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

Title:	Biological Opinion and Conference on Marine Geophysical Surveys of the Puerto Rico Trench and Southern Slope by the National Science Foundation, and the Issuance of a Marine Mammal Protection Act Incidental Harassment Authorization and Possible Renewal by the National Marine Fisheries Service Permits and Conservation Division
Consultation Conducted By:	Endangered Species Act Interagency Cooperation Division, Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce
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1 INTRODUCTION

The Endangered Species Act (ESA) of 1973, as amended (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)).

Section 7(b)(3) of the ESA requires that at the conclusion of consultation, NMFS provides an opinion stating whether the Federal agency is able to insure its action is not 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 (ITS) 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. NMFS, by regulation, has determined that an ITS must be prepared when take is "reasonably certain to occur" as a result of the proposed action (50 C.F.R. §402.14(g)(7)).

The Federal action agencies for this consultation are the National Science Foundation (NSF) and the NMFS, Office of Protected Resources (OPR), Permits and Conservation Division (Permits Division). Two Federal actions are considered in this biological opinion and conference (opinion). The first is the NSF's proposal to sponsor (fund) a marine geophysical (seismic) survey conducted by the Lamont-Doherty Earth Observatory (L-DEO) of the Puerto Rico Trench and southern slope of Puerto Rico in the fall of 2023. The second is the Permits Division's proposal to issue an incidental harassment authorization (IHA) authorizing nonlethal "takes" by Level A and 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. Level A harassment means any act of pursuit, torment, or annoyance that has the potential to injure a marine mammal or marine mammal stock in the wild. Level B harassment refers to acts that have the potential to disturb (but not injure) a marine mammal or marine mammal stock in the wild by disrupting behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering. Note that Level A and/or Level B harassment under the MMPA do not necessarily equate to ESA harassment.

This biological opinion and conference and ITS were prepared by the NMFS OPR ESA Interagency Cooperation Division (hereafter referred to as "we," "us," or "our") in accordance with section 7(a)(2) of the statute, associated implementing regulations (50 C.F.R. §§402.01–

402.17), and agency policy and guidance. Amendments to the regulations governing interagency consultation (50 C.F.R. Part 402) became effective on October 28, 2019 (84 FR 44976). On July 5, 2022, the U.S. District Court for the Northern District of California issued an order vacating the 2019 regulations that were revised or added to 50 C.F.R. part 402 in 2019 ("2019 Regulations," see 84 FR 44976, August 27, 2019) without making a finding on the merits. On September 21, 2022, the U.S. Court of Appeals for the Ninth Circuit granted a temporary stay of the district court's July 5 order. On November 14, 2022, the Northern District of California issued an order granting the government's request for voluntary remand without vacating the 2019 regulations. The District Court issued a slightly amended order 2 days later on November 16, 2022. As a result, the 2019 regulations remain in effect, and we are applying the 2019 regulations here. For purposes of this consultation and in an abundance of caution, we considered whether the substantive analysis and conclusions articulated in the biological opinion and ITS would be any different under the pre-2019 regulations. We have determined that our analysis and conclusions would not be any different.

This document represents our opinion on the effects of these actions on threatened and endangered species and critical habitat that has been designated for those species (Section 6). A complete record of this consultation is on file with NMFS OPR in Silver Spring, Maryland.

1.1 Background

The NSF is proposing marine seismic surveys for scientific research purposes and data collection in the Puerto Rico Trench and southern slope of Puerto Rico in the fall of 2023. The NSF, as the research funding and action agency, has a mission to "promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense…" The proposed seismic survey will collect data in support of a research proposal that was reviewed under the NSF merit review process and identified as a NSF program priority. The seismic surveys would provide new information for examining earthquake and tsunami hazards associated with the Puerto Rico Trench region. In conjunction with this action, the Permits Division proposes the issuance of an IHA pursuant to the MMPA requirements for incidental takes of marine mammals that could occur during the NSF seismic survey.

This document represents our opinion on the effects of the proposed Federal actions on threatened and endangered species, and has been prepared in accordance with section 7(a)(2) of the ESA. The NSF and the Permits Division have conducted similar actions in the past that have been the subject of ESA section 7 consultations. A previous opinion for an NSF seismic survey in the vicinity of the proposed action area included the southeastern Caribbean and adjacent Atlantic (2004), and the issuance of an IHA for the survey, determined that the authorized activities were not likely to jeopardize the continued existence of ESA-listed species.

