between approximately 73.5 to 81.0 degrees North, and 139.5 to 168 degrees West) than their range (which does not extend north of the Bering Strait); however, they

may occur in the action area of the port stops and transit (near Nome, Alaska). Since the proposed seismic survey activities will take place in a location where we do not expect Western DPS of Steller sea lion to be present, we do not expect the animals to be exposed to the potential stressors of acoustic noise from the airgun array. The potential for exposure to the potential stressors of acoustic noise from the airgun array or gear entanglement is extremely unlikely to occur. Western DPS of Steller sea lion may be exposed to the potential stressors of pollution, vessel strike, and vessel noise during the transit and port stops of the R/V *Sikuliaq*. However, we determined any effects associated with these potential stressors are insignificant or discountable (discussed further in Section 7.1). Therefore, we conclude that the National Science Foundation's proposed low-energy and high-energy seismic survey may affect, but is not likely to adversely affect ESA-listed Western DPS of Steller sea lion.

7.4 Proposed Critical Habitat

The proposed critical habitat of Beringia DPS of bearded seal and proposed revised critical habitat of Arctic subspecies of ringed seal occur in the action area and may be affected by the proposed actions.

7.4.1 Proposed Bearded Seal – Beringia Distinct Population Segment Critical Habitat

In 2021, NMFS proposed to designate critical habitat for the Beringia DPS of the Pacific bearded seal subspecies (*Erignathus barbatus nauticus*) (86 FR 1433) (Figure 2). The proposed designation comprises an area of marine habitat in the Bering, Chukchi, and Beaufort seas, extending from the line of mean lower low water to an offshore limit with a maximum water depth of 200 meters (656.2 feet) from the ocean surface within the United States Exclusive Economic Zone. Proposed critical habitat does not extend into tidally-influenced channels of tributary waters of the Bering, Chukchi, or Beaufort seas. The boundary extends offshore from the northern limit of the United States-Canada border to the 200 meter (656.2 feet) isobaths and then follows this isobath generally westward and northwestward to its intersection with the seaward limit of the United States Exclusive Economic Zone. The boundary then follows the limit of the United States Exclusive Economic Zone southwestward and south to the intersection of the southern boundary of the critical habitat in the Bering Sea at 60 degrees 32'26" North/179 degrees 9'53" West. The southern boundary extends southeastward from this intersection point to 57 degrees 58' North/170 degrees 25' West, then eastward to 58 degrees 29' North/164 degrees 46' West, then follows longitude 164 degrees 46' West to the line of mean lower low water near the mouth of the Kolovinerak River. Critical habitat does not include permanent manmade structures such as boat ramps, docks, and pilings that were in existence within the legal boundaries on or before the effective due date of this rule.

The physical or biological features essential to the conservation of the Beringia DPS of bearded seal are:

1. Sea ice habitat suitable for whelping and nursing, which is defined as areas with waters 200 meters (656.2 feet) or less in depth containing pack ice of at least 25 percent concentration and providing bearded seals access to those waters from the ice;
2. Sea ice habitat suitable as a platform for molting, which is defined as areas with waters 200 meters (656.2 feet) or less in depth containing pack ice of at least 15 percent concentration and providing bearded seals access to those waters from the ice;
3. Primary prey resources to support bearded seals in waters 200 meters (656.2 feet) or less in depth: benthic organisms, including epifaunal and infaunal invertebrates, and demersal and schooling pelagic fishes; and
4. Acoustic conditions that allow for effective communication by bearded seals for breeding purposes within waters used by breeding bearded seals.

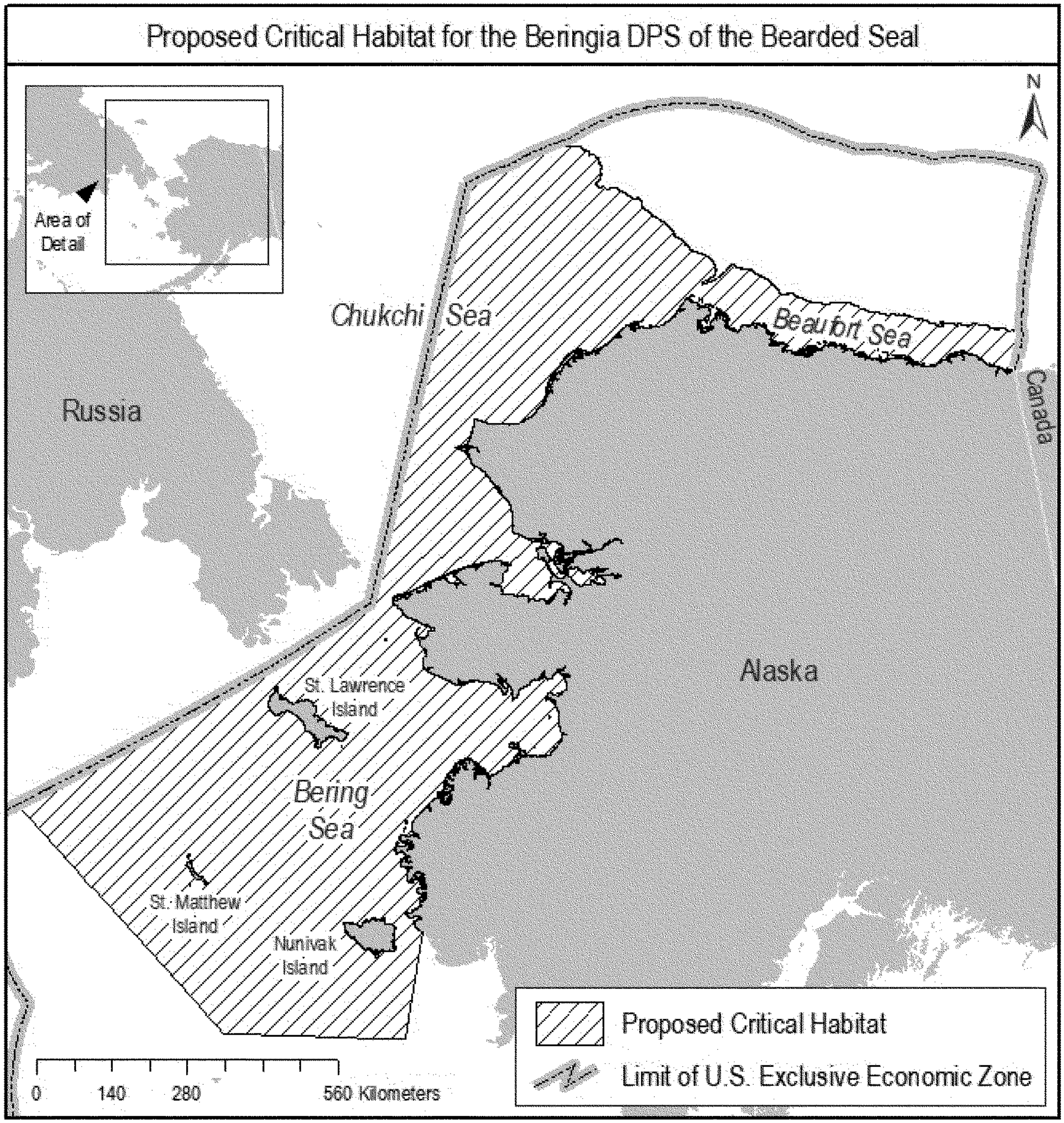

Figure 2. Map identifying proposed critical habitat for the threatened Beringia distinct population segment of bearded seal.

7.4.2 Proposed Revised Ringed Seal – Arctic Subspecies Critical Habitat

In 2014, NMFS proposed to designate critical habitat for the Arctic subspecies of ringed seal in the northern Bering, Chukchi, and Beaufort Seas in Alaska (79 FR 73010) (Figure 3).

The physical or biological features essential to the conservation of the species are:

1. Sea ice habitat suitable for the formation and maintenance of subnivean birth lairs used for sheltering pups during whelping and nursing, which is defined as seasonal landfast

(shorefast) ice, except for any bottom-fast ice extending seaward from the coastline in waters less than 2 meters (6.6 feet) deep, or dense, stable pack ice, that has undergone deformation and contains snowdrifts at least 54 centimeters (21.3 inches) deep;

2. Sea ice habitat suitable as a platform for basking and molting, which is defined as sea ice of 15 percent or more concentration, except for any bottom-fast ice extending seaward from the coastline in waters less than 2 meters (6.6 feet) deep; and
3. Primary prey resources to support Arctic ringed seals, which are defined to be Arctic cod, saffron cod, shrimps, and amphipods.

Figure 3. Map identifying proposed critical habitat for the threatened Arctic subspecies of ringed seal in the Bering, Chukchi, and Beaufort Seas in Alaska.

In 2021, NMFS proposed to revise proposed critical habitat from December 9, 2014, for the Arctic subspecies of ringed seal (*Pusa hispida hispida*) (86 FR 1452) (Figure 4). The revised

proposed designation comprises an area of marine habitat in the Bering, Chukchi, and Beaufort seas. Based on consideration of national security impacts, we propose to exclude a particular area north of the Beaufort Sea shelf from the designation. Proposed critical habitat for the Arctic subspecies of the ringed seal includes marine waters within one specific area in the Bering, Chukchi, and Beaufort seas, extending from the line of mean lower low water to an offshore limit within the United States Exclusive Economic Zone. Proposed critical habitat does not extend into tidally-influenced channels of tributary waters of the Bering, Chukchi, or Beaufort seas. The boundary extends offshore from the northern limit of the United States-Canada border approximately 190 kilometers (102.6 nautical miles) to 71 degrees 17’29” North/139 degrees 28’8” West, and from this point runs generally westward along the line connecting the following points: 71 degrees 43’32” North/141 degrees 59’29” West, 71 degrees 46’18” North/144 degrees 31’13” West, 71 degrees 50’25” North/145 degrees 53’17” West, 72 degrees 10’39” North/149 degrees 10’58”West, 72 degrees 20’4” North/150 degrees West, and 72 degrees 20’4”North/152 degrees West. From this point (72 degrees 20’4” North/152 degrees West) the boundary follows longitude 152 degrees West northward to the seaward limit of the United States Exclusive Economic Zone, and then follows the limit of the United States Exclusive Economic Zone northwestward; then southwestward and south to the intersection of the southern boundary of the proposed critical habitat in the Bering Sea at 61 degrees 18’15” North/177 degrees 45’56” West. The southern boundary extends southeastward from this intersection point to 60 degrees 7’ North/172 degrees 1’ West, then northeastward along a line extending to near Cape Romanzof at 61 degrees 48’42” North/166 degrees 6’5” West, with the shoreward boundary defined by line of mean lower low water. Proposed critical habitat does not include permanent manmade structures such as boat ramps, docks, and pilings that were in existence within the legal boundaries on or before the effective date of this proposed rule. The physical and biological features essential to the conservation of Arctic subspecies of ringed seal are:

1. Snow-covered sea ice habitat suitable for the formation and maintenance of subnivean birth lairs used for sheltering pups during whelping and nursing, which is defined as areas of seasonal landfast (shorefast) ice and dense, stable pack ice, excluding any bottom-fast ice extending seaward from the coastline (typically in waters less than 2 meters [6.6 feet] deep), that have undergone deformation and contain snowdrifts of sufficient depth, typically at least 54 centimeters (21.3 inches) deep;
2. Sea ice habitat suitable as a platform for basking and molting, which is defined as areas containing sea ice of 15 percent or more concentration, excluding any bottom-fast ice extending seaward from the coastline (typically in waters less than 2 meters [6.6 feet] deep); and
3. Primary prey resources to support Arctic ringed seals, which are defined to be Arctic cod (*Boreogadus saida*), saffron cod (*Eleginus gracilis*), shrimps, and amphipods.

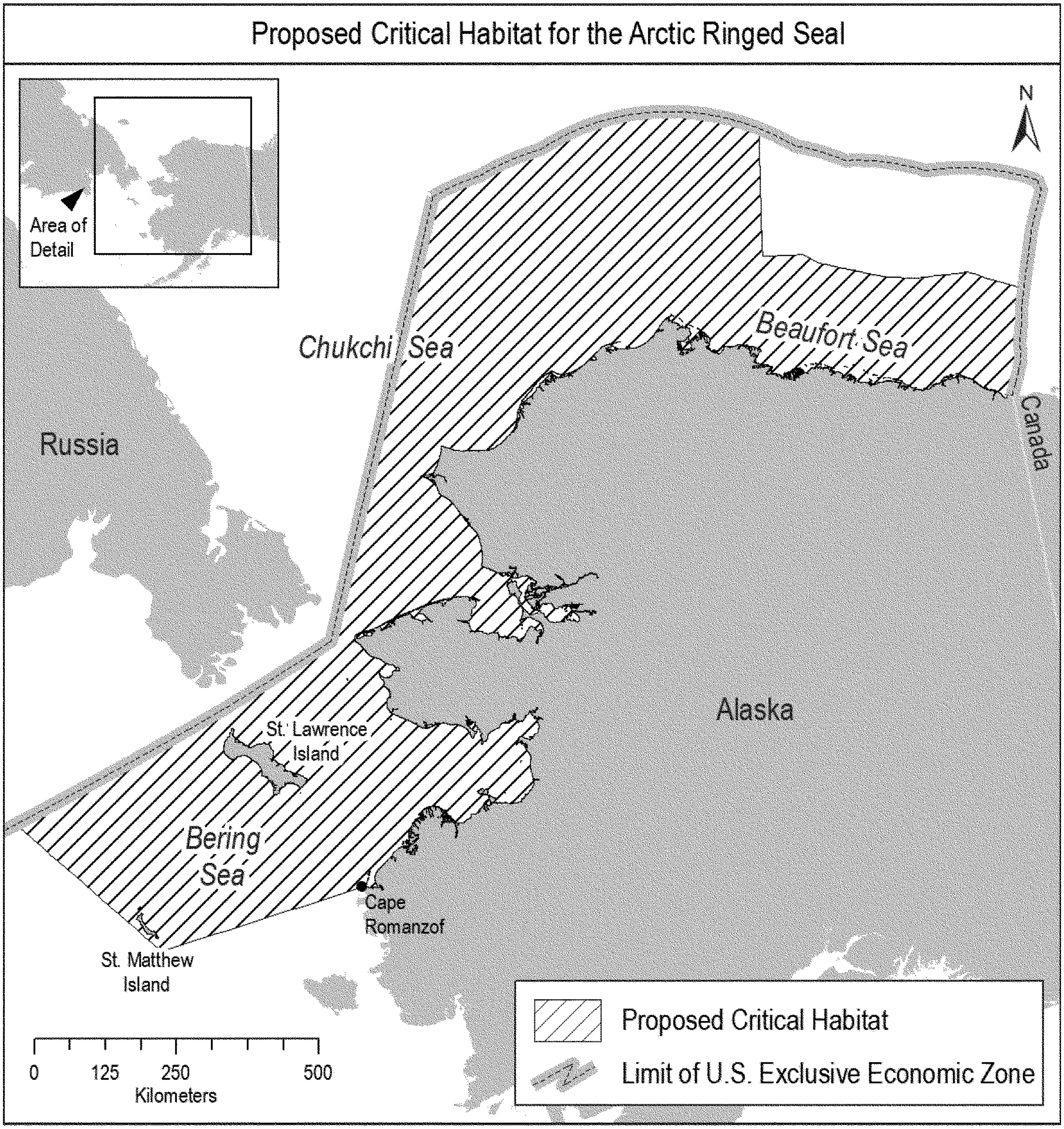

Figure 4. Map identifying proposed revised critical habitat for the threatened Arctic subspecies of ringed seal in the Bering, Chukchi, and Beaufort Seas in Alaska.

7.4.3 Effects to Proposed Critical Habitat

The proposed seismic survey activities overlap with portions of the proposed critical habitat for the Beringia DPS of bearded seal and proposed revised critical habitat of the Arctic subspecies of ringed seal. The seismic survey area is located 63 kilometers (34 nautical miles to the north of the proposed critical habitat for Beringia DPS of bearded seals, but the research vessel will transit through the Bering Strait and Chukchi Sea. The southern portion of the seismic survey

area as well as the research vessel's transit through the Bering Strait and Chukchi Sea overlaps with the proposed revised critical habitat of the Arctic subspecies of ringed seal. Very few effects to this habitat are expected for the reasons detailed below.

Given the nature of the proposed seismic survey activities, none of the physical and biological features essential to the conservation of Beringia DPS of bearded seals and Arctic subspecies of ringed seals will be significantly altered. Vessel transit will not significantly alter large scale physical or oceanographic conditions or processes, nutrients, bathymetry, sea ice habitat, or prey resources and availability. The research vessel can come into close proximity with, or even in contact with, prey species found within these proposed critical habitats. We expect that any such interactions will only result in a temporary, slight displacement of prey. If larger prey were to come into contact with the research vessel's propellers, it is possible that individual prey can be killed. However, even if this unlikely event were to occur, the removal of several individual prey will have a limited impact on the overall abundance of prey resources in the area of the proposed critical habitat. Given the short-term nature of vessel transit, it will not significantly alter ambient noise levels. Any effects from vessel transit will be short-term and minimal, and will not have any measurable impact on the physical and biological features. Because the operations of the research vessel are temporary (i.e., not a permanent structure), the seismic survey activities will not prevent animals from accessing critical habitats in the water, on land, or sea ice. Also, the equipment will not alter, damage, or destroy physical habitat.

The proposed actions will occur during the summer (August through September) when sea ice cover is typically at a minimum. The R/V *Sikuliaq* is expected to encounter only limited ice in the marginal ice zone during the low-energy and high-energy seismic survey. Also, the R/V *Sikuliaq* is not an icebreaker, and will avoid the ice edge and stay in open water in order to avoid damaging the towed seismic equipment. The proposed seismic survey activities will take place approximately 300 kilometers (162 nautical miles) from the Alaska coastline in the Arctic Ocean in water depths ranging from approximately 200 to 4,000 meters (656.2 to 13,123.4 feet). The vast majority of the proposed seismic survey activities will occur in waters greater than 200 meters (656.2 feet) in depth.

The proposed acoustic sound sources from the seismic survey activities will not significantly alter the primary prey resources available given the short duration of the low-energy and high-energy seismic survey within the aquatic area of the proposed critical habitat for the Beringia DPS of bearded seal and proposed revised critical habitat of the Arctic subspecies of ringed seal. If prey fish, shrimp, amphipods, and benthic organisms avoid the area of the active airgun array operations due to aversions from the sound source, it is expected to be temporary with no long-term significant effects. Prey species are mobile and are broadly distributed throughout the action area; therefore, marine mammals that may be temporarily displaced during seismic survey activities are expected to be able to resume foraging once they have moved away from areas with disturbing levels of underwater noise. Because the seismic survey activities are relatively short in duration (30 days of airgun array operations), the disturbance will be temporary in nature, and

similar habitat and prey resources are available in the surrounding area, the impacts to pinnipeds and their prey resources that they utilize for food are not expected to cause significant or long-term consequences for individuals or their populations.

The use of active acoustics during the seismic survey activities will be temporary and relatively short in duration, and are not expected to significantly impair acoustic conditions that allow for effective communication for breeding purposes. The research vessel will be continuously moving during the entire low-energy and high-energy seismic survey. Also, the active acoustics are not expected to overlap in time and space with breeding.

When considering the limit of potential exposure, we conclude that any disturbance to the physical and biological features will be insignificant. Therefore, the proposed seismic survey activities may affect, but are not likely to adversely affect any of the physical and biological features of the proposed critical habitat for the Beringia DPS of bearded seal and proposed revised critical habitat of the Arctic subspecies of ringed seal.

7.5 Summary of Effects Determinations for Potential Stressors Associated with the Proposed Actions

Table 8 depicts our effects analysis by potential stressor for each ESA-listed species and proposed critical habitat considered in this consultation.

The only potential stressors that are likely to adversely affect ESA-listed species within the action area are sound fields produced by the seismic airgun array. These stressors and the sound sources associated with the low-energy and high-energy seismic survey effects may adversely affect the ESA-listed marine mammals and are further analyzed and evaluated in detail in Section 10.

Table 7. Endangered Species Act-listed species that may be affected by the proposed actions and effects determination by potential stressor for Endangered Species Act-listed species expected to be encountered during the proposed low-energy and high-energy seismic survey in the Arctic Ocean during summer 2021 and National Marine Fisheries Service Permits and Conservation Division's proposed issuance of an incidental harassment authorization and possible renewal.

Endangered Species Act-listed Species in the Action Area	Overall Determination	Potential Stressors					
		Pollution	Vessel Strike	Vessel Noise, Visual Disturbance	Acoustic Sources		Gear Entanglement
					SBP MBES ADCP Pinger	Seismic Airgun Array	
Marine Mammals – Cetaceans							
Blue Whale	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Bowhead Whale	LAA	NLAA	NLAA	NLAA	NLAA	LAA	NLAA
Fin Whale	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Gray Whale – Western North Pacific Population	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Humpback Whale – Mexico DPS	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Humpback Whale – Western North Pacific DPS	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA

Endangered Species Act-listed Species in the Action Area	Overall Determination	Potential Stressors					
		Pollution	Vessel Strike	Vessel Noise, Visual Disturbance	Acoustic Sources		Gear Entanglement
					SBP MBES ADCP Pinger	Seismic Airgun Array	
North Pacific Right Whale	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Sei Whale	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Marine Mammals – Pinnipeds							
Bearded Seal – Beringia DPS	LAA	NLAA	NLAA	NLAA	NLAA	LAA	NLAA
Ringed Seal – Arctic Subspecies	LAA	NLAA	NLAA	NLAA	NLAA	LAA	NLAA
Steller Sea Lion – Western DPS	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Critical Habitat							
Proposed Bearded Seal – Beringia DPS Critical Habitat	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Proposed Revised Ringed Seal – Arctic Subspecies Critical Habitat	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA

SBP=Sub-bottom profiler, MBES=Multi-beam echosounder, ADCP=Acoustic Doppler current profiler, DPS=Distinct population segment, NLAA= Not likely to adversely affect, LAA= Likely to adversely affect

8 SPECIES AND CRITICAL HABITAT LIKELY TO BE ADVERSELY AFFECTED

This section identifies the ESA-listed species that occur within the action area (Figure 1) that may be affected by the proposed actions. The only ESA-listed marine mammal species that are likely to be adversely affected by the proposed actions are bowhead whales, Beringia DPS of bearded seals, and Arctic subspecies of ringed seals. The determinations for the effects of stressors that are not likely to adversely affect these same three ESA-listed marine mammals during the proposed low-energy and high-energy seismic survey are discussed in Section 7.1. Other potential stressors (i.e., acoustic noise from the airgun array) are discussed in more detail in Section 10.