The principal investigators, NSF, and L-DEO considered the seasonal presence of marine animals, weather conditions (e.g., hurricane season), equipment, and optimal timing for other proposed seismic surveys using the research vessel (R/V) *Marcus G. Langseth* (hereafter, the R/V *Langseth*), to determine when to carry out the proposed seismic surveys.

1.2 Consultation History

This opinion is based on information provided by the NSF in a draft environmental assessment/analysis (EA) prepared pursuant to the National Environmental Policy Act, the Permits Division's notice of a proposed IHA prepared pursuant to the MMPA, and information from previous NSF seismic surveys in the vicinity of the action area. Unless noted otherwise, our communication with the NSF and the Permits Division regarding this consultation was conducted through email and is summarized as follows:

- **April 20, 2023:** The NSF submitted a consultation request letter and a draft EA to the ESA Interagency Cooperation Division for review.
- **May 22, 2023**: After review of the information, we determined there was sufficient information, as of April 20, 2023, to initiate a formal consultation with NSF.
- **June 1, 2023**: The Permits Division hosted their early review meeting on the IHA application with the ESA Interagency Cooperation Division in attendance. The Permits Division submitted questions back to NSF.
- **June 27, 2023**: The Permits Division and the ESA Interagency Cooperation Division requested that NSF update the exposure numbers for marine mammals based on the publication of more recent data from the Marine Geophysical Ecology Laboratory/Duke University.
- **July 5, 2023**: After conversations with the NMFS Southeast Regional Office, the Permits Division added language to the draft IHA regarding local contacts to notify during the survey.
- **July 20, 2023**: NSF revised the exposure numbers in the draft EA and IHA application package and submitted the information to the Permits Division and the ESA Interagency Cooperation Division.
- **July 27, 2023**: The Permits Division determined that the IHA application was adequate and complete.
- **August 21, 2023:** The Permits Division submitted their initiation package to the ESA Interagency Cooperation Division for review. The ESA Interagency Cooperation Division reviewed the package, determined it was complete, and initiated consultation with the Permits Division on the same date.

2 THE ASSESSMENT FRAMEWORK

Section 7(a)(2) of the ESA requires Federal agencies, in consultation with NMFS, insure that their actions are not likely to jeopardize the continued existence of threatened or endangered species; or adversely modify or destroy their 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 critical habitat for the conservation of an ESA-listed species. Such alterations may include, but are not limited to, those that alter the physical and biological features (PBFs) essential to the conservation of a species or that preclude or significantly delay development of such features (50 C.F.R. §402.02).

The final designations of critical habitat for loggerhead turtles used the term primary constituent element or essential features. The critical habitat regulation revisions (81 FR 7414) have since replaced this term with PBFs. 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, PBFs, or essential features. In this opinion, we use the term PBFs 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 alter 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.

Potential stressors (Section 4): We identify and describe the stressors that could occur because of the proposed actions.

Action area (Section 5): We describe the action area with the spatial and temporal extent of those stressors caused by the proposed action.

Endangered Species Act-listed species and designated and proposed critical habitat present in the action area (Section 6): We identify the ESA-listed species and designated critical habitat that are subject to this consultation because they co-occur with the stressors produced by the proposed actions in space and time.

Species and critical habitat not likely to be adversely affected (Section 7). We identify the ESA-listed species and designated and proposed critical habitat that are not likely to be adversely affected by the stressors produced by the proposed actions.

Status of species likely to be adversely affected (Section 8): During the ESA section 7 consultation process, we identify the ESA-listed species that are likely be adversely affected and detail our effects analysis for these species. In this section, we examine the status of ESA-listed species that may be adversely affected by the proposed actions throughout the action area.

Environmental baseline *(*Section 9): We describe the environmental baseline, which refers to the condition of the ESA-listed species and critical habitat in the action area, without the consequences to the ESA-listed species and 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 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).

Effects of the action (Section 10): Effects of the action are all consequences to ESA-listed species 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 in time and may include consequences occurring outside the immediate area involved in the action (50 C.F.R. §402.17). 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 subpopulations to which individuals belong. This is our exposure analysis. We evaluate the available evidence to determine how individuals of those ESA-listed species are likely to respond given their probable exposure. This is our response analysis.

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 under NMFS's jurisdiction.

With full consideration of the status of the species, we consider the effects of the actions within the action area on populations or subpopulations 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

The results of our jeopardy 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 ITS (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 (Section 15) that may be implemented by the action agency (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 NSF and the Permits Division;
- Government reports (including NMFS biological opinions and stock assessment reports);
- NOAA technical memos; and
- Peer-reviewed scientific literature.

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

3 Description of the Proposed Action

"Action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by Federal agencies in the United States or upon the high seas.

Two actions were evaluated in this consultation. The first action is a pair of proposed marine seismic surveys near Puerto Rico, 1 high-energy geophysical survey and 1 low-energy geophysical survey funded by NSF. The second action is the Permits Division's issuance of an IHA authorizing nonlethal MMPA "takes" by Level A and B harassment pursuant to section 101(a)(5)(D) of the MMPA for the proposed marine seismic surveys.

3.1 National Science Foundation and United States Geological Survey Proposed Activities

The NSF proposes to fund researchers from Woods Hole Oceanographic Institution (WHOI), University of Texas Institute of Geophysics (UTIG), and University of Puerto Rico Mayagüez (UPRM), to conduct seismic surveys, using the R/V *Langseth*, of the Puerto Rico Trench in the North Atlantic Ocean and southern slope of Puerto Rico in the Caribbean Sea (see Figure 1 in Section 5). Additional collaborators from the United States Geological Survey and Dr. Z. Sun (Key Laboratory of Marginal Sea and Ocean Geology, Chinese Academy of Sciences) will not be funded through NSF, but will contribute ultra-deep sea instrumentation necessary for achieving the objectives of this project.

The main goal of the high-energy seismic survey is to investigate the Puerto Rico Trench, its outer rise, and across the island of Puerto Rico, and provide data necessary to illuminate the depth, geometry, and physical properties of the seismogenic fault interface between the subducting Atlantic plate and the overlying accretionary wedge/Puerto Rico arc/Caribbean plate, as well as seismogenic structures in the accretionary wedge and submarine slopes of the island of Puerto Rico. The proposed study would provide new information for examining earthquake and tsunami hazards associated with the Puerto Rico Trench.

The low-energy seismic survey would be located over an area of seismic activity that occurred from 2019–2020 in the Caribbean Sea, to define the geometry of the faults that ruptured and produced earthquakes of moment magnitude ≤6.4 and to examine other potential seismogenic structures.

3.1.1 Overview of Seismic Surveys

The surveys are proposed in-water depths ranging from ~100–8,400 meters within the Exclusive Economic Zones (EEZ) of Puerto Rico, U.S. Virgin Islands, British Virgin Islands, Dominican Republic, and in the territorial seas of Puerto Rico. The proposed survey procedures will use seismic methodology commonly conducted on the R/V *Langseth*. The proposed activities will occur 24 hours per day.

The high-energy NSF seismic survey will use a 36-airgun array to cover approximately 4,070 kilometers of transect lines in waters >1,000 meters deep. Survey transects will include lines that acquire seismic refraction data using Ocean Bottom Seismometers (OBS) and lines that acquire multi-channel seismic (MCS) reflection data using a hydrophone streamer. The high-energy survey is expected to last for 36 days, including approximately 21 days of seismic operations and 15 days for equipment deployment and recovery.

The low-energy seismic survey will use a 2-airgun array to cover approximately 560 kilometers of transect lines that will all collect MCS reflection data using a hydrophone streamer. The low-energy surveys will consist of approximately 3 days of seismic operations with 43% of effort occurring in 100–1000 meter depths, and 57% in >1,000 meters; no effort will occur in <100 meter depths. The low-energy survey will also take place aboard the R/V *Langseth*.

There could be additional seismic transect line coverage during either survey associated with airgun testing and any repeat coverage of areas when initial data quality is determined to be sub-standard by the science team. The following acoustic sources, in addition to the airguns, will be operated from the R/V *Langseth* continuously during the seismic surveys: multibeam echosounder (MBES), sub-bottom profiler (SBP), and Acoustic Doppler Current Profiler (ADCP).