8.1 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 actions. 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 these NMFS websites: https://www.fisheries.noaa.gov/species-directory/threatened-endangered, among others. Because there are not likely to be adverse affects to proposed or designated critical habitat (see Section 7.4.3), only the status of the species likely to be adversely affected 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).

8.2 Bowhead Whale

The bowhead whale is a circumpolar baleen whale found throughout high latitudes in the Northern Hemisphere (Figure 5).

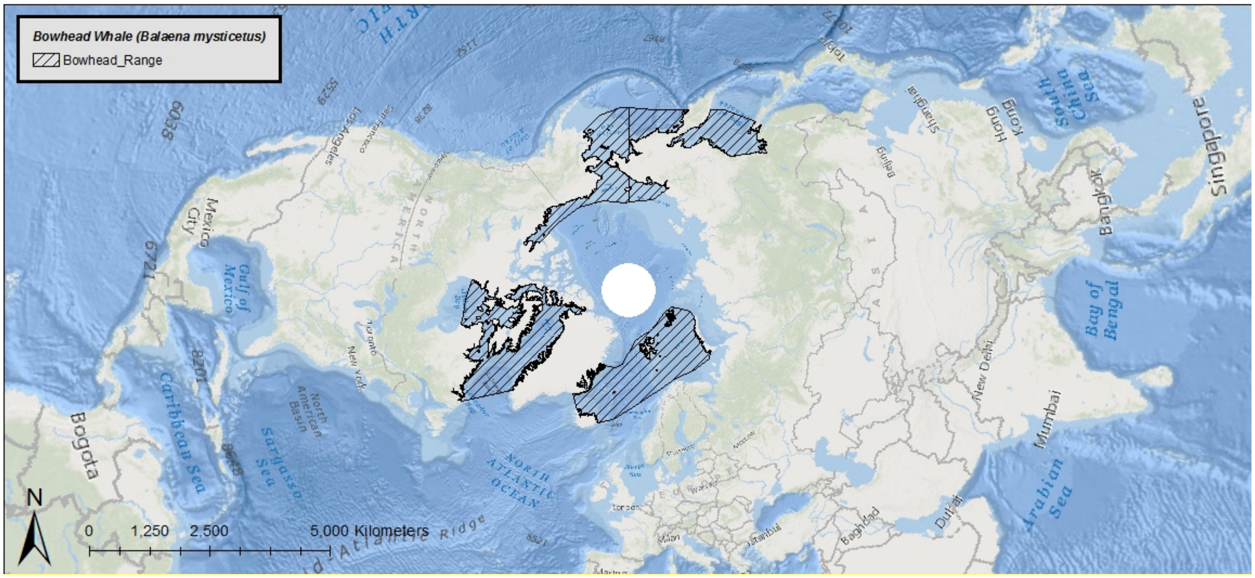

Figure 5. Map identifying the range of the endangered bowhead whale.

Bowheads are baleen whales distinguishable from other whales by a dark body with a distinctive white chin, no dorsal fin, and a bow-shaped skull that takes up about 35 percent of their total body length. The bowhead whale was originally listed as endangered on December 2, 1970.

Information available from the recent stock assessment report (Muto et al. 2017) and the scientific literature was used to summarize the life history, population dynamics, and status of the species as follows.

8.2.1 Life History

The average lifespan of bowhead whales is unknown; however, some evidence suggests that they can live for over one hundred years. They have a gestation period of 13 to 14 months and it is unknown how long calves nurse. Sexual maturity is reached around 20 years of age with an average calving interval of three to four years. They spend the winter associated with the southern limit of the pack ice and move north as the sea ice breaks up and recedes during spring. Bowhead whales use their large skulls to break through thick ice and feed on zooplankton (crustaceans like copepods, euphausiids, and mysids), other invertebrates, and fish.

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 bowhead whale.

The global, pre-exploitation estimate for bowhead whales is 30,000 to 50,000 animals. There are currently four or five recognized stocks of bowhead whales, the Western Arctic (or Bering-Chukchi-Beaufort) stock, the Okhotsk Sea stock, the Davis Strait and Hudson Bay stock (sometimes considered separate stocks), and the Spitsbergen stock (Rugh and Shelden 2009). The only stock thought to be found within United States waters is the Western Arctic stock. The

2011 ice-based abundance estimate puts this stock, the largest remnant stock, at over 16,892 (N_{min}=16,091) individuals. Prior to commercial whaling, there may have been 10,000 to 23,000 whales in this stock (Rugh and Shelden 2009). Historically the Davis Strait and Hudson Bay stock may have contained over 11,000 individuals, but now it is thought to number around 7,000 bowhead whales (Cosens et al. 2006). In the Okhotsk Sea, there were originally more than 3,000 bowhead whales, but now there are only about 200 (Cooke and Reeves 2018). The Spitsbergen stock originally had about 24,000 bowhead whales and supported a huge European fishery, but today is thought to only contain hundreds of individuals (Cooke and Reeves 2018).

Current estimates indicate approximately 16,892 (N_{min}=16,091) bowhead whales in the Western Arctic stock, with an annual growth rate of 3.7 percent (Givens et al. 2013). While no quantitative estimates exist, the Davis Strait and Hudson Bay stock is also thought to be increasing (COSEWIC 2009). We could find no information on population trends for the Okhotsk Sea stock. Likewise, no information is available on the population trend for the Spitsbergen stock, but it is thought to be nearly extinct.

Genetic studies conducted on the Western Arctic stock of bowhead whales revealed 68 different haplotypes defined by 44 variable sites (Leduc et al. 2008) making it the most diverse stock of bowhead whales. These results are consistent with a single stock with genetic heterogeneity related to age cohorts and indicate no historic genetic bottlenecks (Rugh et al. 2003). In the Okhotsk Sea stock, only four to seven mitochondrial DNA haplotypes have been identified, three of which are shared with the Western Arctic stock, indicating lower genetic diversity, as might be expected given its much smaller population size (Alter et al. 2012; LeDuc et al. 2005; MacLean 2002). The Davis Strait and Hudson Bay stock has 23 mitochondrial DNA haplotypes, making it more diverse than the Okhotsk stock but less diverse than the large Western Arctic stock (Alter et al. 2012). Based on historic mitochondrial DNA, the Spitsbergen stock previously had at least 58 mitochondrial DNA haplotypes, but its current genetic diversity remains unknown (Borge et al. 2007). However, given its near extirpation, it likely has low genetic diversity.

The Western Arctic stock is found in waters around Alaska, the Okhotsk Sea stock in eastern Russia waters, the Davis Strait and Hudson Bay stock in northeastern waters near Canada, and the Spitsbergen stock in the northeastern Atlantic Ocean (Rugh and Shelden 2009) (Figure 5).

8.2.3 Vocalization and Hearing

Bowhead whales produce songs of an average source level of 185±2 dB re: 1 µPa at 1 meter (rms) centered at a frequency of 444±48 Hertz (Roulin et al. 2012). Given background noise, this allows bowhead whales an active space of 40 to 130 kilometers (21.6 to 70.2 nautical miles) (Roulin et al. 2012). We are aware of no information directly on the hearing abilities of bowhead whales, but like all marine mammals, we presume they hear best in frequency ranges at which they produce sounds (444±48 Hertz).

8.2.4 Status

The bowhead whale is endangered because of past commercial whaling. Prior to commercial whaling, thousands of bowhead whales existed. Global abundance declined to 3,000 by the 1920's. Bowhead whales may be killed under "aboriginal subsistence whaling" provisions of the International Whaling Commission. Additional threats include vessel strikes, fisheries interactions (including entanglement), contaminants, and noise. The species' large population size and increasing trends indicate that it is resilient to current threats.

8.2.5 Critical Habitat

No critical habitat has been designated for the bowhead whale.

8.2.6 Recovery Goals

NMFS has not prepared a Recovery Plan for the bowhead whale.

8.3 Bearded Seal – Beringia Distinct Population Segment

Two subspecies of bearded seals are recognized by NMFS: *Erignathus barbatus nauticus* in the Pacific Ocean and *Erignathus barbatus* in the Atlantic Ocean (Figure 6). Bearded seals in the Pacific Ocean are distributed from 85 degrees North south to Sakhalin Island (45 degrees North), including the Chukchi, Bering, and Okhotsk Seas.

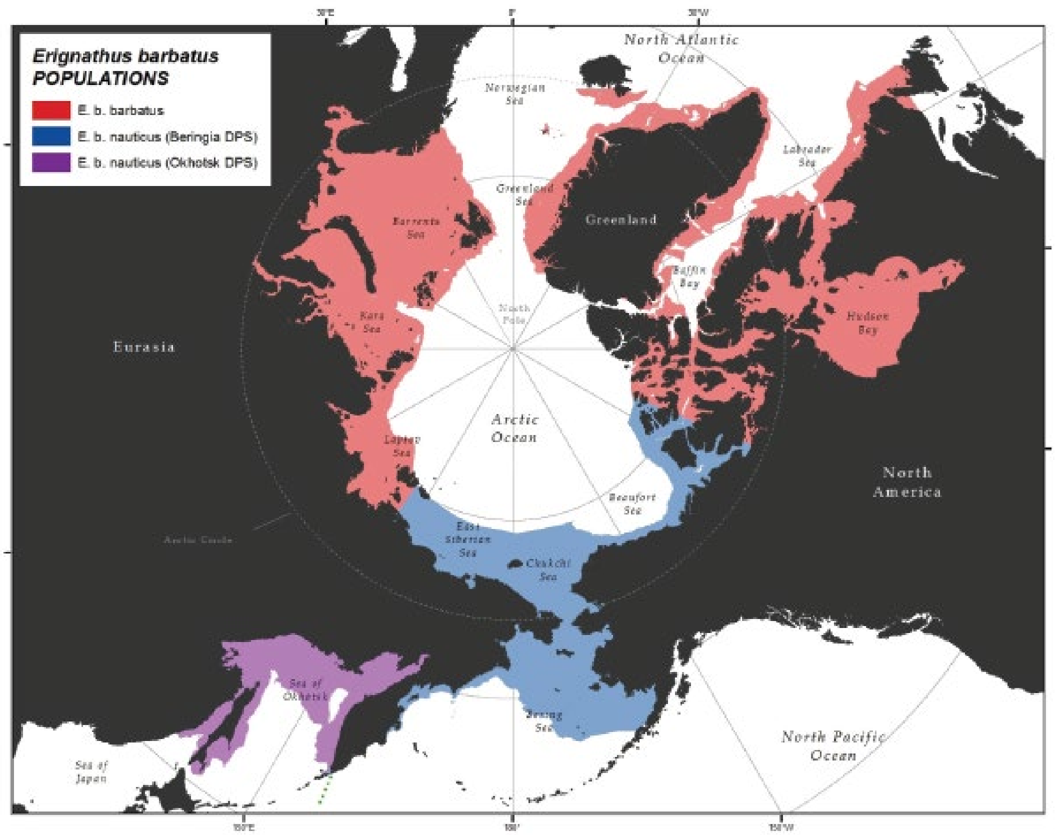

Figure 6. Map identifying the range of the two subspecies and the threatened Beringia and Okhotsk distinct population segments of bearded seal (Cameron et al. 2010).

Bearded seals are distinguished by their small head, small square foreflippers, and thick, long, white whiskers that have resulted in the name "bearded." Pups have lighter markings on the face, resembling a "T". The bearded seal is divided into two subspecies, with the Pacific Ocean subspecies further divided into two geographically and ecologically discrete DPSs, the Beringia DPS and the Okhotsk DPS. On December 20, 2012, the NMFS issued a final determination to list the Beringia DPS and Okhotsk DPS of bearded seal as threatened under the ESA (77 FR 76739). The U.S. District Court for the District of Alaska issued a decision that vacated the ESA listing of the Beringia DPS of bearded seal on July 25, 2014 (Alaska Oil and Gas Association v. Pritzker, Case No. 4:13-cv-00018-RPB). The NMFS appealed that decision. On October 24, 2016, the 9th Circuit Court ruled that the listing decision is reasonable and the threatened status of the Beringia DPS of bearded seal was upheld.

We used information available in the final listing (77 FR 76740), the status review (Cameron et al. 2010), the recent stock assessment report (Muto et al. 2017) and available literature to summarize the status of the bearded seal, as follows.

8.3.1 Life History

Generally, bearded seals move north in late spring and summer, staying along the edge of the pack ice in summer, and then move south in the fall. Bearded seals can live up to 20 to 25 years

old. Female bearded seals become sexually mature at five or six years of age, males at six or seven. Breeding occurs from March through July. Male bearded seals vocalize during the breeding season, with a peak in calling during and after pup rearing. These calls are likely used to attract females and defend their territories to other males (Cameron et al. 2010). Pups are born between mid-March and May, and are usually weaned in 15 days. Dependent pups spend about 50 percent of their time in the water. Nursing females spend more than 90 percent of their time in water, more than other large phocid seals. Bearded seals forage on a wide variety of benthic invertebrates, demersal fishes, and sometimes, schooling fishes.

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 Beringia DPS of the bearded seal. The estimated population size of the Beringia DPS of bearded seal is 155,000 individuals (75 FR 77496). There is substantial uncertainty around this estimate, however, and population trends for the Beringia DPS of bearded seal are unknown. An estimate of bearded seals in the western Bering Sea (63,200; 95 percent CI 38,400 to 138,600) from 2003 through 2008 appears to be similar in magnitude to an estimate from 1974 through 1987 (57,000 to 87,000) (Cameron et al. 2010). Population trends are not available at this time for the Beringia DPS of bearded seal (Muto 2016). Bearded seals are boreoarctic with a circumpolar distribution and are closely associated with sea ice; however some remain near the coasts during the summer and early fall. Most bearded seals move seasonally, following the extent of the sea ice; however, some remain near the coasts during the summer and early fall. Beringia DPS of bearded seals are found in the continental shelf waters throughout the Eastern Siberian, Chukchi, and Beaufort Seas (Figure 6).

8.3.3 Vocalization and Hearing

Male bearded seals vocalize during the breeding season (March through July), with a peak in a calling during and after pup rearing. Their complex vocalizations range from 20 Hertz to 11 kiloHertz in frequency. These calls are likely used to attract females and defend their territories to other males (Cameron et al. 2010).

8.3.4 Status

In summary, the Beringia DPS of bearded seal has a large, apparently stable population size, which makes it resilient to immediate perturbations. It is, however, threatened by future climate change, specifically the loss of essential sea ice and change in prey availability, and as a result, is likely to become endangered in the future. Bearded seals are an important species for Alaska subsistence hunters; the most recent estimate of annual statewide harvest is from 2000 and was 6,788 bearded seals. The current level of subsistence harvest is not known and there are no efforts to quantify statewide harvest numbers. Additional threats to the species include disturbance from vessels, sound from seismic exploration, and oil spills.

8.3.5 Critical Habitat

In 2021, NMFS proposed to designate critical habitat for the Beringia DPS of the Pacific bearded seal subspecies (86 FR 1433) and it is described further in Section 7.4.1.

8.3.6 Recovery Goals

NMFS has not prepared a Recovery Plan for the Beringia DPS of bearded seal.

8.4 Ringed Seal – Arctic Subspecies

Ringed seals have widespread, circumpolar distribution, and are found throughout the Arctic Ocean, as well as the Sea of Okhotsk, Baltic Sea, Lake Ladoga, and Lake Saimaa (Figure 7). There are five subspecies of ringed seals recognized: Ladoga (*P. h. ladogensis*), Saimaa (*P. h. saimensis*), Okhotsk (*P. h. ochotensis*), Baltic (*P. h. botnica*), and Arctic (*P. h. hispida*).

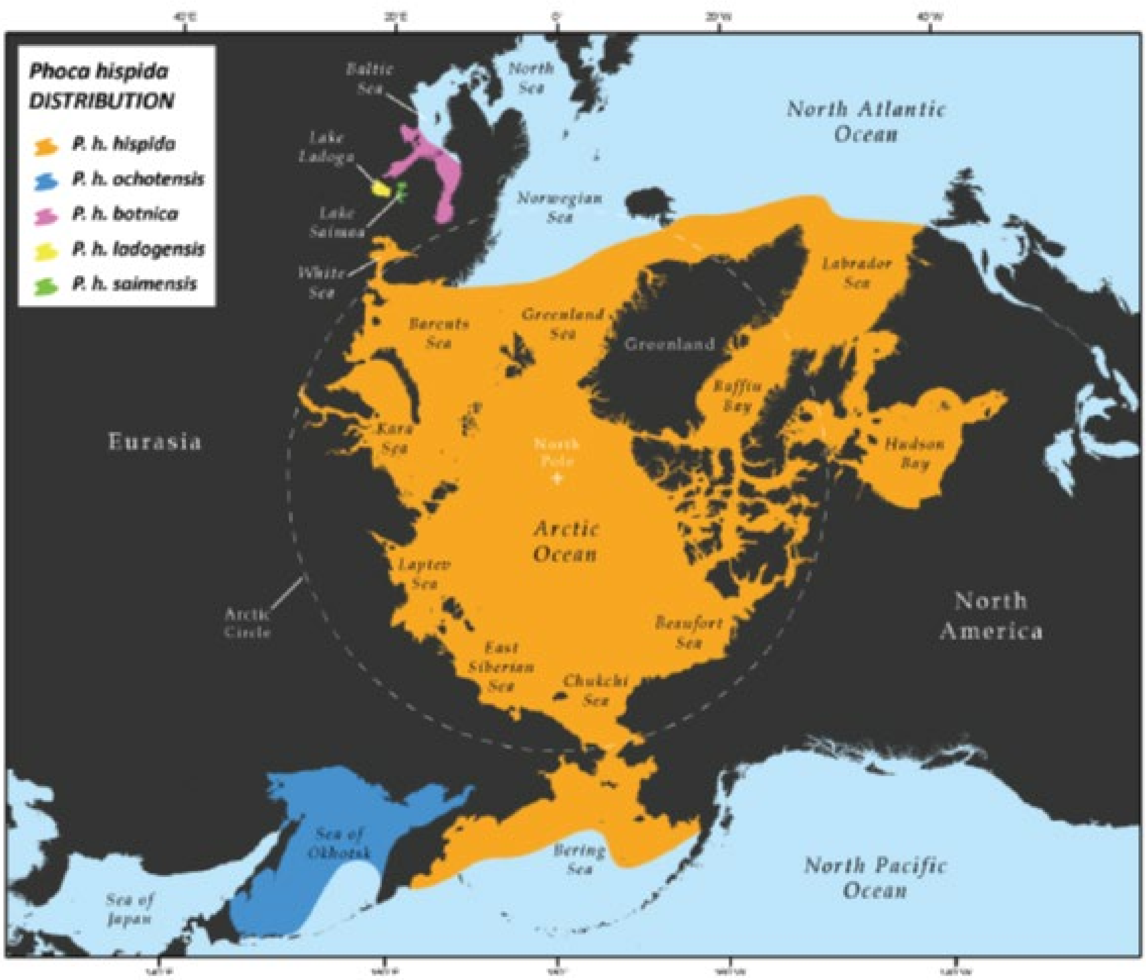

Figure 7. Map identifying the range of the five subspecies of ringed seal, including the threatened Arctic subspecies of ringed seal (Kelly et al. 2010b).

Ringed seals are the smallest of the Arctic seals. Adults can be up to 1.5 meters (5 feet) and weight between 50 to 70 kilograms (110 to 150 pounds). Their coat is variable, but is normally

dark with light to silver rings that encircle spots along the back and sides and silver along the underside. They are distinguished by their small head: short, cat-like snout, and plump body. On December 28, 2012, NMFS issued a final determination to list the Arctic subspecies as threatened under the ESA.

We used information available in the recent stock assessment report (Allen and Angliss 2014), the status review (Kelly et al. 2010a), ESA-listing documents, NMFS species information (NMFS 2015), and available literature to summarize the status of the species, as follows.

8.4.1 Life History

Ringed seals are uniquely adapted to living on the ice. They use stout claws to maintain breathing holes in heavy ice, and excavate lairs in the snow cover above these holes to provide warmth and protection from predators while they rest, pup, and molt. The timing of breeding, whelping, and molting varies spatially and is dependent on the availability of sea ice, with populations at lower latitudes performing these activities earlier in the year. Females give birth in late winter to early spring to a single pup annually; they nurse for five to nine weeks and then the pup is weaned. During this time, pups spend an equal amount of time in the water and in the lair. Females reach sexual maturity at four to eight years of age, males at five to seven years of age. The average lifespan of a ringed seal is 15 to 28 years. They are trophic generalists, bur prefer small schooling prey that form dense aggregations (Kelly et al. 2010b). Ringed seals forage throughout the water column for a wide variety of prey items, from crustaceans to schooling fishes, though members of the cod family usually dominate their diet.

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 related to the Arctic subspecies of ringed seal.

No reliable population estimates for the entire Arctic subspecies of ringed seal population due to the species' widespread distribution across political boundaries. In the status review, the population was estimated at approximately 2,000,000 individuals; however, NMFS considers this a crude estimate, as it relies on outdated data collected in a variety of ways and does not include all areas of its range. In the status review, the population of ringed seals in Alaska waters of the Chukchi and Beaufort Seas was estimated to be at least 300,000 individuals. This is most likely an underestimate of the true abundance because surveys in the Beaufort Sea were limited to within 40 kilometers (21.6 nautical miles) of the shore (Kelly et al. 2010b).

Due to insufficient data, population trends for the Arctic subspecies cannot be calculated. It is unknown if the population is stable or fluctuating. The genetic population structure of the Arctic subspecies of ringed seal is poorly understood. It is likely that population structuring exists in the species, but the extent to which it occurs is unknown.

Arctic subspecies of ringed seals are widely distributed throughout the Arctic Ocean, in waters of Russia, Canada, Greenland, Finland, and the U.S. (Figure 7). In the U.S. waters, Arctic subspecies of ringed seals are found around Alaska in the Bering, Chukchi, and Beaufort Seas. Most ringed seals move seasonally, following the extent of the sea ice.

8.4.3 Vocalization and Hearing

Ringed seals produce underwater vocalizations ranging from approximately 100 Hertz to 1 kiloHertz (Jones et al. 2014). NMFS classifies ringed seals in the phocid pinniped functional hearing group. As a group, it is estimated that phocid pinnipeds can hear frequencies between 75 Hertz and 100 kiloHertz (NOAA 2013). Ringed seals can hear frequencies of 1 to 40 kiloHertz (Blackwell et al. 2004; Richardson et al. 1995b). Though they may be able to hearing frequencies above this limit (Terhune and Ronald 1976); their sensitivity to such sounds diminishes greatly above 45 kiloHertz (Terhune and Ronald 1975). Direct studies of ringed seal hearing have not been conducted, but it is assumed that ringed seals can hear the same frequencies that they produce and are likely most sensitive to this frequency range (Richardson et al. 1995e).

8.4.4 Status

The Arctic subspecies of ringed seal was listed as threatened under the ESA on December 28, 2012. The species is threatened due to climate change, especially from the expected loss of sea ice and snow cover in the foreseeable future. A final determination to list the Arctic subspecies of the ringed seal as threatened under the ESA went into effect on February 26, 2013. On March 11, 2016, the U.S. District Court for the District of Alaska issued a memorandum decision in a lawsuit challenging the listing of ringed seals under the ESA (Alaska Oil and Gas Association et al. v. National Marine Fisheries Service et al., Case No. 4: 14-cv-00029-RRB). The decision vacated NMFS's listing of the Arctic subspecies of ringed seals as a threatened species under the ESA. On appeal, the District Court decision was reversed and remanded by the Ninth Circuit.

Ringed seals are an important species for Alaska subsistence hunters. The most recent estimate of annual statewide harvest is from 2000 and was 9,567 ringed seals. The current level of subsistence harvest is not known and there are no efforts to quantify statewide harvest numbers. Additional threats to the species include fisheries interactions (including entanglement), disturbance from vessel, sound from seismic exploration, and oil spills.

Because of their apparently large population size and the long-term nature of the threat of climate change to the species, ESA section 4(d) protective regulations and section 9 prohibitions were deemed unnecessary for the conservation of the species at the time of listing.

In summary, the Arctic subspecies of ringed seal has an apparently large population, making it resilient to immediate perturbations. However, threatened by climate change in the long-term, the species is likely to become endangered in the future.

8.4.5 Critical Habitat

In 2021, NMFS proposed to revise proposed critical habitat from December 9, 2014, for the Arctic subspecies of ringed seal (86 FR 1452) and it is described further in Section 7.4.2.

8.4.6 Recovery Goals

NMFS has not prepared a Recovery Plan for the Arctic subspecies of ringed seal.

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, targeted hunts (whaling, sealing, and subsistence harvesting), vessel interactions (vessel strike and whale watching), fisheries (fisheries interactions), pollution (marine debris, pesticides and contaminants, authorized discharge, and hydrocarbons), anthropogenic sound (vessel sound and commercial shipping, aircraft, seismic surveys, exploration, drilling, and production, marine construction, and military activities), and scientific research activities.

Focusing on the impacts of the activities in the action area specifically allows us to assess the prior experience and state (or condition) of the threatened and endangered individuals that occur in the action area that will be exposed to effects from the proposed actions under consultation. This is important because in some states or life history stages, or areas of their ranges, ESA-listed individuals or critical habitat features will commonly exhibit, or be more susceptible to, adverse responses to stressors than they would be in other states, stages, or areas within their

distributions. These localized stress responses or stressed baseline conditions may increase the severity of the adverse effects expected from the proposed actions.

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). This section provides some examples of impacts to ESA-listed species and their habitats that have occurred or may occur as the result of climate change. We address climate change as it has affected ESA-listed species and continues to affect species, and we look to the foreseeable future to consider effects that we anticipate will occur as a result of ongoing activities. While the consideration of future impacts may also be suited for our cumulative effects analysis (Section 10), it is discussed here to provide a comprehensive analysis of the effects 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 both within and outside of the action area.

In order to evaluate the implications of different climate outcomes and associated impacts throughout the 21st 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 two 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 one degrees Celsius from 1901 through 2016 (Hayhoe et al. 2018). The *IPCC Special Report on the Impacts of Global Warming* (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 United States since the beginning of the 20th century with Alaska warming faster than any other state and twice as fast as the global average since the mid-20th 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).

Since the 1950s the atmosphere and oceans have warmed, now and sea ice have diminished, sea levels have risen, and concentrations of greenhouse gases have increased (IPCC 2013). While both natural and anthropogenic factors have inclucenced this warming, human influence has been the dominant cause of the observed warming since the mid-20th century (IPCC 2013). In marine ecosystems, shifts in temperature, ocean circulation, stratification, nutrient input, oxygen content, and ocean acidification are associated with climate change and increased atmospheric carbon dioxide (Doney et al. 2012), and these shifts have potentially far-reaching biological effects. The impacts of climate change are especially pronounced at high latitudes.

Average temperatures have increased across Alaska at more than twice the rate of the rest of the United States. In the past 60 years, average air temperatures across Alaska have increased by approximately 1.65 degrees Celsius (3 degrees Farenheit), and winter temperatures have increased by 3.3 degrees Celsius (6 degrees Farenheit) (Chapin et al. 2014). In August 2017, sea surface temperatures in the Barents and Chukchi seas were up to 3.96 degrees Celsius (7.2 degrees Farenheit) warmer than the 1982 through 2010 average August temperatures. Some of the most pronounced effects of climate change in Alaska include disappearing sea ice, shrinking glaciers, thawing permafrost, and changing ocean temperatures and chemistry (Chapin et al. 2014).

Summer sea ice in the Arctic Ocean is receding faster than previously projected and is expected to virtually disappear before mid-century (Chapin et al. 2014). The NOAA 2017 Arctic Report Card states that the Arctic "shows no sign of returning to the reliably frozen region of recent past

decades." While a changing climate may create opportunities for range expansion for some wide-ranging generalist species, the life cycles and physiological requirements of many specialized polar species are closely linked to the annual cycles of sea ice and photoperiod (Doney et al. 2012). Thus, the loss of sea ice may alter marine ecosystems and reduce habitat for ice-associated species such as Beringia DPS of bearded seals and Arctic subspecies of ringed seals in ways to which they cannot adapt at the rate the changes are occurring. Additionally, the loss of sea ice increases the potential for further anthropogenic impacts as vessel traffic for transportation and tourism and resource extraction activities move into newly ice-free regions.

Increasing ocean temperature, decreasing seasonal ice cover and extent, and increasing freshwater content in Alaska's oceans are changing ocean currents and stratification, nutrient cycles, upwelling, food webs, species composition, primary and secondary productivity, species distributions, and predator-prey interactions (Doney et al. 2012). The impacts of these changes and their interactions on ESA-listed species in Alaska are hard to predict.

Climate change and its effects on seasonal ice area are affecting the Bering, Chukchi, and Beaufort seas. The winters of 2017 through 2018 and 2018 through 2019 have seen "marine heat waves" in the Bering Sea (Thoman and Walsh 2019). The heat content of the entire water column was greater in 2018 than ever recorded. In 2018 through 2019, the sea ice in April in the Bering Sea was a small fraction of its historical extent. The "cold pool" of water usually near the bottom of the Bering Sea disappeared during this time. This disappearance has major implications for the region, as the cold pool served as a barrier to northward migration of various aquatic species (Thoman and Walsh 2019). There have also been increases of sub-Arctic species seasonally found in the Chukchi Sea. With increasing sea surface temperatures in the Arctic Ocean, and the loss of the cold water pool, the potential northward movement of sub-Arctic and non-native species increases (Nordon 2014).

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-19th 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, 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.

For 650,000 years or more, the average global atmospheric carbon dioxide concentration varied between 180 and 300 parts per million, but since the beginning of the Industrial Revolution in the late 1700s, atmospheric carbon dioxide concentrations have increased rapidly, primarily due to anthropogenic inputs (Fabry et al. 2008). The world's oceans have absorbed approximately one-third of anthropogenic carbon dioxide released, which has curtailed the increase in atmospheric carbon dioxide concentrations (Sabine et al. 2004). Despite the ocean's role as large carbon sinks, in 2016, the mean monthly average atmospheric carbon dioxide level exceeded 400 parts per million and continues to rise.

As the ocean absorbs more carbon dioxide, the pH of seawater is reduced. This process is commonly referred to as ocean acidification. Ocean acidification reduces the saturation states of certain biologically important calcium carbonate minerals like aragonite and calcite that many organisms use to form and maintain shells (Reisdorph and Mathis 2014). When seawater is supersaturated with these minerals, calcification (growth) of shells is favored. Likewise, when unsaturated, dissolution is favored (Feely et al. 2009).

High latitude oceans have naturally lower saturation states of calcium carbonate minerals than more temperate or tropical waters (Fabry et al. 2009; Jiang et al. 2015), making Alaska's oceans more susceptible to the effects of ocean acidification. Large inputs of low-alkalinity freshwater from glacial runoff and melting sea ice reduce the buffering capacity of seawater to changes in pH (Reisdorph and Mathis 2014). As a result, seasonal undersaturation of aragonite has been detected in the Bering Sea at sampling stations near the outflows of the Yukon and Kuskokwim rivers (Fabry et al. 2009). Glacier Bay (Reisdorph and Mathis 2014), and Chukchi Sea (Fabry et al. 2009). By 2050, all of the Arctic Ocean is predicted to be undersaturated with respect to aragonite (Feely et al. 2009).

Ocean acidification may cause a variety of species- and ecosystem-level effects in high latitude ecosystems. Species-level effects may include reductions in the calcification rates of numerous planktonic and benthic species, alteration of physiological processes such as pH buffering, hypercapnia, ion transport, acid-base regulation, mortality, metabolic suppression, inhibited blood-oxygen binding, and reduced fitness and growth (Fabry et al. 2008). Ecosystem effects could include altered species compositions and distributions, trophic dynamics, rates of primary productivity, and carbon and nutrient cycling (Fabry et al. 2008).

Additionally, as the ocean becomes more acidic, low frequency sounds (1 to 3 kiloHertz and below) travel farther because the concentrations of certain ions that absorb acoustic waves decrease with decreasing pH (Brewer and Hester 2009).

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. 2006; 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 2007), recent research has indicated a range of consequences already occurring.

Changes in the marine ecosystem caused by global climate change (e.g., ocean acidification, salinity, oceanic currents, dissolved oxygen levels, nutrient distribution) could influence the distribution and abundance of lower trophic levels (e.g., phytoplankton, zooplankton, submerged aquatic vegetation, crustaceans, mollusks, 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. Macleod (2009) estimated, based upon expected shifts in water temperature, 88 percent of cetaceans will be affected by climate change, with 47 percent predicted to experience unfavorable conditions (e.g., range contraction).

Similarly, climate-related changes in important prey species populations are likely to affect predator populations. For example, blue whales, as predators that specialize in eating krill, are likely to change their distribution in response to changes in the distribution of krill (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 Eliott 2009).

The main concern regarding the conservation status of Beringia DPS of bearded seals and Arctic subspecies of ringed seals stems from the likelihood that their sea ice habitat is being modified by the warming climate and that the scientific consensus projects accelerated warming in the foreseeable future. A second concern, also associated with the common driver of carbon dioxide emissions, is the modification of habitat by ocean acidification, which may alter prey populations and other important aspects of marine ecosystems (75 FR77496). According to climate model projections, snow cover on sea ice is forecasted to be inadequate for the formation and occupation of birth lairs for Arctic subspecies of ringed seals within this century over their entire range (Kelly et al. 2010b). A decrease in the availability of suitable sea ice conditions may not only lead to high mortality of ringed seal pups but may also produce behavioral changes in ringed seal populations (Loeng et al. 2005). Changes in snowfall over the 21st century were projected to reduce areas of sea ice with suitable snow depths for ringed seal lairs by 70 percent (Hezel et al. 2012).

Bearded seals are mostly found in areas where seasonal sea ice occurs over relatively shallow waters where they are able to forage on the bottom (Fedoseev 2000), through young animals may be found in ice-free areas such as bays and estuaries. Although no scientific studies have directly addressed the impacts of ocean acidification on bearded or ringed seals, ocean acidification will likely affect their ability to find food. The decreased availability or loss of prey species from the ecosystem may have cascading trophic effects on bearded and ringed seals (Kelly et al. 2010b).

However, not all Arctic species are likely to be adversely influenced by global climate change. Conceptual models suggested that overall reductions in sea ice should increase the prey availability of bowhead whales (Moore and Laidre 2006). This theory may be substantiated by the steady increase in the population of the Western Arctic stock of bowhead whales during the nearly 20 years of sea ice reductions (Walsh 2008). George et al. (2006) showed that harvested bowhead whales had better body condition during years of light ice cover. Similarly, George et al. (2015b) found an overall improvement in bowhead whale body condition and a positive correlation between body condition and summer sea ice loss over the last two and a half decades in the Pacific-side of the Arctic Ocean. George et al. (2015) speculated that sea ice loss has positive effects on secondary trophic production within the bowhead whale's summer feeding region. Moore and Huntington (2008) anticipated that bowhead whales will alter migration routes and occupy new feeding areas in response to climate related environmental change.

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 Targeted Hunts – Whaling, Sealing, and Subsistence Harvesting

Within the action area, targeted hunts pose a threat to ESA-listed marine mammals. Targeted hunts can come in the form of whaling, sealing, and subsistence harvesting.

9.2.1 Whaling

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 through 1985, at least 2.4 million baleen whales (excluding minke whales [*Balaenoptera acutorostrata*]) 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 resumed 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 2012b).

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 whales), St. Vincent and the Grenadines (Bequia, humpback whales) and the U.S. (Alaska, bowhead and gray whales). 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 2012b). 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 stated 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.

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.

Many of the whaling numbers reported represent minimum catches, as illegal or underreported catches are not included. For example, recently uncovered Union of Soviet Socialists Republics catch records indicate extensive illegal whaling activity between 1948 and 1979 (Ivashchenko et al. 2014). Additionally, despite the moratorium on large-scale commercial whaling, catch of some of these species still occurs in the Arctic Ocean whether it be under objection of the International Whaling Commission, for aboriginal subsistence purposes, or under an International Whaling Commission scientific permit from 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. Most 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 Arctic Ocean. For example, the North Pacific right whale 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.

9.2.2 Sealing

Seals, sea lions, and fur seals have been hunted by humans for centuries for their fur, meat, and oil. Two species (Caribbean monk seal [*Monichus tropicalis*] and Japanese sea lion [*Zalophus*

japonicus]) were hunted to extinction in the 20th century, while other species were hunted to near extinction (e.g., Hawaiian monk seal [*Neomonachus shauinslandi*] and Guadalupe fur seal [*Arctocephalus townsendi*]), and many species were severely depleted. While hunting was previously the primary cause of population decline among ESA-listed pinnipeds, it no longer represents a major threat. Hunting of most species is illegal, while limited subsistence hunting of Steller sea lions, bearded seals, and ringed seals is permitted.

Local population depletions of ringed seals occurred during the 20th century as a result of commercial harvests (Kelly et al. 2010a). Although the U.S. does not allow commercial harvest of marine mammals, including ringed seals, such harvests are permitted in other portions of the species' ranges. However, commercial harvest is not considered to currently pose a significant threat to ringed seals (Kelly et al. 2010a).

9.2.3 Subsistence Harvesting

Marine mammals are legally hunted in Alaska waters by coastal Alaska Natives. The ESA and MMPA allow for the harvest of marine mammals by Alaska Natives for subsistence purposes and for traditional handcrafts. Whaling by Alaska Natives in the Alaskan Arctic and sub-Arctic has taken place for at least 2,000 years (Marquette and Bockstoce 1980; Stoker and Krupnik 1993). In addition to subsistence hunting, commercial whaling occurred during the late 19th and early 20th centuries. Pelagic commercial whaling for the Western Arctic stock of bowhead whales was conducted from 1849 through 1914 in the Bering, Chukchi, and Beaufort Seas (Bockstoce et al. 2005). Woodby and Botkin (1993) estimated that the historical abundance of bowhead whales in this population was between 10,400 and 23,000 animals before commercial whaling began. Within the first two decades (1850 through 1870), over 60 percent of the estimated pre-whaling population was harvested, although whaling effort remained high into the 20th century (Braham 1984). It is estimated that the pelagic whaling industry harvested 18,684 animals from this stock (Woodby and Botkin 1993). Estimates of mortality likely underestimate the actual harvest as a result of under-reporting of the Soviet catches and incomplete reporting of struck and lost animals (Yablokov 1994). Commercial whaling also may have caused the extinction of some subpopulations and some temporary changes in distribution.

Subsistence harvest has been regulated by the International Whaling Commission and allocated by the Alaska Eskimo Whaling Commission since 1977. Alaska Native subsistence hunters, primarily from 11 Alaska communities, take approximately 0.1 to 0.5 percent of the population per year (Philo et al. 1993; Suydam et al. 2011). Under this quota, the number of kills in any one year has ranged between 14 and 72. The maximum number of strikes per year is set by a quota which is determined by subsistence needs and bowhead whale abundance and trend estimates (Stoker and Krupnik 1993). Suydam and George (2012) summarized Alaska subsistence harvests of bowhead whales from 1974 through 2011 by village and reported that a total of 1,149 animals were landed by hunters from 12 villages, with Barrow (now Utqiagvik) landing the most animals (N=590) and Shaktolik landing only one. The number of animals landed at each village varies greatly from year to year, as success is influenced by village size and ice and weather conditions

(Table 8). The efficiency of the hunt (the percent of animals struck that are retrieved) has increased since the implementation of the bowhead whale quota in 1978. In 1978, the efficiency was about 50 percent. In 2016, 47 of 59 animals struck were landed, resulting in an efficiency of 80 percent, which was slightly higher than the previous ten-year average of 75 percent (Suydam et al. 2017).

Table 8. Annual number of bowhead whales landed by Alaska Natives.

Year	Number of Landed Bowhead Whales
2010	45
2011	38
2012	55
2013	46
2014	38
2015	38
2016	47
2017	43

In 2019, 36 bowhead whales were taken during the Alaska Native subsistence hunt (Suydam et al. 2020). Whaling near Utqiagvik occurs during spring (April and May) and autumn, and can continue into November, depending on the quota and conditions. Communities that harvested bowhead whales during 2019 include Kaktovik, Nuiqsut, Utqiagvik, Wainwright, Point Lay, Point Hope, and Gamgell. Bowhead whales are also taken in the aboriginal subsistence hunt in the Russian Federal (Zharikov et al. 2020).

Canadian and Russian Natives also take bowhead whales from this stock. Hunters from the western Canadian Arctic community of Aklavik harvested one animal in 1991 and one in 1996. No catches for Western Arctic stock of bowhead whales were reported either Canadian or Russian hunters for 2006 through 2007 (IWC 2008; IWC 2009) or by Russia in 2009, 2011, 2012, or 2014 (Ilyashenko 2013; Ilyashenko and Zharijov 2015; IWC 2011), but two bowhead whales were taken in Russia in 2008 (IWC 2010), two in 2010 (IWC 2012a), and one in 2013 (Ilyashenko and Zharijov 2014).

Annual subsistence take by Natives of Alaska, Canada, and Russia from 2010 through 2014 average 44 bowhead whales. During the 2013 through 2018 time period, the International Whaling Commission and Alaska Eskimo Whaling Commission allowed Alaska and Chukotkan whalers to land up to a total of 336 bowhead whales (AEWC 2018). During 2019, one bowhead whale were harvested at Chukotka. The International Whaling Commission set a catch limit of 392 bowhead whales landed for 2019 through 2025.

Bearded seals and ringed seals are important subsistence species for many northern coastal communities. Bearded seals are preferred species to harvest as food and for skin boat coverings, bur ringed seals are commonly taken for food and their blubber (Ice Seal Committee 2019). Ringed seals are typically harvested during the summer and can extend up to 64 kilometers (34.6 nautical miles) from shore (Braund and Huntington 2010).There are seven communities in the North Slope Borough region of Alaska (northwestern and northern Alaska) that harvest seals, including Kaktovik, Nuiqsut, Utqiagvik, Atqasuk, Wainwright, Point Lay, and Point Hope (from east to west) (Ice Seal Committee 2019). Approximately 64 Alaska Native communities in western and northern Alaska, from Bristol Bay to the Beaufort Sea, regularly harvest bearded and ringed seals for subsistence purposes (Ice Seal Committee 2016). Estimates of subsistence harvest of bearded seals and ringed seals are available for 17 of these communities based on annual household surveys conducted from 2009 through 2014 (Table 9), but more than 50 other communities that harvest these species for subsistence were not surveyed within this time period or have never been surveyed. Household surveys are designed to estimate harvest for the specific community surveyed; extrapolation of harvest estimates beyond a specific community is not appropriate because of local differences in seal availability, cultural hunting practices, and environmental conditions (Ice Seal Committee 2017). During 2010 through 2014, the total annual bearded seal and ringed seal harvest estimates across surveyed communities ranged from 695 to 1,286 and 217 to 1,176, respectively (Table 9). However, it should be noted that the geographic distribution of communities surveyed varied among years such that these totals may be geographically or otherwise biased. Table 9 shows the number of bearded and ringed seals harvested in the North Slope Borough during the most recent year that data were available. However, the number of seal harvested each year varies considerably.

Table 9. Estimated bearded and ringed seal harvests in the North Slope Borough of Alaska as well as based on household surveys.

Community	Year	Number of Bearded Seals	Number of Ringed Seals
Kaktovik	2014	3	1
Nuiqsut	2014	26	58
Utqiagvik	2014	1,070	428
Atqasuk	1998	3	0
Wainwright	2003	79	27
Point Lay	2012	55	51
Point Hope	2014	183	246
Kivalina	2011	123	16
Noatak	2011	65	3
Buckland	2011	48	26

Community	Year	Number of Bearded Seals	Number of Ringed Seals
Deering	2011	49	0
Golovin	2012	11	0
Emmonak	2011	106	56
Scammon Bay	2011, 2012	82, 51	137, 169
Hooper Bay	2010, 2011, 2012, 2013, 2014	148, 210, 212, 171, 64	458, 674, 651, 667, 158
Tununak	2010, 2011, 2012	40, 42, 44	162, 257, 219
Tuntutuliak	2013	53	75
Quinhagak	2010, 2011, 2012, 2013, 2014	29, 26, 44, 49, 16	163, 117, 140, 160, 51
Togiak	2010, 2011	0, 2	1, 0
Twin Hills	2010	0	0
Dillingham	2012	7	3
Total	-- --	3,111	5,174

9.3 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.