The R/V *Langseth* is tentatively planned to depart out of and return to port in San Juan, Puerto Rico, during the fall (October/November) of 2023.

3.1.2 Research Vessel Specifications

The seismic survey will involve 1 vessel, the U.S.-flagged R/V *Langseth* owned and operated by L-DEO. The *Langseth* has a length of 72 meters (235 feet), a beam of 17 meters (56 feet), and a maximum draft of 5.9 meters (19.4 feet). It weighs 2,842 gross tons. Its propulsion system consists of 2 diesel Bergen BRG-6 engines, each producing 3,550 horsepower, and an 800 horsepower bow thruster. As a seismic research vessel, the propulsion system was designed to be quiet to avoid interference with the seismic signals.

The vessel speed during seismic operations with the 36-airgun array will be ~7.6 kilometers per hour (~4.1 knots) during MCS seismic reflection surveys and ~9.3 kilometers per hour (~5.0 knots) during OBS seismic refraction surveys. For the 2-airgun, low-energy seismic survey, the vessel speed will be 8.3 kilometers per hour (~4.5 knots). When the R/V *Langseth* is towing the airgun array and hydrophone streamer, the turning rate of the vessel is limited to 5° per minute. Thus, the maneuverability of the vessel is limited during operations with the streamer. When not towing seismic survey gear, the R/V *Langseth* typically cruises at 18.5 kilometers per hour (10 knots).

No chase/support vessel will be used during the proposed seismic survey activities. The R/V *Langseth* will also serve as the platform from which vessel-based PSOs will visually watch for animals (e.g., marine mammals, sea turtles, and fishes).

3.1.3 Airgun Array and Acoustic Receiver Description

The R/V *Langseth* will deploy an airgun array (i.e., a certain number of airguns of varying sizes in a certain arrangement) during the seismic surveys to emit acoustic energy pulses downward through the water column and into the seafloor. The airguns generally consist of a steel cylinder 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. Airgun operations are expected to be continuous during the seismic surveys except for periods of unscheduled shutdowns.

3.1.3.1 High-energy Survey

During the high-energy surveys, the R/V *Langseth* will tow 36 airguns (plus 4 spares) in an array of 4 strings spaced 16 meters apart with a total discharge volume of 108,154.6 cubic centimeters (6,600 cubic inches [in^3]). The 4 airgun strings will be distributed across an area of ~24 x 16 meters (78.7 x 52.5 feet) behind the *Langseth* and will be towed approximately 140 meters behind the vessel at a depth of 12 meter (39.4 feet).

The receiving system will consist of a towed 15-kilometer long solid-state hydrophone streamer, 31 short-period OBSs, and 10 ultra-deep-water broadband OBSs. As the airgun arrays are towed along the survey lines, the hydrophone streamer transfer the data to the onboard processing system. OBSs will be deployed and store the returning acoustic signals, data will be analyzed later after the devices are retrieved.

The airguns will fire at a shot interval of 50 meters (24 seconds) during multi-channel seismic (MCS) reflection surveys with the hydrophone streamer and at a 400-meter (155 seconds) interval during OBS seismic refraction surveys. The firing pressure of the airguns is approximately 1,900 pounds per square inch (psi).

Refraction data will be acquired using 31 short-period OBSs from the Ocean Bottom Seismometer Instrument Center (OBSIC) at WHOI. Short-period OBSs will be deployed at a total of 69 sites in-water depths <6,000 meters. Ten ultra-deep-water broadband OBSs provided by the Helmholtz Centre for Ocean Research Kiel (GEOMAR) will be deployed at a total of 25 sites in-water depths of ~6,000– 8,000 meters. OBSs will be placed every 8-10 kilometers (5-6.2 miles) and, following the refraction shooting of 1 line, OBSs on that line will be recovered, serviced, and redeployed on a subsequent refraction line. The OBSIC OBSs have a height of ~1 meter, a diameter of ~0.5 meter, and a weight of ~22 (kilogram) kg; the steel anchor is 30.5 cm x 38 cm x 2.5 cm high and weighs ~24 kg. The GEOMAR OBSs have a height of ~0.5 meter, a diameter of ~1 meter, and a weight of ~60 kg, including the steel anchor. All OBSs will be recovered by the end of the survey. To retrieve the OBSs, a transponder signals at a frequency of 8-11 kilohertz (kHz) and a response is received at a frequency of 11.5-13 kHz (operator selectable) triggering a burn-wire assembly that releases the instrument from the anchor on the seafloor and the device floats to the surface. The transmitting beam pattern is 55°. The sound source level is approximately 93 decibels (dB). The pulse duration is 2 milliseconds (±10%) and the pulse repetition rate is 1 per second (±50 microseconds). The anchor for the OBS is left on the seafloor.