Ferries, cruise ships, tankers, ore carriers, commercial fishing vessels, and recreational vessels transit or operate within Alaska state and U.S. Exclusive Economic Zone waters. Much of the vessel traffic in Alaska waters is concentrated in coastal areas of southeastern and southcentral Alaska during the summer months, where recreational vessels, charter vessels, commercial whale watch vessels, tour boats, and cruise ships are prevalent. Traffic from large vessels is more likely to occur year-round statewide, in both nearshore and offshore waters, and includes commercial fishing vessels, freighters, tankers, passenger ferries, etc. In general, there is less vessel traffic off western and northern Alaska compared to other parts of the state, although considerable traffic passes through the Aleutian Islands via the Great Circle Route. These trends are changing with climate change-driven decreases in sea ice in the Bering, Chukchi, and Beaufort seas (Neilson et al. 2012).

9.3.1 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).

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 (Pirotta et al. 2019a). 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). 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 moralities 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.

Increased vessel traffic resulting from a reduction in sea ice in the Arctic Ocean may lead to more vessel strike incidents in the future. There has been one reported vessel strike of a bowhead whale from Utqiagvik in 2015. To date, no bearded seal or ringed seal carcasses have been found with propeller marks.

9.3.2 Whale Watching

Whale watching is a profitable rapidly-growing business with more than 3,300 operators worldwide, serving 13 million participants in 119 countries and territories, and may increase

types of disturbance and negatively affect the species (Hoyt 2001; 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 consultation 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 2002; Felix 2001; Magalhaes et al. 2002; Richter et al. 2003; Scheidat et al. 2004; Simmonds 2005a; 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 the 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 low-energy and high-energy seismic survey will take place approximately 300 kilometers (162 nautical miles) from the Alaska coastline (north of Utqiagvik) in the Arctic Ocean (Figure 1). Given the proposed seismic survey activities will occur in a remote area away from populated areas (e.g., Nome and Utqiagvik) where whale watching may occur and not occur within approximately 300

kilometers (162 nautical miles) of land (Alaska coastline), few (if any) whale watching vessels will be expected to co-occur with the proposed action's research vessel.

9.4 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.

The North Pacific Fishery Management Council adopted an Arctic Fishery Management Plan which closed all Federal waters of the Chukchi and Beaufort seas to commercial fishing for any species of finfish, mollusks, crustaceans, and all other forms of marine animal and plant life, with limited exceptions. The Arctic Fishery Management Plan does not regulate subsistence or recreational fishing or State of Alaska-managed fisheries in the Arctic Ocean. Because no commercial fisheries occur in the Chukchi and Beaufort seas, any observed serious injury or mortality to ESA-listed species in the Arctic Ocean that can be associated with commercial fisheries is currently attributable to interactions with fisheries in other areas, including in the Bering Sea/Aleutian Islands management area and Gulf of Alaska.

9.4.1 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 and pinnipeds 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 and pinniped species 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 marine mammals through changes in prey abundance remain unknown in the action area.

No commercial fishing occurs in the Chukchi and Beaufort seas, but does occur in the Bering Sea portion of the action area. Recreational and subsistence fishing occurs throughout the action area. Commercial, recreational, and subsistence fisheries may impact marine mammals as they migrate through the action area through direct interactions (i.e., incidental take or bycatch) and indirectly through competition for prey resources and other impacts on prey populations.

9.5 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, authorized discharges, and hydrocarbons.

9.5.1 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 mortality 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). 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 Arctic 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.

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 proposed actions although the risk of ingestion or entanglement and the resulting impacts are uncertain at the time of this consultation.

It is estimated that between 62,000 to 105,000 tons of plastic are transported to the Arctic Ocean each year (Zarfl and Matthies 2010). With increased development in the Chukchi and Beaufort seas, increased vessel traffic through the Northwest Passage, increased number of observers (i.e., staff, scientists, and tourists), and longer periods of open water which can promote delivery of plastics and marine debris to the Arctic Ocean, it is anticipated that entanglement and ingestion by marine mammals will be documented in coming years.

9.5.2 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.

9.5.2.1 Bowhead Whales

Some environmental contaminants, such as chlorinated pesticides, are lipophilic and can be found in the blubber of marine mammals (Becker et al. 1995a). Tissues collected from bowhead whales landed at Barrow (now Utqiagvik) in 1992 indicated that animals had very low levels of mercury, polychlorinated-biphenyls, and chlorinated hydrocarbons, but they had elevated concentrations of cadmium in their liver and kidneys. Bratton et al. (1993) measured organic arsenic in the liver tissue of one bowhead whale and found that about 98 percent of the total arsenic was arsenobetaine. Aresenobetaine is a common substance in marine biological systems and is relatively non-toxic.

Bratton et al. (1993) looked at eight metals (arsenic, cadmium, copper, iron, mercury, lead, selenium, and zinc) in the kidneys, liver, muscle, blubber, and visceral fat from bowhead whales

harvested from 1983 through 1990. They observed considerable variation in tissue metal concentration among the bowhead whales tested. Metal concentrations evaluated did not appear to increase over time. The metal levels observed in all tissues of the bowhead whale are similar to levels reported in the literature in other baleen whales. The bowhead whale has little metal contamination as compared to other Arctic marine mammals, except for cadmium. Moessner and Ballschmiter (1997) reported that total levels of polychlorinated biphenyls and chlorinated pesticides in bowhead whale blubber from the North Pacific and Arctic Oceans were many times lower than those in beluga whales or northern fur seals. However, while total levels were low, the combined level of three isomers of hexachlorocyclohexanes (chlorinated pesticides) was higher in the blubber tested from bowhead whales than from three marine mammals species (i.e., pilot whale, common dolphin, and harbor seal) sampled in the North Atlantic Ocean. These results were believed to be due to the lower trophic level of the bowhead whale as compared to the other marine mammals tested.

9.5.2.2 Bearded Seals and Ringed Seals

Research on contaminants in bearded seals is limited compared to the information for ringed seals. However, pollutants such as organochlorine compounds and heavy metals have been found in most bearded seal populations. Climate change has the potential to increase the transport of pollutants from lower latitudes to the Arctic (Tynan and Demaster 1997).

Contaminants research on ringed seals is extensive throughout the Arctic where ringed seals are an important part of the diet for coastal human communities. Pollutants such as organochlorine compounds and heavy metals have been found in all of the subspecies of ringed seal (with the exception of the Okhotsk). The variety, sources, and transport mechanisms of contaminants vary across ringed seal ecosystems (Kelly et al. 2010c). Heavy metals such as mercury, cadmium, lead, selenium, arsenic, and nickel accumulate in ringed seal vital organs, including liver and kidneys, as well as in the central nervous system (Kelly et al. 2010c). Gaden et al. (2009a) suggested that during ice-free periods the ringed seals eat more Arctic cod (and mercury). They also found that mercury levels increased with age for both sexes (Dehn et al. 2005; Gaden et al. 2009b). Becker et al. (1995b) reported ringed seals had higher levels of arsenic in Norton Sound (inlet in the Bering Sea) than ringed seals taken by residents of Point Hope, Point, Lay, and Barrow (now Utqiagvik). Arsenic levels in ringed seals from Norton Sound were quite high for marine mammals, which might reflect localized natural arsenic sources.

9.5.3 Authorized Discharge

Discharges authorized from development activities occurring in portions of the action area are the source of multiple pollutants that may be bioavailable (i.e., may be taken up and absorbed by animals to ESA-listed species and their prey items. Drill cutting and fluids contain contaminants such as dibenzofuran and polycyclic aromatic hydrocarbons that have high potential for bioaccumulation. Historically, drill cutting s and fluids have been discharged from oil and gas developments in the Beaufort Sea, and residues from these historical discharges may be present

in the environment (Brown et al. 2010). Polycyclic aromatic hydrocarbons are also emitted to the atmosphere by flaring water gases at production platforms or gas treatment facilities.

The Clean Water Act of 1972 (CWA) has several sections or programs applicable to activities on offshore waters. Section 402 of the CWA authorizes the U.S. Environmental Protection Agency (EPA) to administer the National Pollutant Discharge Elimination System (NPDES) permit program to regulate point source discharges into waters of the U.S. Section 403 of the CWA requires that EPA conduct an ocean discharge criteria evaluation for discharges of pollutants from point sources into the territorial seas, contiguous zones, and the oceans. The Ocean Discharge Criteria (40 C.F.R. Part 125, Subpart M) sets forth specific determinations of unreasonable degradation that must be made before permits may be issued.

On November 28, 2012, EPA issued a NPDES general permit for discharges from oil and gas exploration facilities on the outer continental shelf and in contiguous state waters of the Beaufort Sea. The general permit authorizes 13 types of discharges from exploration drilling operations and establishes effluent limitations and monitoring requirements for each waste steam.

On January 21, 2015, EPA issued a NPDES general permit for wastewater discharges associated with oil and gas geotechnical surveys and related activities in Federal waters of the Chukchi and Beaufort Seas. This general permit authorizes 12 types of discharges from facilities engaged in oil and gas geotechnical surveys to evaluate the subsurface characteristics of the seafloor and related activities in Federal waters of the Chukchi and Beaufort Seas.

Both the Beaufort Sea exploration and geotechnical general permits establish effluent limitations and monitoring requirements specific to each type of discharge and include seasonal prohibitions and area restrictions for specific waste streams. For example, both general permits prohibit the discharge of drilling fluids and drill cuttings to the Beaufort Sea from August 25 until fall bowhead whale hunting activities by the communities of Nuiqsut and Kaktovik have been completed. Additionally, both general permits require environmental monitoring programs to be conducted at each drill site or geotechnical site location, corresponding to before, during, and after drilling activities, to evaluate the impacts of discharges from exploration and geotechnical activities in the marine environment.

The principal regulatory mechanism for controlling pollutant discharges from vessels (grey water, black water, coolant, bilge water, ballast, deck wash, etc.) into waters of the Arctic Region Outer Continental Shelf is also the CWA. The EPA issued a NPDES vessel general permit that applies to pollutant discharges from non-recreational vessels that are at least 24 meters (79 feet) in length, as well as ballast water discharged from commercial vessels less than 24 meters (79 feet). This general permit restricts the seasons and areas of operation, as well as discharge depths, and includes monitoring requirements and other conditions.

In addition, the U.S. Coast Guard has issued regulations that address pollution prevention with respect to discharges from vessels carrying oil, noxious liquid substances, garbage, municipal or

commercial waste, and ballast water (33 C.F.R. Part 151). The State of Alaska regulates water quality standards within three miles of the shore.

9.5.4 Hydrocarbons

There has never been a large-scale oil spill in the action area, but numerous small-scale vessel spills likely occur. Since the late 1960s, small spills have occurred with routine frequency in Beaufort and Chukchi Seas from refueling operations, pipelines, and loss of well control during drilling as part of oil and gas activities. Leaks and spills have also been reported from fuel tanks and tank farms. 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.

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 (bowhead whale, Beringia DPS of bearded whale, and Arctic subspecies of ringed seal) 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.

9.6 Aquatic Nuisance Species

Aquatic nuisance species are nonindigenous species that threaten the diversity or abundance of native species, the ecological stability of infested waters, or any commercial, agricultural or recreational activities dependent on such waters. Aquatic nuisance species include nonindigenous species that may occur within inland, estuarine, or marine waters and that presently or potentially threaten ecological processes and natural resources. 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.

Gurevitch and Padilla (2004) note that of the 21 total marine species in the International Union for Conservation of Nature (IUCN) database listed to have gone extinct (four mammals, 11 birds, one fish, four molluscs, one alga), none are attributed to invasive alien species; most were extinct prior to 1900 and before many modern invasions.

Dueñas et al. (2018) conducted a systematic literature review of the available scientific evidence on invasive species' interactions with all threatened and endangered species protected under the ESA. Relevant to this consultation Dueñas et al. (2018) did not find any studies indicating that ESA-listed marine mammals negatively impacted by invasive species.

Many studies have demonstrated a close relationship between trade and aquatic nuisance species, with shipping being identified as the main vector of aquatic nuisance species in aquatic ecosystems (Nong 2018, Chan et al. 2019). Olson (2006) reviewed numerous studies of biological invasions and highlighted that international trade is an important vecor that links to the existence and spread of invasive species internationally. Globally, shipping has been found to be responsible for 69 percent of marine invasive species (Molnar et al. 2008). Chan et al. (2019) found that vessels transferred the greatest number of aquatic nuisance species (39 percent) to the Arctic Ocean, followed by natural spread (30 percent) and aquaculture activities (25 percent).

Risks associated with oceanic shipping come primarily from hitchhiking species on vessel hulls (fouling) and in ballast water (Drake and Lodge 2007; Keller and Perrings 2011). Until recently, the Arctic Ocean has had very low exposure to aquatic nuisance species because of the extensive ice cover, remoteness, and harshness of the environment. The Arctic Ocean is about to undergo extensive and unprecedented biotic introductions (Miller and Ruiz 2014). In general, the introduction of aquatic nuisance species is one of the primary causes decreased biodiversity in an ecosystem (Trombulak et al. 2004). The impact of aquatic nuisance species in marine systems ranges from extirpation of native species through competition or predation, shifts in ecosystem food webs, to changes to the physical structure of the habitat (Norse et al. 2005). Although it is not possible to predict which aquatic nuisance species will arrive and thrive in the Arctic Ocean, it is reasonably certain that they will be yet another facet of change and potential stress to native biota which may affect either the health or prey base of native fauna.

9.7 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 (vessel sound and commercial shipping), aircraft, seismic surveys (exploration and research), exploration, drilling, and production, marine construction, and military readiness activities. These activities occur to varying degrees throughout the year. Cetaceans and pinnipeds generate and rely on sound to navigate, hunt, and/or 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. Responses to sound exposure may include lethal or nonlethal injury, temporary hearing impairment, behavioral harassment and stress, or no apparent response. 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 bowhead 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. 2006; 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).

9.7.1 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.

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

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).

The general season pattern of vessel traffic in the Arctic Ocean is correlated with seasonal ice conditions, which results in the bulk of the traffic being concentrated within the months of July through October. Unaided navigation is limited to an even narrower timeframe. Decreasing ice levels will facilitate an increase in vessel traffic associated with oil and gas exploration, tourism, and open historically closed trade routes. The Northern Sea Route reduces the distances between Northwest Europe and Northeast Asia by 40 percent compared to the passage throughout the

Suez Canal. The Northwest Passage reduces the sailing distance between Northeast Asia and the U.S. Atlantic coast by 23 percent compared to the route via the Panama Canal (Bekkers et al. 2016). The two Artic routes allow shipping companies to avoid increased tolls in the Panama and Suez Canals and provide routes for super ships that are larger and able to carry greater volumes of cargo (Nong et al. 2018). In an effort to predict the increase of vessel traffic through the Northwest Passage and the Northern Sea Route, Melia et al. (2016) used global climate models to project how sea ice loss might increase shipping in the Arctic Ocean. For a high-emission scenario, by late century, trans-Arctic chipping may be commonplace, with a season ranging from four to eight months. For a low-emission scenario, with global mean temperature stabilization of less than two degrees Celsius above preindustrial levels, the frequency of open water vessel transits still has the potential to double by midcentury with a season ranging from two to four months Melia et al. (2016).

The number of unique vessels tracked via Automatic Identification System in U.S. waters north of the Pribilof Islands increased from 120 in 2008 to 250 in 2012, an increase in 108 percent (ICCT 2015). This includes only the northern Bering Sea, the Bering Strait, Chukchi Sea, and Beaufort Sea to the Canadian border. The increase in vessel traffic on the outer continental shelf of the Chukchi Sea and the nearshore from oil and gas development is particularly pronounced (ICCT 2015). However, the number of vessels identified in this region in 2012 likely also reflects traffic associated with the offshore exploratory drilling program that was conducted by Shell on the outer continental shelf of the Chukchi Sea that year. Overall, in 2012, there was a shift toward more offshore traffic and there were also noticeable localized changes in vessel traffic conditions near Prudhoe Bay, Alaska and in the vicinity of the drilling project in the Chukchi Sea (ICCT 2015).

9.7.2 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 and pinnipeds 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.

9.7.3 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 re: 1 μPa (rms) 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 federal waters and 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 have been conducted in the Chukchi and Beaufort Seas since the late 1960s and early 1970s, resulting in extensive coverage over the area. More information on exploration, drilling, and production is described in Section 9.7.4.

The National Science Foundation funded and conducted seismic surveys on the United States Coast Guard Cutter (USCGC) *Healy* across the Arctic Ocean during August through September 2005 (conducted by the University of Alaska Fairbanks); on the USCGC *Healy* of the Western Canada Basin, Chukchi Borderland, and Mendeleev Ridge in the Arctic Ocean during August 2006 (conducted by the University of Texas Institute of Geophysics); and on the R/V *Marcus G. Langseth* in the Arctic Ocean during September through October 2011 (conducted by the L-DEO and University of Alaska Fairbanks). The U.S. Geological Survey funded and conducted seismic survey on the USCGC *Healy* and CCGS *Louis S. St. Laurent* in the Arctic Ocean during August through September 2010. There are two 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 and Mexico) in 2021. 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.

9.7.4 Exploration, Drilling, and Production

Noise levels in the Chukchi and Beaufort seas are higher due to oil and gas development, which have occurred on the North Slope of Alaska since the early 1900s. Seismic surveys have been conducted in the Chukchi and Beaufort seas since the late 1960s and early 1970s, resulting in extensive coverage over the action area. Analysis of sound associated with seismic surveys in the Beaufort Sea and central Arctic Ocean during ice-free conditions also documented propagation distances up to 1,300 kilometers (701.9 nautical miles) (Richardson 1998, 1999, Thode et al. 2010). Because the continental shelf in the Chukchi Sea has a highly uniform depth of 30 to 50 meters (98 to 164 feet), it strongly supports sound propagation in the 50 to 500 Hertz frequency band (Funk et al. 2008).

Seismic surveys for oil and gas development and exploration are often followed by test drilling. Test drilling involves fewer direct impacts than seismic surveys for exploration, but the potential risks for test drilling, such as oil spills, may have broader consequences (Smith et al. 2017). Oil and gas development and exploration activities include, but are not limited to: seismic surveys; exploratory, development, and production drilling; construction of artificial islands, causeways, ice roads, shore-based facilities, and pipelines; and vessel and aircraft operations.

The greatest noise levels from drilling platforms originate from operating noises from the oil platform, not from the noise generated by drilling, with frequencies generally below 10 kiloHertz. In general, noise from the platform itself is thought to be very weak because of the small surface area (the four legs) in contact with the water (Richardson et al. 1995c) and that the majority of the machinery is on the deck of the platform, which is above the water's surface. However, noise carried down the legs of the platform likely contributed to the higher noise levels than anticipated (Blackwell et al. 2003). For example, Blackwell et al. (2003) recorded underwater noise produced at *Phillips A* oil platform (now the *Tyonek* platform) at distances ranging from 0.3 to 19 kilometers (0.2 to 10.3 nautical miles) from the sound source in Cook Inlet, Alaska. The highest recorded sound level was 119 dB at a distance of 1.2 kilometers (0.6 nautical miles). Noise between 2 and 10 kiloHertz was measured as high as 85 dB as far out as 19 kilometers (10.3 nautical miles) from the sound source.

9.7.5 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 in the Bering, Chukchi, and Beaufort seas. All or some of these activities may occur within the action area and can affect ESA-listed marine mammals.

9.7.6 Military Activities

Within the action area, multiple stressors associated with military activities pose a threat to ESA-listed marine mammals. The U.S. Navy conducts Ice Exercise to evaluate submarine operability in Arctic conditions as well as test emerging technologies and gather data on Arctic capabilities

and environmental conditions. This includes testing and training of equipment and personnel, and performing research activities. The proposed action's activities includes the construction and demobilization of a temporary camp on a suitable ice floe; snowmobiles and all-terrain tracked vehicles, fixed-wing and rotary-wing aircraft, and submarines and in-water vessels.

The majority of the training and testing and research activities the U.S. Navy conducts in the action area are similar, if not identical to activities that have been occurring in the same locations for decades; therefore, the ESA-listed species located in the action area have been exposed to these military activities often and repeatedly.

The U.S. Navy's activities produce sound and visual disturbance to marine mammals throughout the action area. Anticipated impacts from harassment due to the U.S. Navy's activities include changes from foraging, resting, milling, and other behavioral states that require low energy expenditures to traveling, avoidance, and behavioral states that require higher energy expenditures. Based on the currently available scientific information, behavioral responses that result from stressors associated with these training and testing and research activities are expected to be temporary and will not affect the reproduction, survival, or recovery of these species. Sound (in-air and in-water) produced during U.S. Navy activities is also expected to result in instances of behavioral harassment to marine mammals. The U.S. Navy's activities constitute a federal action and take of ESA-listed marine mammals and proposed or designated critical habitat considered for these activities have previously undergone separate ESA section 7 consultation. Through these consultations with NMFS, the U.S. Navy has implemented monitoring and conservation measures to reduce the potential effects of in-air and underwater sound from activities on ESA-listed species in the Arctic Ocean. Conservation measures include aircraft operating a certain altitudes and transit corridors, avoiding pinniped haul-outs and lairs, employing visual observers, and implementing mitigation zones during activities using noise.

9.8 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 Arctic Ocean, some of which extend into portions of the action area for the proposed actions. 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, prey mapping, remote ultrasound, passive acoustic monitoring, biological sampling (i.e., body and weight measurements, biopsy, blood, breath, clipped hair, fecal, muscle, oral and nasal, sloughed skin,

urine), and tagging. In addition, capture and restraint of pinnipeds may be conducted for the injection of sedative, administration of drugs (intramuscular, subcutaneous, or topical), attachment of instruments to hair or flippers, and ultrasound. Research activities generally 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 activities in the action area (e.g., Permit No. 19309 for captures of bearded seals and ringed seals; Permit No. 20466 for captures of bearded seals and ringed seals; Permit No. 18890 for captures of bearded seals and ringed seals; Permit No. 14856 for harassment of bearded and ringed seals during vessel surveys; and Permit No. 20465 for harassment of bearded seals and ringed seals during aerial surveys). 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 proposed or designated critical habitat.

Occasionally, mortalities may occur incidental to research activities on marine mammals authorized under scientific research permits. In 2010 through 2014, one mortality was reported incidental to research on ringed seals in Alaska, resulting in an average of 0.2 ringed seal mortalities per year from the Alaska stock (Muto et al. 2017).

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 Arctic 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 and high-energy seismic survey and research activities.

9.9 Impact of the Baseline on Endangered Species Act-Listed Species

Collectively, the baseline described above has had, and likely continues 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 consultation is difficult. This difficulty is compounded by the fact that many of the species in this consultation 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* section on ESA-listed resources to be the status and trends of those species. As noted in Section 8.1, 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 activities identified in the *Environmental Baseline* section are 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* section. Therefore, while the impacts addressed in the *Environmental Baseline* section 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* section is preventing their recovery. However, is also possible that their populations are at such low levels (e.g., due to historical commercial whaling) that even when the species' primary threats are removed, the species may not be able to achieve recovery. At small population sizes, species may experience phenomena such as demographic stochasticity, inbreeding depression, and Allee effects, among others, that cause their limited population size to become a threat in and of itself. A thorough review of the status and trends of each species is discussed in the *Status of Species Likely to be Adversely Affected* section (Section 8.1) of this consultation and what this means for the populations is discussed in the *Integration and Synthesis* section (Section 12).

10 Effects of the Actions

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). 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 effects assessment and, ultimately, of this consultation is to determine if the proposed action's 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 proposed or designated critical habitat. The seismic survey activities and issuance of an incidental harassment authorization will authorize activities that may expose ESA-listed cetaceans and pinnipeds within the action area to a variety of stressors.

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

1. Pollution by exhaust, fuel, oil, trash, and other debris;
2. Vessel strike;
3. Vessel noise and visual disturbance;
4. Entanglement in the airgun array and towed hydrophone streamer;
5. Sound fields produced by the sub-bottom profiler, multi-beam echosounder, acoustic Doppler current profiler, and acoustic release transponder; and
6. Sound fields produced by the airgun array.

Based on a review of available information, during consultation we determined which of these possible stressors will be reasonably certain to occur and which will be insignificant or extremely unlikely to occur for the species and habitats affected by these activities. These species and habitats were discussed in Sections 7 and 8, and will not be further addressed. Stressors (i.e., sound fields produced by the airgun array) that are likely to adversely affect ESA-listed species are discussed in the *Exposure and Response Analysis* sections.

During consultation we determined that sound fields produced by the airgun array will likely 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 Actions* section (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 include the use of proposed exclusion and buffer zones, shut-down procedures, pre-clearance and ramp-up procedures, vessel-based 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 and possible renewal will contain additional mitigation measures to minimize or avoid exposure that are described in *Appendix A* (see Section 18).

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* section 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* section evaluates the available evidence to determine how individuals of those ESA-listed species are likely to respond given their probable exposure. The *Response Analysis* section 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 actions, the stressor of primary concern is the acoustic impacts of the airgun arrays. Airguns contribute a massive amount of anthropogenic energy to the world's oceans (3.9×10^{13} Joules cumulatively), second only to nuclear explosions (Moore and Angliss 2006). Although most energy is in the low-frequency range, airguns emit a substantial amount of energy up to 150 kiloHertz (Goold and Coates 2006). Seismic airgun noise can propagate substantial distances at low frequencies (e.g., Nieukirk et al. 2004).

In this section, we quantify the likely exposure of ESA-listed species to sound from the airgun array. For this consultation, the National Science Foundation and NMFS Permits and Conservation Division estimated exposure to the sounds from the airgun array that will result in take, as defined under the MMPA, for all 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. §1362(13)) 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 actions, the two levels of harassment are further defined under the MMPA (16 U.S.C. §1362(18)) 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" (16 U.S.C. §1532(19)). 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 constitute harassment under the ESA and all forms of Level A harassment under the MMPA constitute harm under the ESA (e.g., NMFS 2017).

Therefore, under the ESA, harassment is expected to occur during the seismic survey activities and may involve a wide range of behavioral responses for ESA-listed 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 if these behavioral responses are reasonably certain to occur 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 reasonably certain to be affected (i.e., exhibit some response). Using this information, and information on the proposed low-energy and high-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 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 three ESA-listed marine mammal species that are likely to be adversely affected by the proposed actions: bowhead whales, Beringia DPS of bearded seals, and Arctic subspecies of ringed seals.

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 and high-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 draft environmental assessment/analysis. 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, although other equipment producing sound will be used during airgun array operations (e.g., the sub-bottom profiler, multi-beam echosounder, acoustic Doppler current profiler, and acoustic release transponder).

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 consultation. 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 and request for comments and possible renewal, the NMFS Permits and Conservation Division stated that they did not expect the sound emanating from the other equipment to exceed the levels produced by the airgun array. Therefore, the NMFS Permits and Conservation Division did not expect additional exposure from sound sources other than the airgun array. We agree with this assessment and similarly focus our analysis on exposure from the airgun array. The sub-bottom profiler, multi-beam echosounder, acoustic Doppler current profiler, and acoustic release transponder 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 is usually 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, pre-clearance and ramp-up procedures, vessel-based 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.

Marine Mammal Occurrence – Density Estimates

We reviewed available cetacean and pinniped densities and group dynamics 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 draft environmental assessment/analysis and incidental harassment authorization application, they utilized estimates of cetacean and pinniped densities in the action area. Habitat-based estimates of cetacean density in the U.S. Arctic were

published by Schick et al. (2017). This study used line-transect aerial survey data from the ASAMM collected in the U.S. Chukchi and Beaufort seas from 2000 through 2016 and associated habitat covariates to estimate abundance monthly (from July through October within ten kilometer by ten kilometers (5.4 nautical miles by 5.4 nautical miles) grid cells (equivalent to a density in units of individuals per 100 square kilometers) which are provided in GIS raster files. Estimates were produced for bowhead whales. The spatial extent of the model predictions and density estimates differed by species, but the bowhead whale is the only ESA-listed whale expected in the proximity to the seismic survey area.

In general, marine mammals are expected to be encountered more frequently to the south of the seismic survey area. Therefore, estimated exposure numbers produced through use of the density model products are expected to be very conservative. Previous monitoring reports from recent Arctic surveys using the R/V *Sikuliaq* sighted low numbers of baleen whales (i.e., humpback whales) and pinnipeds (i.e., spotted and unknown seals). More detailed information on this monitoring report can be found on the following website at: https://media.fisheries.noaa.gov/dam-migration/onr_arcticresearch_2018iha_monrep_opr1.pdf. Furthermore, based on tagging information from the summer and fall, bowhead whales migrate across the continental shelf of Alaska in the Beaufort Sea to the central Chukchi Sea in September and remain in this area for the fall (Quakenbush et al. 2013). Only one bowhead whale was reported to travel north towards the seismic survey area. Based on this information, NMFS believes that the estimated exposure numbers for bowhead whales are conservative.

For all species, the methods described below that were used to extend the Schick et al. (2017) predictions to areas farther north likely produced conservative density estimates since those species are rarely sighted in the seismic survey area. The spatial coverage of density estimates for bowhead whales extends northward to approximately 74 degrees North, which overlaps the southern-most survey tracklines by approximately 25 kilometers (13.5 nautical miles). However, the majority of the survey tracklines do not overlap with the spatial coverage of the Schick et al. (2017) density estimates, so the following method was used to produce a conservative estimate of average bowhead density farther north. The two northern-most rows of ten kilometer by 10 kilometer (5.4 nautical miles by 5.4 nautical miles) grid cells (i.e., northern 20 kilometers [10.8 nautical miles] of estimates) and the two additional cells overlapped by the southern-most survey tracklines, were selected from the bowhead whale GIS raster files for August and September between 140 degrees West and 165 degrees West, the approximate east-west extent of the survey tracklines. Density estimates within those cells were then evaluated and cells east of approximately 157 degrees West were excluded as they contained densities that were effectively zero which will reduce the calculated average. The mean of the remaining cells (west of 157 degrees West) was then calculated resulting in an overall density estimate of 0.01237 bowhead whales per 100 square kilometers or 0.00012 bowhead whales per square kilometer.

During ASAMM, sightings of pinnipeds were recorded when possible and the resulting data were used by Schick et al. (2017) to produce habitat-based density estimates in the same manner

as for cetaceans. However, given ASAMM was designed for large whales, including typically being flown at altitudes above 304.8 meters (1,000 feet) above sea level, and small pinniped sightings may not have been recorded as consistently, the Schick et al. (2017) pinniped densities were not used in this analysis. Instead, NMFS recommended using bearded seal and ringed seal densities from their biological opinion for the U.S. Navy's Arctic research activities 2018 through 2021, which were based on habitat-based modeling by Kaschner et al. (2006) and Kaschner (2004). As the best estimate of the population of ringed seals in the Alaskan Chukchi Sea is approximately 208,000 animals (Bengston et al. 2005), this resulted in a ratio of 0.18. The density estimate is 0.0332 individuals per square kilometer for the Beringia DPS of bearded seal and 0.3760 individuals per square kilometer for the Arctic subspecies of ringed seal.

Highly variable oceanographic and atmospheric conditions determine the amount and distribution of sea ice in the Arctic, which heavily influences the species and number of marine mammals potentially present at these high latitudes. Thus, there is considerable year-to-year variation in the distribution and abundance of the marine mammal species in the seismic survey area. Data sources and density calculations are described in detail in the National Science Foundation's environmental assessment/analysis and incidental harassment authorization application. There is uncertainty about the representativeness of the density data and the assumptions used to estimate exposures. For some marine mammal species, the densities derived from past surveys may not be precisely representative of the densities that will be encountered during the proposed seismic surveys activities. Density estimates for each marine mammal species are found in Table 10. The approach used here is based on the best available data.

The low-energy and high-energy seismic survey will be contained in the Arctic Ocean along approximately 5,850 kilometers (3,158.7 nautical miles) (including 5,170 kilometers (2,791.6 nautical miles) of MCS reflection [low-energy] surveys and 680 kilometers (367.2 nautical miles) of OBS refraction [high-energy] surveys). The ensonified area (for the 160 dB re: 1 μPa [rms] harassment threshold) is estimated to be approximately 31,003.1 square kilometers (9,039.1 square nautical miles), based on the distances multiplied by the various isopleths for intermediate and deep water depths anticipated to be ensonified to the predicted 160 dB re: 1 μPa (rms) distance around the planned tracklines. Using GIS, the ensonified area (for the 160 dB re: 1 μPa [rms] harassment threshold) is estimated to be approximately 27,308.8 square kilometers (7,962 square nautical miles) after adjusting for overlap around tracklines. Water depths will range from approximately 200 to 4,000 meters (656.2 to 13,123.4 feet) in 100 percent of the tracklines.

To determine exposures, the National Science Foundation and NMFS Permits and Conservation Division calculated ESA harassment by using the radial distances from the airgun array to the predicted isopleths corresponding to the ESA harassment. The entirety of the proposed low-energy and high-energy seismic survey will be conducted in intermediate and deep waters depths between 100 to 1,000 meters (328.1 to 3,281 feet) and greater than 1,000 meters (3,280 feet). The product is then multiplied by 1.25 to account for the additional 25 percent contingency 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 (adjusted for overlap) at 160 dB re: 1 μPa (rms) is 27,308.8 square kilometers (7,962 square nautical miles), which was calculated by multiplying the ESA harassment buffer zone widths for the airgun array configuration in intermediate and deep water depths by the trackline distance (see Table 11). 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 (see Table 10). Summing exposures along all of the tracklines yields the total exposures for each species for the proposed actions for the two and six G airgun array configuration for the seismic survey activities and NMFS Permits Conservation Division's proposed issuance of an incidental harassment authorization and possible renewal.

Table 10. Densities of Endangered Species Act-listed marine mammals in the action area during National Science Foundation's low-energy and high-energy seismic survey in the Arctic Ocean and National Marine Fisheries Service Permits and Conservation Division's proposed issuance of an incidental harassment authorization and possible renewal.

Species	Density (Individuals per km^2)
Bowhead Whale	0.00012[1]
Bearded Seal – Beringia DPS	0.0332[2]
Ringed Seal – Arctic Subspecies	0.3760[2]

km^2=square kilometers, [1]=Schick et al. (2017), [2]=Kaschner (2004), and Kaschner et al. (2006)

Total Ensonified Area

Table 11. Relevant isopleths, trackline distance, ensonified area, percent increase, and total ensonified areas during the National Science Foundation's low-energy and high-energy seismic survey in the Arctic Ocean and National

Marine Fisheries Service Permits and Conservation Division's proposed issuance of an incidental harassment authorization and possible renewal.

Criteria (Depth)	Radius (km)	Diameter (km)	Trackline Distance (km)	Ensonified Area (km^2)	Ensonified Area with 25 Percent Increase (km^2)	Ensonified Area Adjusted for Overlap (km^2)	Ensonified Area Adjusted for Overlap with 25 Percent Increase (km^2)	Total Ensonified Areas for Exposure Calculations (No Overlap/Overlap) (km^2)
Source – Two G Airgun Array								
160 dB re: 1 μPa (rms) (100 to 1,000 m)	2.406	4.812	1,189	5,721.5	7,151.8	5,419	6,773.8	7,151.8 6,773.8
160 dB re: 1 μPa (rms) (>1,000 m)	1.604	3.208	3,981	12,771	15,963.8	10,256	12,820	15,963.8 12,820
Source – 6 G Airgun Array								
160 dB re: 1 μPa (rms) (100 to 1,000 m)	6.960	NA	NA	NA	NA	NA	NA	NA
160 dB re: 1 μPa (rms) (>1,000 m)	4.640	9.280	680	6,310	7,887.5	6,172	7,715	7,887.5 7,715
Source – 2 G Airgun Array								
PTS for LF Cetaceans – Bowhead Whale	0.0172	0.0344	5,170	177.8	222.25	154.3	192.9	222.25 192.9
PTS for Phocid Pinnipeds	0.0116	0.0232	5,170	119.9	149.93	104.1	130.1	149.93 130.1

Criteria (Depth)	Radius (km)	Diameter (km)	Trackline Distance (km)	Ensonified Area (km^2)	Ensonified Area with 25 Percent Increase (km^2)	Ensonified Area Adjusted for Overlap (km^2)	Ensonified Area Adjusted for Overlap with 25 Percent Increase (km^2)	Total Ensonified Areas for Exposure Calculations (No Overlap/Overlap) (km^2)
Source – 6 G Airgun Array								
PTS for LF Cetaceans – Bowhead Whale	0.0506	0.1012	680	68.82	86.02	68.8	86	86.02 86
PTS for Phocid Pinnipeds	0.0336	0.0672	680	45.70	57.12	45.7	57.1	57.12 57.1

km=kilometers, km^2=square kilometers, NA=not applicable, PTS=permanent threshold shift, LF=low frequency

Bowhead whales of all age classes are likely to be exposed during the proposed seismic survey activities. Given that the proposed low-energy and high-energy seismic survey will be conducted in summer, we expect that most animals will be on or migrating to/from their feeding grounds. Bowhead whales are expected to be feeding, traveling, or migrating in the action area and some females will have young-of-the-year accompanying them. These individuals can be exposed to the proposed seismic survey activities while they are transiting through the action area. We will normally assume that sex distribution is even for bowhead whales, Beringia DPS of bearded seals, and Arctic subspecies of ringed seals and sexes are exposed at a relatively equal level.

Calculated exposures of bowhead whales, Beringia DPS of bearded seals, and Arctic subspecies of ringed seals are likely to be overestimates. These three species are most common within 100 kilometers (54 nautical miles) of shore, whereas the low-energy and high-energy seismic survey will occur no closer than 300 kilometers (162 nautical miles) from shore, with most effort further north. Bearded seals are widely distributed throughout the summer and fall, following ice coverage northward, while juveniles remain near the coasts of the Chukchi and Bering seas (Burns 1967; Burns 1981; Cameron et al. 2018; Heptner et al. 1976; Nelson 1981) . During the summer months, ringed seals forage along ice edges or in open water areas of high productivity and have been observed in the northern Beaufort Sea (Freitas et al. 2008; Harwood et al. 2015; Harwood and Stirling 1992; Kelly et al. 2010b). This open water movement becomes limited with the onset of ice in the fall forcing the animals to move west and south as ice packs advance, dispersing the animals throughout the Chukchi and Bering seas, with only a portion remaining in the Beaufort Sea (Crawford et al. 2012; Frost and Lowry 1984; Harwood et al. 2012). Despite their prevalence in waters of the Arctic Ocean north of Alaska, we expect there to be a low

likelihood of encountering these three species of marine mammals in the action area of the seismic survey activities given the distance from shore.

Exposures as a Percentage of Population

Bowhead Whale

The estimated exposure of the regional population (approximately 16,820) of bowhead whales is a total of three, which is approximately 0.02 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 exposed given the mitigation and monitoring 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, it is more likely that there will be multiple exposures of a smaller number of individuals that will occur within the action area.

Bearded Seal – Beringia DPS

The estimated exposure of the regional population (approximately 125,000) of Beringia DPS of bearded seals is a total of 907, which is approximately 0.73 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 likely to be exposed given the mitigation and monitoring 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, it is more likely that there may be multiple exposures of a smaller number of individuals that will occur within the action area.

Ringed Seal – Arctic Subspecies

The estimated exposure of the regional population (approximately 171,418) of Arctic subspecies of ringed seals is a total of 10,268, which is approximately 5.99 percent of the regional population (Conn et al. 2014). For reasons previously described, this estimate is conservative, that is, it is likely higher than the actual exposures and a fewer number are likely to be exposed given the mitigation and monitoring 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, it is more likely that there may be multiple exposures 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 consultation. 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 (Section 2) of this consultation, 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.

During the proposed actions, ESA-listed marine mammals may be exposed to sound from the airgun array. 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 μPa (rms) for the airgun array sound sources, respectively. Our exposure estimates stem from the best available information on marine mammal densities and a predicted radial distance (Table 13 and Table 14) based on isopleths corresponding to harm and harassment thresholds along tracklines for the low-energy and high energy seismic survey. 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.

In consideration of the received sound levels in the nearfield, we expect the potential for ESA harm of low-frequency cetaceans (bowhead whales) and phocid pinnipeds (Beringia DPS of bearded seals and Arctic subspecies of ringed seals) to be de minimis, even before the likely moderating effects of aversion and/or other compensatory behaviors (e.g., Nachtigall et al. 2018) are considered. Based on the small anticipated isopleths for ESA harm and in consideration of the proposed mitigation and monitoring measures, take by ESA harm is not expected to occur and MMPA Level A harassment 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 threshold during the National Science Foundation's low-energy and high-energy seismic survey on the R/V *Sikuliaq* in the Arctic Ocean 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 R/V *Sikuliaq* 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.

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 that are likely to result in adverse effects to the animals.

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. Generally, the NMFS Permits and Conservation Division estimates "take" by considering:

1. Acoustic thresholds above which NMFS believes the best available science indicates marine mammals will be behaviorally harassed or incur some degree of permanent hearing impairment;
2. The area or volume of water that will be ensonified above these levels in a day;
3. The density or occurrence of marine mammals within these ensonified areas; and
4. The number of days of seismic survey activities.

They note that while these basic factors can contribute to a basic calculation to provide an initial prediction of "takes," additional information that can qualitatively inform "take" estimates is also sometimes available (e.g., previous monitoring results or average group size). We adopted the NMFS Permits and Conservation Division's analysis because, after our independent review, we determined it utilized the best available scientific information and methods to evaluate exposure to ESA-listed marine mammals. Below we describe the exposure analysis for ESA-listed marine mammals.

10.3.2.1 Acoustic Thresholds

To determine at what point during exposure to airgun arrays 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 at the following website: 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 μPa (rms) for 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 actions, 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 and high-energy seismic survey.

For physiological responses to active acoustic sources, such as TTS and PTS, the NMFS Permits and Conservation Division relied on NMFS' technical guidance for auditory injury of marine mammals (NOAA 2018). Unlike NMFS' 160 dB re: 1 μPa (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 12). 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 ESA harm 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 12) as auditory injury, and thus MMPA Level A harassment, and harm under the ESA. Any exposure below the threshold for the onset of PTS, but equal to or above the 160 dB re: 1 μPa (rms) acoustic threshold is classified as MMPA Level B harassment, which will also be considered ESA harassment. Among ESA harassment 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 12. 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 underwater (NOAA 2018).

Hearing Group	Generalized Hearing Range*	Permanent Threshold Shift Onset	Temporary Threshold Shift Onset
Low-Frequency Cetaceans (Baleen Whales) (LE,LF,24 hour)	7 Hertz to 35 kiloHertz	$L_{pk,flat}$: 219 dB $L_{E,LF,24h}$: 183 dB	213 dB peak SPL 168 dB SEL
Phocid Pinnipeds (True Seals) (LE,MF,24 Hour)	50 Hertz to 86 kiloHertz	$L_{pk,flat}$: 218 dB $L_{E,MF,24h}$: 185 dB	212 dB peak SPL 170 dB SEL

LE, X, 24 Hour=Frequency Sound Exposure Level (SEL) Cumulated over 24 Hour, LF=Low-Frequency, MF=Mid-Frequency
*Represents the generalized hearing range for the entire group as a composite (i.e., all species within the group), where individual species' hearing ranges are typically not as broad. Generalized hearing range 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 (Lpk) has a reference value of 1 μPa, and cumulative sound exposure level (LE) has a reference value of 1 $\mu Pa^2 s$. In this table, thresholds are abbreviated to reflect American National Standards Institute standards (ANSI 2013). However, peak sound pressure is defined by ANSI as incorporating frequency weighting, which is not the intent for this technical guidance. Hence, the subscript "flat" is being included to indicate peak sound pressure should be flat weighted or unweighted within the generalized hearing range. The subscript associated with cumulative sound exposure level thresholds indicates the designated marine mammal auditory weighting function and that the recommended accumulation period is 24 hours. The cumulative sound exposure level thresholds could be exceeded in a multitude of ways (i.e., varying exposure levels and durations, duty cycle). When possible, it is valuable for action proponents to indicate the conditions under which these acoustic thresholds will be exceeded.