3.1.3.2 Low-energy Surveys

During the low-energy surveys, the R/V *Langseth* will tow a 2 airgun cluster with a total discharge volume of 90 in^3. The 2 inline GI airguns will be spaced 2.46 meters apart. The array will be towed at a depth of 3 meters, and the shot interval will be 6.25 meters. The firing pressure of the airguns is 1,900 psi. During firing, a brief (~0.1 second) pulse of sound is emitted. The airguns are silent during the intervening periods. The receiving system will be only the 150-meter long solid-state hydrophone streamer and no OBSs.

3.1.4 Additional Acoustical Data Acquisition Systems

Along with the airgun operations, 3 additional acoustical data acquisition systems will operate during the seismic survey from the R/V *Langseth*: MBES, SBP, and an ADCP.

The MBES and SBP will map the ocean floor during the seismic survey operations. The ADCP is mounted on the ship to measure the speed of the water currents. The ADCP operates at a frequency of 35-1,200 kHz and a maximum acoustic source level of 224 dB referenced to 1 microPascal at 1 meter (re: 1µPa-m) over a conically-shaped 30 degree beam.

The Kongsberg EM122 is a hull-mounted MBES operating at 10.5-13 (usually 12) kHz. The transmitting beamwidth is 1 or 2° fore-aft and 150° (maximum) athwartship (i.e., perpendicular to the ship's line of travel). The maximum sound source level is 242 dB re: 1 µPa-m. Each ping consists of 8 (in-water greater than 1,000 meters [3,281 feet]) or 4 (in-water less than 1,000 meters [3,281 feet]) successive fan-shaped transmissions, each ensonifying a sector that extends 1 degree fore-aft. Continuous-wave signals increase from 2-15 milliseconds long in-water depths up to 2,600 meters (8,530 feet). Frequency-modulated chirp signals up to 100 milliseconds long are used in-water depths greater than 2,600 meters (8,530 feet). The successive transmissions span an overall cross-track angular extent of about 150°, with 2 millisecond gaps between the pings for successive sectors.

The Knudsen 3260 SBP is operated to provide information about the near seafloor sedimentary features and the bottom topography that is mapped simultaneously by the multi-beam echosounder. The beam is transmitted as a 27-degree cone, which is directed downward by a 3.5-kHz transducer in the hull of the R/V *Langseth*. The nominal power output is 10 kilowatts, but the actual maximum radiated power is 3 kilowatts or 222 dB re: 1 µPa-m root mean square (rms). The ping duration is up to 64 milliseconds, and the ping interval is 1 second. A common mode of operation is to broadcast 5 pulses at one-second intervals followed by a five-second pause. The sub-bottom profiler is capable of reaching depths of 10,000 meters (32,808.4 feet).

3.2 National Marine Fisheries Service's Proposed Incidental Harassment Authorization

On April 26, 2023, the Permits Division received a request from the L-DEO, owner and operator of the R/V *Langseth,* for an IHA on behalf of itself: NSF, WHOI, UTIG, UPRM, and the U.S. Geological Survey (the applicants).

On July 27, 2023, the Permits Division deemed the IHA application to be adequate and complete. The request was for the incidental (i.e., not intentional) harassment of small numbers of 27 species of marine mammals, including 4 ESA-listed species, by MMPA Level A and Level B harassment that could occur during marine geophysical surveys of the Puerto Rico Trench and southern slope of Puerto Rico. The applicants and the Permits Division do not expect serious injury or mortality to result from the proposed activities; therefore, an IHA is appropriate. The proposed seismic surveys are not expected to exceed 1 year; hence, the Permits Division does not anticipate issuing subsequent IHAs for this action. The IHA will be valid for a period of 1 year from the date of issuance.

The Permits Division proposes to issue the final IHA by September 27, 2023, so the applicants will have the IHA prior to the start of the proposed survey activities. Appendix A (Section 17) contains a copy of the proposed IHA.

3.2.1 Proposed Incidental Harassment Authorization

The Permits Division is proposing to issue an IHA authorizing nonlethal "takes" by MMPA Level A and Level B harassment of marine mammals incidental to the planned high-energy seismic survey. The IHA will authorize the incidental harassment of the following threatened and endangered species: blue whale (*Balaenoptera musculus*), fin whale (*Balaenoptera physalus*), sei whale (*Balaenoptera borealis*), and sperm whale (*Physeter macrocephalus*). The proposed IHA identifies requirements that the NSF and L-DEO must comply with as part of its authorization.

The Permits Division does not expect the NSF and L-DEO's planned high-energy seismic survey to exceed 1 year and does not expect subsequent MMPA IHAs will be issued for this particular activity. Nevertheless, the Permits Division recognizes that delays to the activity have the potential to occur and, as a result, may issue a one-year renewal to the IHA.

On a case-by-case basis, the Permits Division may issue a one-time, one-year IHA renewal following notice to the public providing an additional 15-days for public comment when: (1) up to another year of identical, or nearly identical, activities as described in the description of the proposed activity section of the *Federal Register* notice (88 FR 56964-56993) is planned; or (2) the activities as described in the description of the proposed activity section of the *Federal Register* notice (88 FR 56964-56993) will not be completed by the time the IHA expires and a second IHA (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 IHA effective date (recognizing that the renewal IHA expiration date cannot extend beyond 1 year from the expiration of the initial IHA).
- The request for renewal must include the following: (1) an explanation that the activities to be conducted under the proposed renewal IHA are identical to the activities analyzed under the initial IHA, are a subset of the activities, or include changes so minor (e.g., reduction in pile size) that the changes do not affect the previous analyses, mitigation and monitoring requirements, or take estimates (with the exception of reducing the type or amount of take); 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, Permits 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 IHA remain valid.

On August 21, 2023, Permits Division published a notice of proposed IHA and request for comments on the proposed IHA and possible renewal in the *Federal Register* (88 FR 56964-56993). The public comment period closed on September 20, 2023. The Permits Division did not receive any public comments. Appendix A (Section 17) contains the Permits Division's proposed IHA and possible renewal. The text in Appendix A (Section 17) was taken directly from the proposed IHA and possible renewal provided to us in the consultation initiation package.

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

In order to issue an IHA under section 101(a)(5)(D) of the MMPA, the Permits 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 (latter not applicable for the proposed actions). Permits 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 Permits Division carefully considers 2 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, the Permits Division 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 Permits Division reviewed seismic mitigation protocols required or recommended elsewhere (HESS 1999; Kyhn et al. 2011; Nowacek et al. 2013; JNCC 2017), recommendations received during public comment periods for previous actions, and the available scientific literature. The Permits Division also considered recommendations given in a number of review articles (Weir and Dolman 2007; Compton et al. 2008; Parsons et al. 2009; Wright and Consentino 2015). This exhaustive review and consideration of public comments regarding previous similar activities led to development of the protocols included in the section below.

3.3 National Science Foundation, Lamont-Doherty Earth Observatory of Columbia University, and National Marine Fisheries Service's Conservation Measures

The NSF and L-DEO must implement conservation measures (i.e., mitigation [pre-planning and during seismic survey activities], monitoring, and reporting measures) in order for their action to result in the least practicable adverse impact on marine mammal species or stocks and to reduce the likelihood of adverse effects to ESA-listed marine species or adverse effects on their designated critical habitats. Mitigation is a measure that avoids or reduces the severity of the effects of the action on ESA-listed species and their habitat. 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 and their habitat are successful.

NSF and L-DEO indicated that they reviewed monitoring and conservation measures implemented during seismic surveys authorized by Permits Division under previous IHAs, as well as recommended best practices in Richardson et al. (1995a), Pierson et al. (1998), Weir and Dolman (2007), Nowacek et al. (2013), Wright (2014), and Wright and Consentino (2015), and incorporated a suite of monitoring and conservation measures into their proposed actions based on the above sources.