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

10.3.2.2 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 and high-energy seismic survey at or above 160 dB re: 1 μPa (rms) based upon the information described above, and the acoustic thresholds correlating to the onset of PTS or TTS provided in Table 12. 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 ESA-defined harassment and harm 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 µPa (rms) zone, which corresponds to the ESA harassment threshold for ESA-listed marine mammals. The area estimated to be ensonified (within each depth category and functional hearing group) 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 R/V *Sikuliaq* (areas of overlap are removed). 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 L-DEO, 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 L-DEO, the National Science Foundation provided sound source levels of the airgun array and estimated distances for the 160 dB re: 1 µPa (rms) sound levels as well as ESA harm thresholds generated by the airgun array configurations and water depth. The predicted and modeled radial distances for the various ESA harm and harassment thresholds for marine mammals for the R/V *Sikuliaq*'s airgun arrays can be found in Table 13 and Table 14.

Table 13. Predicted radial distances in meters from the Research Vessel *Sikuliaq* seismic sound sources to isopleth corresponding to the harassment (160 dB re: 1 µPa [rms]) threshold.

Source	Volume (in^3)	Maximum Tow Depth (m)	Water Depth (m)	Predicted Distance to Threshold (160 dB re: 1 µPa [rms]) (m)[1]
2 (520 in^3) G Airguns	1,040	9	100 to 1,000	2,406
2 (520 in^3) G Airguns	1,040	9	Greater than 1,000	1,604
6 (520 in^3) G Airguns	3,120	9	100 to 1,000	6,960
6 (520 in^3) G Airguns	3,120	9	Greater than 1,000	4,640

in^3=cubic inches, m=meters, G=Generator, [1]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 14. Modeled radial distances in meters from the Research Vessel *Sikuliaq*'s two to six G airgun array corresponding to harm thresholds.

Functional Hearing Group	SEL_{cum} Threshold (dB)	Airgun Array Distance (m)	Peak SPL_{flat} Threshold (dB)	Airgun Array Distance (m)	Exclusion Zone for all Water Depths (m)
Source – 2 G Airgun Array					
Low Frequency Cetaceans (L_{pk} flat: 219 dB; LE,LF,24_h: 183 dB)	183	17.2	219	10.3	100
Phocid Pinnipeds (L_{pk} flat: 218 dB; LE,LF,24_h: 185 dB)	185	0.2	218	11.6	100
Source – 6 G Airgun Array					
Low Frequency Cetaceans (L_{pk} flat: 219 dB; LE,LF,24_h: 183 dB)	183	50.6	219	29.8	500
Phocid Pinnipeds (L_{pk} flat: 218 dB; LE,LF,24_h: 185 dB)	185	0.4	218	33.6	500

SELcum=x, dB=Decibel, GI=Generator Injector, m=meters, SPL=sound pressure level, LF=low frequency, h=hours, MF=mid-frequency

Note: The largest distances of the dual criteria (SEL_{cum} or Peak SPL_{flat}) were used to calculate takes and harm 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. 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.

10.3.2.3 Total Ensonified Area for Harm and Harassment

Table 15. Total ensonified areas (with 25 percent increase) for Endangered Species Act-listed marine mammals in the action area during National Science Foundation's low-energy and high-energy seismic survey in the Arctic Ocean and

National Marine Fisheries Service Permits and Conservation Division's proposed issuance of an incidental harassment authorization and possible renewal.

Species	Potential Harassment 160 dB re: 1 µPa (rms) Ensonified Area (km²) (Total)	Potential Harassment 160 dB re: 1 µPa (rms) Ensonified Area Adjusted for Overlap (km²) (Total)	Potential Permanent Threshold Shift Ensonified Area (km²) (Total)	Potential Permanent Threshold Shift Ensonified Area Adjusted for Overlap (km²) (Total)
Bowhead Whale	7,151.8 15,963.8 7,887.5 (Total=31,003.1)	6,773.8 12,820 7,715 (Total=27,308.8)	222.25 86.02 (Total=308.27)	192.9 86 (Total=278.9)
Bearded Seal – Beringia DPS	7,151.8 15,963.8 7,887.5 (Total=31,003.1)	6,773.8 12,820 7,715 (Total=27,308.8)	149.93 57.12 (Total=207.05)	130.1 57.1 (Total=187.1)
Ringed Seal – Arctic Subspecies	7,151.8 15,963.8 7,887.5 (Total=31,003.1)	6,773.8 12,820 7,715 (Total=27,308.8)	149.93 57.12 (Total=207.05)	130.1 57.1 (Total=187.1)

dB=decibel, rms=root mean square, km²=square kilometers

Table 16. Density, total ensonified areas adjusted for overlap, and calculated exposures during the National Science Foundation's low-energy and high-energy seismic survey in the Arctic Ocean and National Marine Fisheries Service Permits and Conservation Division's proposed issuance of an incidental harassment authorization and possible renewal.

Species	Density (Individuals per km2)	Potential Harassment 160 dB re: 1 µPa (rms) Total Ensonified Area (km²)	Potential Harassment 160 dB re: 1 µPa (rms) Calculated Exposures	Potential Permanent Threshold Shift Total Ensonified Area (km²)	Potential Permanent Threshold Shift Calculated Exposures
Bowhead Whale	0.00012	27,308.8	3.27	278.9	0.03
Bearded Seal – Beringia DPS	0.0332	27,308.8	906.65	187.1	6.21

Species	Density (Individuals per km2)	Potential Harassment 160 dB re: 1 μPa (rms) Total Ensonified Area (km^2)	Potential Harassment 160 dB re: 1 μPa (rms) Calculated Exposures	Potential Permanent Threshold Shift Total Ensonified Area (km^2)	Potential Permanent Threshold Shift Calculated Exposures
Ringed Seal – Arctic Subspecies	0.3760	27,308.8	10,268.1	187.1	70.35

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 arrays during the low-energy and high-energy seismic survey in the Arctic Ocean.

Species	Potential Permanent Threshold Shift	Potential Temporary Threshold Shift and Behavioral Harassment
Bowhead Whale	0	3
Bearded Seal – Beringia DPS	6	907
Ringed Seal – Arctic Subspecies	70	10,268

It should be noted that the proposed exposure numbers by ESA 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 or insufficient, and in recognition of the uncertainties in the density estimates used to estimate exposures as described above. This approach assumes that no marine mammals will move away or toward the trackline in response to increasing sound levels before they reach the threshold as the R/V *Sikuliaq* approaches. 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 ESA harm. 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. Also, the location of the seismic survey activities are far north in the Arctic Ocean and the density values used are conservative estimates of what is likely to be encountered during the seismic survey activities.

10.3.2.4 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 actions (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 3) (Southall 2007). For pinnipeds in water, data were limited to measurements of TTS in harbor seals (*Phoca vitulina*), an elephant seal (*Mirounga angustirostris*), and California sea lions (*Zalophus californianus*) (Kastak et al. 1999; Kastelein et al. 2012). Phocid pinnipeds (true seals) have an estimated functional hearing range of 50 Hertz to 86 kiloHertz. Otariid pinnipeds (sea lions and fur seals), like Guadalupe fur seals (*Arctocephalus townsendi*), have an estimated functional hearing range of 60 Hertz to 39 kiloHertz.

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 μPa (rms) in order to produce a low-level TTS from a single pulse (Southall et al. 2007c). Permanent threshold shift 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 R/V *Sikuliaq*'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 μPa (peak) (Caldwell

and Dragoset 2000a). If an individual experienced exposure to several airgun pulses of approximately 219 dB for low-frequency cetaceans and 218 dB for phocid pinnipeds, PTS could occur. Marine mammals (cetaceans and pinnipeds) will have to be within certain modeled radial distances specified in Table 13 and Table 14 from the R/V *Sikuliaq*'s two to six G airgun array to be within the ESA harm to be within the threshold isopleth and risk a PTS and within the ESA harassment to be within the threshold isopleth and risk behavioral responses.

Research and observations show pinnipeds in the water are tolerant of anthropogenic noise and activity. If Beringia DPS of bearded seals and Arctic subspecies of ringed seals are exposed to active acoustic sources they may react in a number of ways depending on their experience with the sound source and what activity they are engaged in at the time of the acoustic exposure. Beringia DPS of bearded seals and Arctic subspecies of ringed seals may not react at all until the sound source is approaching within a few hundred meters and then may alert, approach, ignore the stimulus, change their behaviors, or avoid the immediate area by swimming away or diving (Finneran et al. 2003b; Götz and Janik 2011; Kvadsheim et al. 2010). Significant behavioral reactions would not be expected in most cases, and long-term consequences for individuals or the population are unlikely.

As stated earlier in Section 10.3.1, only ESA harassment in the form of TTS and/or behavioral harassment of ESA-listed cetaceans and pinnipeds is expected to occur during the proposed low-energy and high-energy seismic survey. Behavioral reactions will be short-term, likely lasting the duration of the exposure, and long-term consequences for individuals or populations are unlikely. Take in the form of ESA harm (i.e., PTS) is not expected (see Section 10.3.1).

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 or PTS, 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 or PTS. 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) or 500 meter (1,640.4 feet) exclusion zones during two or six G airgun array operations, respectively, 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* section, each individual is expected to be potentially be exposed to 160 dB re: 1 μPa (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 or PTS.

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).

There is sound frequency overlap of airgun array sounds and vocalizations of ESA-listed marine mammals, particularly baleen whales and to some extent pinnipeds overlaps to an extent. The proposed low-energy and high-energy seismic survey could mask baleen whale and pinniped 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 (Evans 1998; NMFS 2006h). 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 R/V *Sikuliaq* are planned to occur over the course of approximately 45 days (i.e., approximately 30 days of airgun array operations, approximately seven days of equipment deployment and recovery, and approximately eight days of transit).

Given the disparity between pinniped communication-related sounds with the dominant frequencies for seismic surveys, masking is not likely to be significant for Beringia DPS of bearded seals and Arctic subspecies of ringed seals (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 R/V *Sikuliaq*'s airgun array will emit an approximately 0.1 second pulse when fired approximately every 15 seconds for the low-energy seismic survey and approximately every 60 seconds for the high-energy seismic survey. 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 sound from the airgun array 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 detectible 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 as 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. 1995c). 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 consultation. This masking is expected to be more prominent for baleen whales, including bowhead whales, given the lower frequencies at which they hear best and produce calls. For pinnipeds (e.g., bearded seals and ringed seals), which hear best at frequencies above the predominant ones produced by airguns, may have adaptations to allow them to reduce the effects of masking on higher frequency sounds. As such, pinnipeds are not expected to experience significant masking during the period of time the airgun arrays are producing sound for the proposed actions.

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 consultation directly, additional studies to other related whales (such as gray, North Atlantic right, and sperm 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 and request for comments and possible renewal (86 FR 28787) 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. 1995; Nieukirk et al. 2004; Richardson et al. 1986a; Smultea 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. 1995). 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 μPa (rms) (Wilcock et al. 2014). Blue whales may also attempt to compensate for elevated ambient sound by calling more frequently during seismic surveys (Iorio and Clark 2009). Bowhead whale calling rates were found to decrease during migration in the Beaufort Sea when seismic surveys were being conducted (Nations et al. 2009). Calling rates decreased when exposed to seismic airguns at estimated received levels of 116 to 129 dB re: 1 μPa (rms), but did not change at received levels of 99 to 108 dB re: 1 μPa (rms) (Blackwell et al. 2013). A more recent study examining cumulative sound exposure found that bowhead whales began to increase call rates as soon as airgun sounds were detectable, but this increase leveled off at approximate 94 dB re: 1 μPa^2-s over the course of ten minutes (Blackwell et al. 2015). Once sound levels exceeded approximately 127 dB re: 1 μPa^2-s over ten minutes, call rates began to decline and at approximately 160 dB re: 1 μPa^2-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 μPa (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 R/V *Sikuliaq*'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 R/V *Sikuliaq*'s airgun array during the course of the proposed low-energy and high-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 μPa (rms) (the level used in this consultation 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. 1995c). 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. 1995d; Richardson et al. 1995c; Richardson et al. 1999). Migrating bowhead whales show strong avoidance reactions to received 120 to 130 dB re: 1 μPa (rms) exposures at distances of 20 to 30 kilometers (10.8 to 16.2 nautical miles), but only changed dive and respiratory patterns while feeding and showed avoidance at higher received sound levels (152 to 178 dB re: 1 μPa [rms]) (Harris et al. 2007; Ljungblad et al. 1988; Miller et al. 1999; Miller et al. 2005; Richardson et al. 1995d; Richardson et al. 1995c; 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 as those 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 surveys as described for bowhead whales. Gray whales discontinued feeding and/or moved away at received sound levels of 163 dB re: 1 μPa (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 μPa (rms) and slight behavioral changes at 140 to 160 re: 1 μPa (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 actions, we expect some of the ESA-listed marine mammal species considered in this consultation 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 μPa (rms) when females with calves were present, or 7 to 12 kilometers (3.8 to 6.5 nautical miles) from the acoustic source (McCauley et al. 2000a; McCauley et al. 1998). A startle response occurred as low as 112 dB re: 1 μPa (rms). Closest approaches were generally limited to 3 to 4 kilometers (1.6 to 2.2 nautical miles), although some individuals (mainly males) approached to within 100 meters (328.1 feet) on occasion where sound levels were 179 dB re: 1 μPa (rms). Changes in course and speed generally occurred at estimated received levels of 157 to 164 dB re: 1 μPa (rms). Similarly, on the east coast of Australia, migrating humpback whales appear to avoid seismic airguns at distances of 3 kilometers (1.6 nautical miles) at levels of 140 dB re: 1 μPa^2-second. A recent study examining the response of migrating humpback whales to a full 51,291.5 cubic centimeters (3,130 cubic inch) airgun array found that humpback whales exhibited no abnormal behaviors in response to the active airgun array, and while there were detectible changes in respiration and diving, these were similar to those observed when baseline groups (i.e., not exposed to active sound sources) were joined by another humpback whale (Dunlop et al. 2017). While some humpback whales were also found to reduce their speed and change course along their migratory route, overall these results suggest that the behavioral responses exhibited by humpback whales are unlikely to have significant biological consequences for fitness (Dunlop et al. 2017). Feeding humpback whales appear to be somewhat more tolerant. Humpback whales off the coast of Alaska startled at 150 to 169 dB re: 1 μPa (rms) and no clear evidence of avoidance was apparent at received levels up to 172 dB re: 1 μPa (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 2005a). When spotted at the average sighting distance, individuals will have likely been exposed to approximately 169 dB re: 1 μPa (rms) (Moulton and Miller 2005b).

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 2005a; 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 μPa 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 μPa. Other anthropogenic sounds, such as pingers and sonars, disrupt behavior and vocal patterns (Goold 1999; Watkins et al. 1985; Watkins and Schevill 1975). 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. 1995c). 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 μPa lower at 1 kiloHertz and 60 dB re: 1 μPa 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 2010).

Similar to other marine mammal species, behavioral responses of pinnipeds can range from a mild orienting response, or a shifting attention, to flight and panic. They may react in a number of ways depending on their experience with the sound source that what activity they are engaged in at the time of exposure. For example, different responses displayed by captive and wild phocid seals to sound judged to be ‘unpleasant’ have been reported; where captive seals habituated (did not avoid the sound), and wild seals showed avoidance behavior (Götz and Janik 2011). Captive seals received food (reinforcement) during sound playback, while wild seals were exposed opportunistically. These results indicate that motivational state (e.g., reinforcement via food acquisition) can be a factor in whether or not an animal habituates to novel or unpleasant sounds. Captive studies with other pinnipeds have shown a reduction in dive times when presented with qualitatively ‘unpleasant’ sounds. These studies indicated that the subjective interpretation of the unpleasantness of a sound, minus the more commonly studies factors of received sound level and sounds associated with biological significance, can affect diving behavior (Götz and Janik 2011). More recently, a controlled-exposure study was conducted with U.S. Navy California sea lions at the Navy Marine Mammal Program facility specifically to study behavioral reactions (Houser et al. 2013). Animals were trained to swim across a pen, touch a panel, and return to the starting location. During transit, a simulated mid-frequency sonar signal was played. Behavioral reactions included increased respiration rates, prolonged submergence, and refusal to participate, among others. Younger animals were more likely to respond than older animals, while some sea lions did not respond consistently at any level.

Kvadsheim et al. (2010) found that captive hooded seal (*Cystophora cristata*) reacted to 1 to 7 kiloHertz sonar signals by moving to the areas of last sound pressure level, at levels between 160 and 170 dB re: 1 µPa. Finneran et al. (2003a) found that trained captive sea lions showed avoidance behavior in response to impulsive sounds at levels above 165 to 170 dB re: 1 µPa (rms). These studies are in contrast to the results of Costa (1993) which found that free ranging elephant seals showed no change in diving behavior when exposed to very low frequency sounds (55 to 95 Hertz) at levels up to 137 dB re: 1 µPa (though the received level in this study were much lower (Costa et al. 2003). Similar to behavioral responses of mysticetes and odontocetes, potential behavioral responses of pinnipeds to the proposed seismic survey activities are not expected to impact the fitness of any individual animals as the responses are not likely to adversely affect the ability of the animals to forage, detect predators, select a mate, or reproduce successfully. As noted in Southall et al. (2007a) , a substantive behavioral reactions to noise exposure (such as disruption of critical life functions, displacement, or avoidance of important habitat) are considered more likely to be significant if they last more than 24 hours, or recur on subsequent days. Behavioral reactions are not expected to last more than 24 hours or recur on subsequent days such that an animal’s fitness could be impacted. That we do not expect fitness consequences to bowhead whales, Beringia DPS of bearded seals, and Arctic subspecies of ringed seals is further supported by U.S. Navy monitoring of Navy-wide activities since 2006 which has documented hundreds of thousands of marine mammals on training and testing range complexes and there are only two instances of overt behavioral change that have been observed

and there have been no demonstrable instances of injury to marine mammals as a result of non-impulsive acoustic sources such as low-frequency active sonar. Because we do not expect any fitness consequences from any individual animals to result from instances of behavioral response, we do not expect any population level effects from these behavioral responses.

Pinnipeds are not likely to show a strong avoidance reaction to the airgun array sources proposed for use. Visual monitoring from seismic survey vessels has shown only slight (if any) avoidance of airgun arrays by pinnipeds and only slight (if any) changes in behavior. Monitoring work in the Alaskan Beaufort Sea during 1996 through 2001 provided considerable information regarding the behavior of Arctic ice seals exposed to seismic pulses (Harris et al. 2001; Moulton and Lawson 2002). These seismic survey projects usually involved airgun arrays of six to 16 airguns with total volumes of 9,176.8 to 24,580.6 cubic centimeters (560 to 1,500 cubic inches). The combined results suggest that some seals avoid the immediate area around seismic survey vessels. In most survey years, ringed seal sightings tended to be farther away from the seismic survey vessel when the airgun arrays were operating than when they were not (Moulton and Lawson 2002). However, these avoidance movements were relatively small, approximately 100 meters (328.1 feet) to a few hundred of meters, and many seals remained within 100 to 200 meters (328.1 to 656.2 feet) of the trackline as the operating airgun array passed by the animals. Seal sighting rates at the water surface were lower during airgun array operations than during no-airgun periods in each survey year except 1997. Similarly, seals are often very tolerant of pulsed sounds from seal-scaring devices (Jefferson and Curry 1994; Mate and Harvey 1987; Richardson et al. 1995a). However, initial telemetry work suggests that avoidance and other behavioral reactions by two other species of seals to small airgun array sources may at times be stronger than evident to date from visual studies of pinniped reactions to airguns (Thompson et al. 1998).

Elephant seals are unlikely to be affected by short-term variations in prey availability (Costa 1993), as cited in New et al. (2014). We expect the Beringia DPS of bearded seals and Arctic subspecies or ringed seals considered in this consultation to be similarly unaffected. We have no information to suggest animals eliciting a behavioral response (e.g., temporary disruption of feeding) from exposure to the proposed seismic survey activities will be unable to compensate for this temporary disruption in feeding activity by either immediately feeding at another location, by feeding shortly after cessation of acoustic exposure, or by feeding later.

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 (i.e., bowhead whales) are expected to mostly exhibit avoidance behavior, and may also alter their vocalizations. Pinnipeds (i.e., Beringia DPS of bearded seals and Arctic subspecies of ringed seals) are expected to exhibit avoidance and behavioral changes. These responses are expected to be temporary with behavior returning to a baseline state shortly after the sound source becomes inactive or leaves the area.

Marine Mammals and Physical or Physiological Effects

Individual whales exposed to airguns (as well as other sound sources) could experience effects that are 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. Therefore, 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. 2003; Costantini et al. 2011; Dickens et al. 2010; Dierauf and Gulland 2001; Elftman et al. 2007; Fonfara et al. 2007; Kaufman and Kaufman 1994; Mancia 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; Herraez 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 μPa at 1 meter peak-to-peak) and single pure tones (up to 201 dB re: 1 μPa) had increases in stress chemicals, including catecholamines, which could affect an individual's ability to fight off disease. During the time following September 11, 2001, shipping

traffic and associated ocean noise decreased along the northeastern U.S. This decrease in ocean sound was associated with a significant decline in fecal stress hormones in North Atlantic right whales, providing evidence that chronic exposure to increased noise levels, although not acutely injurious, can produce stress (Rolland et al. 2012a; Rolland et al. 2012b). These levels returned to baseline after 24 hours of vessel 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 160 dB re: 1 μPa (rms) threshold, will experience a stress response, which may also be associated with an overt behavioral response. However, since in all cases 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* section). Nonetheless, seismic survey activities can potentially lead cetaceans and pinnipeds 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 actions will take place over approximately 45 days (approximately 30 days of airgun array operations, approximately seven days of equipment deployment and recovery, and approximately eight 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 and high-energy seismic survey. The low-energy and high-energy seismic survey will take place in the Arctic Ocean, and the closest approach to the coastline of Alaska will be at least approximately 300 kilometers (162 nautical miles) for the low-energy seismic survey and at least approximately 530 kilometers (286.2 nautical miles) for the high-energy seismic survey from land. 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.

Responses of Marine Mammal Prey

Seismic surveys may also have indirect, adverse effects on ESA-listed marine mammals by affecting their prey availability (including larval stages) through lethal or sub-lethal damage, stress responses, or alterations in their behavior or distribution. Such prey includes fishes, zooplankton, cephalopods, and other invertebrates such as crustaceans, molluscs, and jellyfish. Studies described herein provide extensive support for this, which is the basis for later discussion on implications for ESA-listed marine mammals. In a fairly exhaustive review, Carroll et al. (2017) summarized the available information on the impacts seismic surveys have on fishes and invertebrates. In many cases, species-specific information on the prey of ESA-listed marine mammals is not generally available. Until more specific information is available, we expect that prey (e.g., teleosts, zooplankton, cephalopods) of ESA-listed marine mammals considered in this consultation will react in manners similar to those fish and invertebrates described herein.

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.

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 others 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.

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).

Additionally, the majority of copepod prey available to baleen whales or fishes which are prey to these marine mammals, are expected to be near the water's surface (Witherington et al. 2012), results of McCauley et al. (2017) provide little information on the effects to copepods at the water 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 actions will be towed at depths of one to four meters (3.3 to 13.1 feet), we expect that sounds from airgun array will be relatively low at the water 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 and high-energy seismic survey may temporarily alter copepod or crustacean abundance in the action area, we expect such effects to be insignificant because most copepods will be near the water 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 marine mammals. 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 μPa) at close distances, with some cases of injury (Booman et al. 1996; McCauley et al. 2003). Effects from TTS were not found in whitefish at received levels of approximately 175 dB re: 1 μPa^2-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 μPa 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 μPa (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 μPa 0-to-peak and alarm responses at greater than 177 dB re: 1 μPa 0-to-peak (Pearson et al. 1992). Fish also tightened schools and shifted their distribution downward. Normal position and behavior resumed 20 to 60 minutes after firing of the airgun ceased. A downward shift was also noted by Skalski et al. (1992) at received seismic sounds of 186 to 191 dB re: 1 μPa 0-to-peak. Caged European sea bass (*Dichentrarchus labrax*) showed elevated stress levels when exposed to airguns, but levels returned to normal after three days (Skalski 1992). These fish also showed a startle response when the seismic survey vessel was as much as 2.5 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 μPa 0-to-peak sound from airguns, but habituated to the sound after one hour and returned to normal depth (sound environments of 185 to 192 dB re: 1 μPa) despite airgun activity (Chapman and Hawkins 1969). Whiting may also flee from sounds from airguns (Dalen and Knutsen 1986). Hake (*Merluccius* spp.) may re-distribute downward (La Bella et al. 1996). Lesser sand eels (*Ammodytes tobianus*) exhibited initial startle responses and upward vertical movements before fleeing from the seismic survey area upon approach of a vessel with an active source (Hassel et al. 2003; Hassel et al. 2004).

McCauley et al. (2000; 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 μPa (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 μPa 0-to-peak, but did exhibit continual startle responses and fled from the acoustic source when visible (Wardle et al. 2001). Blue whiting (*Micromesistius poutassou*) and mesopelagic fishes were found to re-distribute 20 to 50 meters (65.6 to 164 feet) deeper in response to airgun ensonification and a shift away from the seismic survey area was also found (Slotte et al. 2004). Startle responses were infrequently observed from salmonids receiving 142 to 186 dB re: 1 μPa peak-to-peak sound levels from an airgun (Thomsen 2002). Cod (*Gadus* spp.) and haddock (*Melanogrammus aeglefinus*) likely vacate seismic survey areas in response to airgun activity and estimated catchability decreased starting at received sound levels of 160 to 180 dB re: 1 μPa 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 Lokkeborg 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 μPa 0-to-peak (Turnpenny and Nedwell 1994). Similarly, European sea bass apparently did not leave their inshore habitat during a four to five month seismic survey (Pickett et al. 1994). La Bella et al. (1996) found no differences in trawl catch data before and after seismic survey activities and echosurveys of fish occurrence did not reveal differences in pelagic biomass. However, fish kept in cages did show behavioral responses to approaching operating airguns.

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 μPa (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 μPa (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 ±5 dB re: 1 μPa. They reported lesions to the sensory hair cells of the statocysts of the exposed animals that increased in severity with time, suggesting that cephalopods are particularly sensitive to low-frequency sound. The received sound pressure level was 157 ±5 dB re: 1 μPa, with peak levels at 175 dB re: 1 μPa. Guerra et al. (2004) suggested that giant squid mortalities were associated with seismic surveys based upon coincidence of carcasses with the seismic surveys in time and space, as well as

pathological information from the carcasses. Another laboratory 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 μPa (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. Therefore, we do not expect any adverse effects from lack of prey availability to baleen whales (i.e., bowhead whales). Bearded seals and ringed seals regularly feed on fishes and marine invertebrates 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 μPa (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.

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 effects of the proposed seismic survey activities in space and time. We further consider these long-term, aggregate effects in our *Risk Analysis* section.

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 three bowhead whales, 907 Beringia DPS of bearded seals, and 10,268 Arctic subspecies of ringed seals (see Table 17), to be exposed to acoustic noise from the airgun array within 160 dB re: 1 μPa (rms) ensonified areas during the seismic survey activities.

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 required mitigation and monitoring measures in the NMFS Permits and Conservation Division's proposed incidental harassment authorization, and the nature of the seismic survey activities (low-energy and high-energy airgun array and reduced zones of ensonification), as described above, we do not expect adverse effects to result in any injury or mortality to ESA-listed species from the exposure to the acoustic sources resulting from the proposed actions. As described above, the proposed actions will result in temporary effects, largely behavioral responses (e.g., avoidance, discomfort, loss of foraging opportunities, loss of mating opportunities, masking, alteration of vocalizations, and stress) but with some potential for TTS, to the exposed marine mammals (bowhead whales, Beringia DPS of bearded seal, and Arctic subspecies of ringed seal). Harassment is not expected to have more than short-term effects on individual ESA-listed marine mammal species (bowhead whales, Beringia DPS of bearded seals, and Arctic subspecies of ringed seal). Harm under the ESA is not expected to occur with high probability given the mitigation and monitoring measures (e.g., proposed exclusion and buffer zones, shut-down procedures, pre-clearance and ramp-up procedures, vessel-based visual monitoring by NMFS-approved protected species observers, and vessel strike avoidance measures) in place for the proposed seismic survey activities to protect ESA-listed species.

Given that individual bowhead whales, Beringia DPS of bearded seals, and Arctic subspecies of ringed seals may experience temporary behavioral responses from the proposed seismic survey activities and those exposures are a small percentage of the regional population (0.02 percent of bowhead whales, 0.73 percent of Beringia DPS of bearded seals, and 5.99 percent of Arctic subspecies of ringed seals), we do not expect any population level effects. These estimates are conservative, that is, it is likely higher than the actual exposures and a fewer number are likely to

be harassed given the mitigation and monitoring measures that will be implemented. Because of the large range of bowhead whales, Beringia DPS of ringed seals, and Arctic subspecies of ringed seals compared to the relatively small size of the action area, combined with the relatively short duration of the seismic survey activities, it is likely that there may be multiple exposures of a small number of individuals in the action area. Also, the calculated exposures of bowhead whales, Beringia DPS of ringed seals, and Arctic subspecies of ringed seals are likely to be overestimates given their distribution during summer months and we expect there to be low likelihood of encountering these three species of marine mammals in the action area during seismic survey activities given the distance from shore. As such, we believe the fitness consequences (temporary behavioral responses [e.g., avoidance, discomfort, loss of foraging opportunities, loss of mating opportunities, masking, alteration of vocalizations, and stress] and some potential for TTS) to ESA-listed marine mammals exposed to the sounds sources from the low-energy and high-energy seismic survey will have a minimal effect on the populations those individuals represent or the species those populations comprise. No proposed critical habitat for these species will be adversely affected by the seismic survey activities associated with the proposed actions (Section 7.4).

11 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 (Section 9) will continue to impact ESA-listed resources into the foreseeable future. We expect climate change, targeted hunts (whaling, sealing, and subsistence harvesting), vessel interactions (vessel strikes and whale watching), fisheries (fisheries interactions), pollution (marine debris, pesticides and contaminants, authorized discharge, and hydrocarbons), anthropogenic sound (vessel sound and commercial shipping, aircraft, seismic surveys, exploration, drilling and production, marine construction, and military activities), 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 consultation.

12 Integration and Synthesis

The *Integration and Synthesis* section is the final step in our assessment of the risk posed to species and their designated critical habitat as a result of implementing the proposed actions. In this section, we add the *Effects of the Action* section (Section 10) to the *Environmental Baseline* section (Section 9) and the *Cumulative Effects* section (Section 11) to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) reduce appreciably the likelihood of both the survival and recovery of a ESA-listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) reduce the value of proposed or designated critical habitat for the conservation of the species. These assessments are made in full consideration of the *Species and Critical Habitat Not Likely to be Adversely Affected* section (Section 7), *Species Likely to be Adversely Affected* section (Section 8), and *Status of the Species Likely to be Adversely Affected* section (Section 8.1).

Some ESA-listed species and proposed critical habitat are located within the action area but are not expected to be adversely affected by the proposed actions, or the effects of the proposed actions on these ESA-listed species and proposed critical habitat were determined to be insignificant or discountable. Some seismic survey activities evaluated individually were determined to have insignificant or discountable effects and thus to be not likely to adversely affect some ESA-listed species and proposed critical habitats (Section 7).

The following discussions separately summarize the probable risks the proposed actions pose to threatened and endangered species that are likely to be exposed (and be adversely affected) 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 consultation.

12.1 Jeopardy Analysis

The jeopardy analysis relies upon the regulatory definition of "to jeopardize the continued existence of a listed species," which is "to engage in an action that would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species" (50 C.F.R. §402.02). Therefore, the jeopardy analysis considers both the survival and recovery of the species.

Based on our effect analysis, adverse effect to ESA-listed species are likely to result from the proposed actions. The following discussions summarize the probably risks that seismic survey activities pose to ESA-listed species that are likely to be exposed over the approximately 30 days of seismic survey activities. These summaries integrate our exposure, response, and risk analyses from the *Effects of the Actions* section (Section 10).

12.2 Bowhead Whale

Adult and juvenile bowhead whales are present in the action area and are expected to be exposed to noise from the seismic survey activities. The severity of an animal's response to noise associated with the low-energy and high-energy seismic survey will depend on the duration and severity of exposure.

The bowhead whale is endangered as a result of past commercial whaling. Prior to commercial whaling, thousands of bowhead whales existed. Global abundance declined to 3,000 by the 1920's. Bowhead whales may be killed under "aboriginal subsistence whaling" provisions of the International Whaling Commission. Additional threats include vessel strikes, fisheries interactions (including entanglement), contaminants, and noise. The species' overall large population size and increasing trends indicated that it is resilient to current threats.

The global, pre-exploitation estimate for bowhead whales is 30,000 to 50,000 animals. There are currently four or five recognized stocks of bowhead whales, the Western Arctic (or Bering-Chukchi-Beaufort) stock (found in waters around Alaska), the Okhotsk Sea stock (found in eastern Russia waters), the Davis Strait and Hudson Bay stock (sometimes considered separate stocks) (found in northeastern waters near Canada), and the Spitsbergen stock (found in the northeastern Atlantic Ocean) (Rugh and Shelden 2009). The only stock thought to be found within U.S. waters is the Western Arctic stock. The 2011 ice-based abundance estimate puts this stock, the largest remnant stock, at over 16,892 (N_{min}=16,091) individuals (Givens et al. 2013). Prior to commercial whaling, there may have been 10,000 to 23,000 whales in this stock (Rugh and Shelden 2009). Historically the Davis Strait and Hudson Bay stock may have contained over 11,000 individuals, but now it is thought to number around 7,000 bowhead whales (Cosens et al. 2006). In the Okhotsk Sea, there were originally more than 3,000 bowhead whales, but now there are only about 200 (Cooke and Reeves 2018). The Spitsbergen stock originally had about 24,000 bowhead whales and supported a huge European fishery, but today is thought to only contain hundreds of individuals (Cooke and Reeves 2018).

Current estimates indicate approximately 16,892 (N_{min}=16,091) bowhead whales in the Western Arctic stock, with an annual growth rate of 3.7 percent (Givens et al. 2013). While not quantitative estimates exist, the Davis Strait and Hudson Bay stock is also thought to be increasing (COSEWIC 2009). We could find no information on population trends for the Okhotsk Sea stock. Likewise, no information is available on the population trend for the Spitsbergen stock, but it is thought to be nearly extinct.

No reduction in the distribution of bowhead whales from the Arctic Ocean or changes to the geographic range of the species are expected because of the National Science Foundation's seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization and possible renewal.

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. Non-lethal take of three individuals,

adults and juveniles, is expected as a result of the proposed seismic survey activities. We anticipate temporary behavioral responses (e.g., avoidance, discomfort, loss of foraging opportunities, loss of mating opportunities, masking, alteration of vocalizations, and stress) with some potential for TTS, with individuals returning to normal shortly after the exposure has ended, and thus do not anticipate any delay in reproduction as a result. Because we do not anticipate a reduction in numbers or reproduction of bowhead whales as a result of the proposed seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization and possible renewal, a reduction in the species' likelihood of survival is not expected.

NMFS has not prepared a Recovery Plan for the bowhead whale.

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

12.3 Bearded Seal – Beringia Distinct Population Segment

Adult and juvenile Beringia DPS of bearded seals are present in the action area and are expected to be exposed to noise from the seismic survey activities. The severity of an animal's response to noise associated with the low-energy and high-energy seismic survey will depend on the duration and severity of exposure.

The Beringia DPS of bearded seal has a large, apparently stable population size, which makes it resilient to immediate perturbations. It is however, threatened by future climate change, specifically the loss of essential sea ice and change in prey availability, and as a result, is likely to become endangered in the future. Bearded seals are an important species for Alaska Native subsistence hunters; the most recent estimate of annual statewide harvest is from 2000 and was 6,788 animals (Allen and Angliss 2011). The current level of subsistence harvest is not known and there are no efforts to quantify statewide harvest numbers. Additional threats to the species include disturbance from vessels, sound from seismic exploration, and oil spills.

The estimated population size of the Beringia DPS of bearded seal is 155,000 individuals (77 FR 77496, December 28, 2012). There is substantial uncertainty around this estimate, however, and population trends for the Beringia DPS of bearded seal are unknown. An estimate of bearded seals in the western Bering Sea (63,200; 95 percent CI 38,400 to 138,600) from 2003 through 2008 appears to be similar in magnitude to an estimate from 1974 through 1987 (57,000 to 87,000) (Cameron et al. 2010). Population trends are not available for the Beringia DPS of bearded seal (Muto 2016). Bearded seals are boreoarctic with a circumpolar distribution and are closely associated with the sea ice; however, some remain near the coasts during the summer and

early fall. Beringia DPS of bearded seals are found in the continual shelf waters throughout the Eastern Siberian, Chukchi, and Beaufort seas.

No reduction in the distribution of Beringia DPS of bearded seal from the Arctic Ocean or changes to the geographic range of the species are expected because of the National Science Foundation's seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization and possible renewal.

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. Non-lethal take of 907 individuals, adults and juveniles, is expected as a result of the proposed seismic survey activities. We anticipate temporary behavioral responses (e.g., avoidance, discomfort, loss of foraging opportunities, loss of mating opportunities, masking, alteration of vocalizations, and stress) with some potential for TTS, with individuals returning to normal shortly after the exposure has ended, and thus do not anticipate any delay in reproduction as a result. Because we do not anticipate a reduction in numbers or reproduction of Beringia DPS of bearded seals as a result of the proposed seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization and possible renewal, a reduction in the species' likelihood of survival is not expected.

NMFS has not prepared a Recovery Plan for the Beringia DPS of bearded seal.

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

12.4 Ringed Seal – Arctic Subspecies

Adult and juvenile Arctic subspecies of ringed seals are present in the action area and are expected to be exposed to noise from the seismic survey activities. The severity of an animal's response to noise associated with the low-energy and high-energy seismic survey will depend on the duration and severity of exposure.

The Arctic subspecies of ringed seal is threatened due to climate change especially from the expected loss of sea ice and snow cover in the foreseeable future (77 FR 76706, December 28, 2012). Ringed seals are an important species for Alaska Native subsistence hunters. The most recent estimate of annual statewide harvest is from 2000 and was 9,567 ringed seals (Allen and Angliss 2010). The current level of subsistence harvest is not known and there are no efforts to quantify statewide harvest numbers. Additional threats to the species include fisheries interactions (including entanglement), disturbance from vessels, sound from seismic exploration, and oil spills.

The Arctic subspecies of ringed seal has a seemingly large population (approximately 171,418 animals in the regional population), making it resilient to immediate perturbations (Conn et al. 2014). However, threatened by climate change in the long-term, the species is likely to become endangered in the future.

No reduction in the distribution of Arctic subspecies of ringed seals from the Arctic Ocean or changes to the geographic range of the species are expected because of the National Science Foundation's seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization and possible renewal.

No reliable population estimates for the entire Arctic subspecies of ringed seal population due to the species' widespread distribution across geopolitical boundaries. In the status review of the ringed seal, the population was estimated at approximately 2,000,000 individuals; however, NMFS considers this a crude estimate, as it relies on outdated data collected in a variety of ways and does not include all areas of its range (Kelly et al. 2010a). In the status review, the population of ringed seals in Alaska waters of the Chukchi and Beaufort seas was estimated to be at least 300,000 individuals. This is most likely an underestimate of the true abundance because surveys in the Beaufort Sea were limited to within 40 kilometers (21.6 nautical miles) of the shore (Kelly et al. 2010b).

Due to insufficient data, population trends for the Arctic subspecies of ringed seal cannot be calculated. It is unknown if the population is stable or fluctuating. The genetic population structure of the Arctic subspecies of ringed seal is poorly understood. It is likely that population structuring exists in the species, but the extent to which it occurs is unknown.

Arctic subspecies of ringed seals are widely distributed throughout the Arctic Ocean, in waters of Russia, Canada, Greenland, Finland, and the U.S. In the U.S. waters, Arctic subspecies of ringed seals are found around Alaska in the Bering, Chukchi, and Beaufort seas. Most ringed seals move seasonally, following the extent of the sea ice.

No reduction in numbers is anticipated as part of the proposed actions because we do not expect mortality of animals and only harassment. Therefore, no reduction in reproduction is expected as a result of the proposed actions. Non-lethal take of 10,268 individuals, adults and juveniles, is expected as a result of the proposed seismic survey activities. We anticipate temporary behavioral responses (e.g., avoidance, discomfort, loss of foraging opportunities, loss of mating opportunities, masking, alteration of vocalizations, and stress) with some potential for TTS, with individuals returning to normal shortly after the exposure has ended, and thus do not anticipate any delay in reproduction as a result. Because we do not anticipate a reduction in numbers or reproduction of Arctic subspecies of ringed seals as a result of the proposed seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization and possible renewal, a reduction in the species' likelihood of survival is not expected.

NMFS has not prepared a Recovery Plan for the Arctic subspecies of ringed seal.

Because no mortalities or effects on the abundance, distribution, and reproduction of Arctic subspecies of ringed seal populations are expected as a result of the proposed actions, we do not anticipate the proposed seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization and possible renewal will impede the recovery for Arctic subspecies of ringed seals. In conclusion, we believe the non-lethal effects of take associated with the proposed actions are not expected to cause a reduction in the likelihood of survival and recovery of Arctic subspecies of ringed seals in the wild.

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 bowhead whale, Beringia DPS of bearded seal, and Arctic subspecies of ringed seal.

14 Incidental Take Statement

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of threatened and endangered 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).

Section 9 take prohibitions do not apply to threatened species. This incidental take statement, however, includes limits on taking of threatened species since those numbers were analyzed in the jeopardy analysis and to provide guidance to the action agency on its requirement to reinitiate consultation if the take limit for any species covered by this opinion is exceeded. The ESA does not prohibit the take of threatened species unless special regulations have been promulgated, pursuant to section 4(d), to promote the conservation of the species. ESA section 4(d) rules have not been promulgated for Beringia DPS of bearded seals and Arctic subspecies of ringed seals; therefore, section 9 take prohibitions do not apply to these two species. This incidental take statement includes numeric limits on the take of these species because specific amounts of take were analyzed in our jeopardy analysis. These numeric limits provide guidance to the action agency on its requirements to reinitiate consultation if the amount of take estimated in the jeopardy analysis of this opinion is exceeded. This incidental take statement includes reasonable and prudent measures and terms and conditions designed to minimize and monitor take of these threatened species.

Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. 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. 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 marine mammals (cetaceans and pinnipeds).

ESA section 7(b)(4) states that take of ESA-listed cetaceans and pinnipeds 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 August 1, 2021, through August 1, 2022 (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).

14.1 Amount or Extent of Take

Section 7 regulations require NMFS to specify the impact of any incidental take of threatened or endangered 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 low-energy and high-energy 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 low-energy and high-energy 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 anticipate the proposed low-energy and high-energy seismic survey in the Arctic Ocean is likely to result in the incidental take of ESA-listed marine mammals by harassment (Table 18). Behavioral harassment is expected to occur at received levels at or above 160 dB re: 1 μPa (rms) for airgun array operations 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 ESA

harassment, and is not expected to result in the death or injury of any individuals that will be exposed. It is believed that no ESA harm or PTS will be incurred in these marine mammals as a result of the proposed seismic survey activities, because of the constant movement of both the R/V *Sikuliaq* 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 R/V *Sikuliaq*'s approach due to the research vessel's relatively low speed when conducting seismic survey activities.

Table 18. Estimated amount of incidental take of Endangered Species Act-listed marine mammals authorized in the Arctic Ocean by the incidental take statement.

Species	Authorized Incidental Take by Harassment (Potential Temporary Threshold Shift and Behavioral) by Seismic Survey Activities
Marine Mammals – Cetaceans	
Bowhead Whale	3
Marine Mammals – Pinnipeds	
Bearded Seal – Beringia DPS	907
Ringed Seal – Arctic Subspecies	10,268

DPS=distinct population segment

14.2 Reasonable and Prudent Measures

The measures described below 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, we 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 measures that are necessary or appropriate to minimize the amount or extent of incidental take (50 C.F.R. §402.02). We believe the reasonable and prudent measures described below are necessary and appropriate to minimize the impacts of incidental take on threatened and endangered species:

- The NMFS Permits and Conservation Division must ensure that the National Science Foundation implements a program to mitigate and report the potential effects of seismic survey activities as well as the effectiveness of mitigation measures incorporated as part of the proposed incidental harassment authorization and possible renewal for the incidental taking of bowhead whales and Beringia DPS of bearded seals and Arctic subspecies or ringed seals 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 and possible renewal are carried out, and to inform us if take is exceeded.
- The NMFS Permits and Conservation Division must ensure that the National Science Foundation implement a program to monitor and report any potential interactions between seismic survey activities and threatened and endangered species of marine mammals.

14.3 Terms and Conditions

In order to be exempt from the prohibitions of section 9 of the ESA, the Federal action agency (i.e., National Science Foundation and NMFS Permits and Conservation Division) must comply (or must ensure that any applicant complies) with the following terms and conditions. These include the take minimization, monitoring and reporting measures required by the section 7 regulations (50 C.F.R. §402.14(i)).

The terms and conditions detailed below for each of the *Reasonable and Prudent Measures* include monitoring and minimization measures where needed:

1. The National Science Foundation must provide 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 by the National Science Foundation to the ESA Interagency Cooperation Division immediately to Cathy Tortorici, Chief, ESA Interagency Cooperation Division by e-mail at cathy.tortorici@noaa.gov.

15 CONSERVATION RECOMMENDATIONS

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

We make the following discretionary conservation recommendations that we believe are consistent with this obligation and therefore may be considered by the National Science

Foundation and NMFS Permits and Conservation Division in relation to their 7(a)(1) responsibilities. These recommendations will provide information for future consultations involving seismic surveys and the issuance of incidental harassment authorizations that may affect ESA-listed species.

1. We recommend that the National Science Foundation promote and fund research examining the potential effects of seismic surveys on ESA-listed marine mammal, sea turtle, fish, and marine 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 high 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.
5. We recommend that the NMFS Permits and Conservation Division develops 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 (and NMFS Permits and Conservation Division require in MMPA incidental take authorizations) clinometers or geometers, such as those described in Hansen et al. 2020, to accurately measure lateral distances from the research vessel to ESA-listed species for potential implementation of mitigation measures (e.g., shutdown procedure) during daytime and nighttime visual observations.
8. 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.
9. 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.

10. We recommend the National Science Foundation utilize real-time sighting services such as the WhaleAlert application (http://www.whalealert.org/) for cetaceans or the Ocean Alert mobile application (https://www.boem.gov/boem-harnessing-citizen-science-new-ocean-alert-mobile-app) for marine megafauna (e.g., sea turtles, sharks, and whales). We recognize that the research vessel may not have reliable internet access during operations far offshore, but nearshore, where many of the ESA-listed species 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 species sightings, and may also be valuable during other activities to alert others of ESA-listed species within the area, which they can then avoid.
11. 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.
12. We recommend the research vessel operator and other relevant vessel personnel (e.g., crew members) on the R/V *Sikuliaq* take the U.S. Navy's marine species awareness training available on the following website 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 NMFS 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 and high-energy marine seismic survey by the R/V *Sikuliaq* in the Arctic Ocean 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. Consistent with 50 C.F.R. §402.16, reinitiation of formal consultation is required and shall be requested by the Federal agency, where discretionary Federal agency 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 ESA-listed species or critical habitat in a manner or to an extent not previously considered.
3. The identified action is subsequently modified in a manner that causes an effect to ESA-listed species or designated critical habitat that was not considered in this opinion.
4. A new species is listed or critical habitat designated under the ESA that may be affected by the action.

If the amount of tracklines, location of tracklines, acoustic characteristics of the airgun arrays, timing of the low-energy and high-energy seismic survey, 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 one or more of the reinitiation triggers above may be met and reinitiation of consultation may be necessary.

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18 APPENDICES

Appendix A – Proposed Incidental Harassment Authorization and Possible Renewal

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 and possible renewal published in the *Federal Register* on May 28, 2021 (86 FR 28787), 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 University of Alaska Geophysics Institute (UAGI) 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 incidentally harass marine mammals, under the following conditions:

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

2. This IHA authorizes take incidental to geophysical survey activity in the Arctic Ocean, as specified in UAGI's IHA application.

3. General Conditions

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

   b. The species and/or stocks authorized for taking are listed in Table 1. Authorized take, by Level B harassment only, is limited to the species and numbers listed in Table 1.

   c. The taking by Level A harassment, serious injury, or death of any of the species listed in Table 1 or any taking of any other species of marine mammal is prohibited and may result in the modification, suspension, or revocation of this IHA. Any taking exceeding the authorized amounts listed in Table 1 is prohibited and may result in the modification, suspension, or revocation of this IHA.

   d. During use of the acoustic source, if any marine mammal species that are not listed in Table 1 appear within or enter the Level B harassment zone (Table 3) the acoustic source must be shut down.

   e. UAGI must ensure that relevant vessel personnel and the PSO team participate in a joint onboard briefing led by the vessel operator and lead PSO to ensure that

responsibilities, communication procedures, protected species monitoring protocols, operational procedures, and IHA requirements are clearly understood.

4. Mitigation Requirements

a. UAGI must use independent, dedicated, trained visual PSOs, meaning that the PSOs must be employed by a third-party observer provider, must not have tasks other than to conduct observational effort, collect data, and communicate with and instruct relevant vessel crew with regard to the presence of protected species and mitigation requirements (including brief alerts regarding maritime hazards), and must have successfully completed an approved PSO training course.

b. At least one visual PSO must have a minimum of 90 days at-sea experience working in that role during a deep penetration seismic survey, with no more than 18 months elapsed since the conclusion of the at-sea experience.

c. Visual Observation

i. During survey operations (e.g., any day on which use of the acoustic source is planned to occur, and whenever the acoustic source is in the water, whether activated or not), a minimum of two PSOs 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 ramp-up 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 acoustic source ceases or until 30 minutes past sunset.

ii. Visual 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. Estimated harassment zones are provided in Tables 2-3 for reference.

iii. During good conditions (e.g., daylight hours; Beaufort sea state (BSS) 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.

iv. Visual 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 of observation per 24-hour period.

d. Exclusion zones and buffer zones

i. Except as provided below in 4(d)(ii), the PSOs must establish and monitor exclusion zones and additional buffer zones. During high energy survey

effort[1], the exclusion zone shall be 500 m with an additional 500 m buffer zone (total 1,000 m). During low energy survey effort[2], the exclusion zone shall be 100 m with an additional 100 m buffer zone (total 200 m). The 1,000-m and 200-m zone, for high energy and low energy survey effort, respectively, shall serve to focus observational effort but not limit such effort; observations of marine mammals beyond these distances shall also be recorded as described in 5(d) below and/or trigger shutdown as described in 4(g)(iv) below, as appropriate. The exclusion zone encompasses the area at and below the sea surface out to the defined distance from the edges of the airgun array (rather than being based on the center of the array or around the vessel itself). The buffer zone encompasses the area at and below the sea surface from the edge of the exclusion zone, out to the defined distance from the edges of the airgun array. During use of the acoustic source, occurrence of marine mammals within the buffer zone (but outside the exclusion zone) must be communicated to the operator to prepare for the potential shutdown of the acoustic source. PSOs must monitor the exclusion zone and buffer zone for a minimum of 30 minutes prior to ramp-up (i.e., pre-start clearance).

ii. An extended 1,500-m or 500-m exclusion zone must be established for bowhead whales during high energy and low energy survey effort, respectively. No buffer zone is required.

e. Pre-start clearance and Ramp-up

i. A ramp-up procedure must be followed at all times as part of the activation of the acoustic source, except as described under 4(e)(v).

ii. Ramp-up must not be initiated if any marine mammal is within the exclusion or buffer zone. If a marine mammal is observed within the exclusion zone or the buffer zone during the 30 minute pre-start clearance period, ramp-up may not begin until the animal(s) has been observed exiting the zone or until an additional time period has elapsed with no further sightings (15 minutes for small odontocetes and pinnipeds, and 30 minutes for mysticetes and all other odontocetes, including beluga whales and killer whales).

iii. Ramp-up must begin by activating a single airgun of the smallest volume in the array and must continue in stages by doubling the number of active elements at the commencement of each stage, with each stage of approximately the same duration. Ramp-up duration for the high energy array must not be less than 20 minutes.

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[1] High energy survey effort refers to use of the 6-airgun, 3,120 in^3 array.

[2] Low energy survey effort refers to use of the 2-airgun, 1,040 in^3 array.

iv. PSOs must monitor the exclusion and buffer zones during ramp-up, and ramp-up must cease and the source must be shut down upon visual observation of a marine mammal within the exclusion zone. Once ramp-up has begun, observations of marine mammals within the buffer zone do not require shutdown, but such observation must be communicated to the operator to prepare for the potential shutdown.

v. If the acoustic source is shut down for brief periods (i.e., less than 30 minutes) for reasons other than that described for shutdown (e.g., mechanical difficulty), it may be activated again without ramp-up if PSOs have maintained constant observation and no detections of marine mammals have occurred within the applicable exclusion zone. For any longer shutdown, pre-start 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, but if the shutdown period was brief and constant observation was maintained, pre-start clearance watch is not required.

vi. Testing of the acoustic source involving all elements requires ramp-up. Testing limited to individual source elements or strings does not require ramp-up but does require pre-start clearance watch.

f. Shutdown

i. Any PSO on duty has the authority to delay the start of survey operations or to call for shutdown of the acoustic source.

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

iii. 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 exclusion zone, the acoustic source must be shut down. When shutdown is called for by a PSO, the airgun array must be immediately deactivated. Any dispute regarding a PSO shutdown must be resolved after deactivation.

iv. The airgun array must be shut down if any of the following are detected at any distance.

1. Bowhead whale.
2. Large whale (defined as any mysticete 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).
3. Aggregation of six or more large whales.

v. Upon implementation of shutdown, the source 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 a clearance period (15 minutes for small odontocetes and pinnipeds, and 30 minutes for mysticetes and all other odontocetes, including beluga whales and killer whales) with no further observation of the marine mammal(s).

g. Vessel strike avoidance:

i. Vessel operators and crews must maintain a vigilant watch for all protected species and slow down, stop their vessel, or alter course, as appropriate and regardless of vessel size, to avoid striking any protected species. A visual observer aboard the vessel must monitor a vessel strike avoidance zone around the vessel (distances stated below). Visual observers monitoring the vessel strike avoidance zone may be third-party observers (i.e., PSOs) or crew members, but crew members responsible for these duties must be provided sufficient training to 1) distinguish protected species from other phenomena and 2) broadly to identify a marine mammal as a bowhead whale, other whale (defined in this context as baleen whales other than bowhead whales), or other marine mammal.

ii. Vessel speeds must also be reduced to 10 knots or less when mother/calf pairs, pods, or large assemblages of cetaceans are observed near a vessel.

iii. The vessel must maintain a minimum separation distance of 500 m from bowhead whales. If a whale is observed but cannot be confirmed as a species other than a bowhead whale, the vessel operator must assume that it is a bowhead whale and take appropriate action.

iv. All vessels must maintain a minimum separation distance of 100 m from all other baleen whales.

v. All vessels must, to the maximum extent practicable, attempt to maintain a minimum separation distance of 50 m from all other protected species, with an understanding that at times this may not be possible (e.g., for animals that approach the vessel).

vi. When protected species are sighted while a vessel is underway, the vessel shall take action as necessary to avoid violating the relevant separation distance (e.g., attempt to remain parallel to the animal's course, avoid excessive speed or abrupt changes in direction until the animal has left the area). If protected species are sighted within the relevant separation distance, the vessel must reduce speed and shift the engine to neutral, not engaging the engines until animals are clear of the area. This does not apply to any vessel towing gear or any vessel that is navigationally constrained.

vii. 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.

5. Monitoring Requirements

a. The operator must provide PSOs with bigeye binoculars (e.g., 25 x 150; 2.7 view angle; individual ocular focus; height control) of appropriate quality solely for PSO use. These must be pedestal-mounted on the deck at the most appropriate vantage point that provides for optimal sea surface observations, PSO safety, and safe operation of the vessel.

b. The operator must work with the selected third-party observer provider to ensure PSOs have all equipment (including backup equipment) needed to adequately perform necessary tasks, including accurate determination of distance and bearing to observed marine mammals. Such equipment, at a minimum, must include:

i. Reticle binoculars (e.g., 7 x 50) of appropriate quality (at least one per PSO, plus backups).

ii. Global Positioning Unit (GPS) (plus backup).

iii. Digital single-lens reflex cameras of appropriate quality that capture photographs and video (plus backup).

iv. Compass (plus backup)

v. Radios for communication among vessel crew and PSOs (at least one per PSO, plus backups).

vi. Any other tools necessary to adequately perform necessary PSO tasks.

c. Protected Species Observers Qualifications

i. PSOs must have successfully completed an approved PSO training course.

ii. NMFS must review and approve PSO resumes.

iii. NMFS shall have one week to approve PSOs from the time that the necessary information is submitted, after which PSOs meeting the minimum requirements shall automatically be considered approved.

iv. One PSO with experience as shown in 4(b) shall be designated as the lead for the PSO team. The lead must coordinate duty schedules and roles for the PSO team and serve as primary point of contact for the vessel operator. (Note that the responsibility of coordinating duty schedules and roles may instead be assigned to a shore-based, third-party monitoring coordinator.) To the

maximum extent practicable, the lead PSO must devise the duty schedule such that experienced PSOs are on duty with those PSOs with appropriate training but who have not yet gained relevant experience.

v. PSOs must successfully complete relevant training, including completion of all required coursework and passing (80 percent or greater) a written and/or oral examination developed for the training program.

vi. PSOs must have successfully attained a bachelor's degree from an accredited college or university with a major in one of the natural sciences, a minimum of 30 semester hours or equivalent in the biological sciences, and at least one undergraduate course in math or statistics.

vii. The educational requirements may be waived if the PSO has acquired the relevant skills through alternate experience. Requests for such a waiver must be submitted to NMFS and must include written justification. Requests must be granted or denied (with justification) by NMFS within one week of receipt of submitted information. Alternate experience that may be considered includes, but is not limited to (1) traditional ecological knowledge; (2) secondary education and/or experience comparable to PSO duties; (3) previous work experience conducting academic, commercial, or government-sponsored protected species surveys; or (4) previous work experience as a PSO; the PSO should demonstrate good standing and consistently good performance of PSO duties.

d. Data Collection

i. PSOs must use standardized data collection 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. If required mitigation was not implemented, PSOs should record a description of the circumstances.

ii. At a minimum, the following information must be recorded:

1. Vessel name and call sign;

2. PSO names and affiliations;

3. Date and participants of PSO briefings;

4. Dates of departure and return to port with port name;

5. Dates and times (Greenwich Mean Time) of survey effort and times corresponding with PSO effort;

6. Vessel location (latitude/longitude) when survey effort began and ended and vessel location at beginning and end of visual PSO duty shifts;

7. Vessel heading and speed at beginning and end of visual PSO duty shifts and upon any line change;

8. Environmental conditions while on visual survey (at beginning and end of PSO shift and whenever conditions changed significantly), including BSS and any other relevant weather conditions including cloud cover, fog, sun glare, and overall visibility to the horizon;

9. Factors that may have contributed to impaired observations during each PSO shift change or as needed as environmental conditions changed (e.g., vessel traffic, equipment malfunctions); and

10. 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-start clearance, ramp-up, shutdown, testing, shooting, ramp-up completion, end of operations, streamers, etc.).

iii. Upon visual observation of any protected species, the following information must be recorded:

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

2. PSO who sighted the animal;

3. Time of sighting;

4. Vessel location at time of sighting;

5. Water depth;

6. Direction of vessel's travel (compass direction);

7. Direction of animal's travel relative to the vessel;

8. Pace of the animal;

9. Estimated distance to the animal and its heading relative to vessel at initial sighting;

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

11. Estimated number of animals (high/low/best);

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

13. 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);

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

15. Animal's closest point of approach (CPA) and/or closest distance from any element of the acoustic source;

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

17. Description of any actions implemented in response to the sighting (e.g., delays, shutdown, ramp-up) and time and location of the action.

6. Reporting

a. UAGI must submit a draft comprehensive report to NMFS on all activities and monitoring results within 90 days of the completion of the survey or expiration of the IHA, whichever comes sooner. A final report must be submitted within 30 days following resolution of any comments on the draft report. The draft report must include the following:

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

ii. Summary of all data required to be collected (see 5(d));

iii. Full documentation of methods, results, and interpretation pertaining to all monitoring;

iv. Summary of dates and locations of survey operations (including (1) the number of days on which the airgun array was active, including which array was being used and (2) the percentage of time and total time the array was active during daylight vs. nighttime hours (including dawn and dusk)) and all marine mammal sightings (dates, times, locations, activities, associated survey activities);

v. Geo-referenced time-stamped vessel tracklines for all time periods during which airguns were operating. Tracklines should include points recording any change in airgun status (e.g., when the airguns began operating, when they were turned off, or when they changed from full array to single gun or vice versa);

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

vii. Raw observational data.

b. Reporting injured or dead marine mammals:

i. Discovery of injured or dead marine mammal – In the event that personnel involved in the survey activities covered by the authorization discover an injured or dead marine mammal, the UAGI must report the incident to the Office of Protected Resources (OPR) (301-427-8401), NMFS and to the NMFS Alaska Regional Stranding Coordinator as soon as feasible. The report must include the following information:

1. Time, date, and location (latitude/longitude) of the first discovery (and updated location information if known and applicable);
2. Species identification (if known) or description of the animal(s) involved;
3. Condition of the animal(s) (including carcass condition if the animal is dead);
4. Observed behaviors of the animal(s), if alive;
5. If available, photographs or video footage of the animal(s); and
6. General circumstances under which the animal was discovered.

ii. Vessel Strike – In the event of a ship strike of a marine mammal by any vessel involved in the activities covered by the authorization, the IHA-holder shall report the incident to OPR, NMFS and to the Alaska Regional Stranding Coordinator as soon as feasible. The report must include the following information:

1. Time, date, and location (latitude/longitude) of the incident;
2. Species identification (if known) or description of the animal(s) involved;
3. Vessel's speed during and leading up to the incident;
4. Vessel's course/heading and what operations were being conducted (if applicable);
5. Status of all sound sources in use;

6. Description of avoidance measures/requirements that were in place at the time of the strike and what additional measures were taken, if any, to avoid strike;

7. Environmental conditions (*e.g.*, wind speed and direction, Beaufort sea state, cloud cover, visibility) immediately preceding the strike;

8. Estimated size and length of animal that was struck;

9. Description of the behavior of the marine mammal immediately preceding and following the strike;

10. If available, description of the presence and behavior of any other marine mammals immediately preceding the strike;

11. Estimated fate of the animal (*e.g.*, dead, injured but alive, injured and moving, blood or tissue observed in the water, status unknown, disappeared); and

12. To the extent practicable, photographs or video footage of the animal(s).

7. This Authorization may be modified, suspended or revoked if the holder fails to abide by the conditions prescribed herein (including, but not limited to, failure to comply with monitoring or reporting requirements), or if NMFS determines: (1) the authorized taking is likely to have or is having more than a negligible impact on the species or stocks of affected marine mammals, (2) the authorized taking is likely to have or is having an unmitigable adverse impact on the availability of the affected species or stocks for subsistence uses, or (3) the prescribed measures are likely not or are not effecting the least practicable adverse impact on the affected species or stocks and their habitat.

8. <u>Renewals</u>

a. On a case-by-case basis, NMFS may issue a one-time, one-year Renewal IHA following notice to the public providing an additional 15 days for public comments when (1) up to another year of identical, or nearly identical, activities are planned or (2) the specified activities would not be completed by the time this IHA expires and a Renewal would allow for completion of the activities, provided all of the following conditions are met:

i. A request for renewal is received no later than 60 days prior to the needed Renewal IHA effective date (the Renewal IHA expiration date cannot extend beyond one year from expiration of this IHA).

ii. The request for renewal must include the following:

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

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.

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

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Catherine Marzin,

Acting Director, Office of Protected Resources,

National Marine Fisheries Service.

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

Species	Authorized Take by Level B Harassment
Bowhead whale (*Balaena mysticetus*)	3
Gray whale (*Eschrichtius robustus)*	2
Fin whale (*Balaenoptera physalus*)	2
Humpback whale (*Megaptera novaeangliae*)	2
Minke whale (*Balaenoptera acutorostrata*)	2
Beluga whale (*Delphinapterus leucas)*	697
Killer whale (*Orcinus orca)*	6
Narwhal (*Monodon Monoceros)*	2
Harbor porpoise (*Phocoena phocoena)*	2
Bearded seal (*Erignathus barbatus)*	907
Ribbon seal (*Histriiophoca fasciata)*	1849
Ringed seal (*Histriophoca fasciata)*	10268
Spotted seal (*Phoca largha)*	19

Table 2. Modeled Radial Distances (m) to Isopleths Corresponding to Level A Harassment Thresholds.

Airgun Configuration	Threshold	Level A harassment zone (m)			
		LF cetaceans	MF cetaceans	HF cetaceans	Phocids
Two 520 in^3 G-airguns ($1040\ in^3$)	SEL_{cum}	17.2	0	0	0.2
	Peak	10.3	2.9	72.8	11.6
Six 520 in^3 G-airgun array ($3120\ in^3$)	SEL_{cum}	50.6	0	0	0.4
	Peak	29.8	7.2	211.5	33.6

Table 3. Modeled Radial Distances (m) to Isopleths Corresponding to Level B Harassment Threshold.

Airgun Configuration	Water Depth (m)	Level B harassment zone (m)
Two 520 in^3 G-airguns (1040 in^3)	>1,000	1604
	100-1,000	2406
Six 520 in^3 G-airgun array (3120 in^3)	>1,000	4640
	100-1,000	6960