Under the MMPA, the Permits Division requires mitigation, monitoring, and reporting measures that the NSF and L-DEO will implement during the high-energy seismic survey, listed below. Additional detail for each mitigation and monitoring measure is in subsequent sections of this opinion:

- Proposed shutdown and buffer zones;
- Shutdown procedures;
- Pre-start clearance and ramp-up procedures;
- Vessel-based visual monitoring by NMFS-approved protected species observers (PSOs);
- Vessel strike avoidance measures;
- Additional conservation measures considered; and
- Reporting.

A summary table of the mitigation and monitoring protocols are in Table 1 (high-energy) and Table 2 (low-energy). Additional details for the mitigation and monitoring measures (e.g., shutdown and ramp-up procedures) as well as reporting can be found in Permits Division *Federal Register* notice of proposed IHA and possible renewal (88 FR 37390-37422) and Appendix A (Section 17).

Table 1. Proposed Mitigation and Monitoring Protocols for the High-Energy Airgun Array in the National Marine Fisheries Service Permits and Conservation Division's Proposed Incidental Harassment Authorization and Possible Renewal

Mitigation and Monitoring Protocols	High-Energy Airgun Array (36 Airguns with 108,154.6 cubic centimeters (6,600 cubic inches)
Vessel-Based Visual Mitigation Monitoring	Minimum of 2 NMFS-approved PSOs on duty during daylight hours (30 minutes before sunrise through 30 minutes after sunset); General limit of 2 consecutive hours on watch followed by a break of at least 1 hour; Maximum of 12 hours on watch per 24-hour period.

Mitigation and Monitoring Protocols	High-Energy Airgun Array (36 Airguns with 108,154.6 cubic centimeters (6,600 cubic inches)
Passive Acoustic Monitoring	Minimum of 1 NMFS-approved PAM operator on duty from 30 minutes before start of source to 1 hour past the end of source use; Limit of 4 consecutive hours on watch followed by a break of at least 1 hour; Maximum of 12 hours on watch per 24-hour period
Buffer Zones	1,000 meters (3280 ft; marine mammals) 150 meters (492 ft; sea turtles)
Shutdown Zones	500 meters (1,640 ft; marine mammals, except certain large assemblages) 1,500 meters (4,921 ft; large whales with calves, and groups of 6 or more large whales) 150 meters (492 ft; sea turtles)
Pre-Start Clearance and Ramp-Up Procedures	Required; 30-minute clearance period of the following zones: • 1,000 meters (3280 ft; marine mammals) • 150 meters (492 ft; sea turtles) Following detection within zone, animal must be observed exiting or additional period of 15 or 30 minutes
Ramp-Up Procedures	Required; duration ≥ 20 minutes
Shutdown Procedures	Shutdown required for marine mammals and sea turtles detected within defined shutdown zones; Exception for certain delphinids; Re-start allowed following clearance period of 15 or 30 minutes
Vessel Strike Avoidance Measures	Vigilant watch by PSOs and crew; vessel speeds reduced when assemblages of marine mammals observed near the research vessel; maintain a minimum separation distance between species of concern; avoid vessel course changes in the vicinity of marine mammals.

Table 2. Proposed Mitigation and Monitoring Protocols for the Low-Energy Airgun Array in the National Marine Fisheries Service Permits and Conservation Division's Proposed Incidental Harassment Authorization and Possible Renewal

Mitigation and Monitoring Protocols	Low-Energy Airgun Array (2 Airguns with 1,474.8 cubic centimeters (90 cubic inches)
Vessel-Based Visual Mitigation Monitoring	Minimum of 2 NMFS-approved PSOs on duty during daylight hours (30 minutes before sunrise through 30 minutes after sunset); General limit of 2 consecutive hours on watch followed by a break of at least 1 hour; Maximum of 12 hours on watch per 24-hour period.
Passive Acoustic Monitoring	Not required
Buffer Zones	200 meters (656 ft; marine mammals) 100 meters (328 ft; sea turtles)
Shutdown Zones	100 meters (328 ft; marine mammals, except certain large assemblages) 500 meters (1,640 ft; large whales with calves, and groups of 6 or more large whales) 100 meters (328 ft; sea turtles)
Pre-Start Clearance and Ramp-Up Procedures	Required; 30-minute clearance period of the following zones: • 200 meters (656 ft; marine mammals) • 100 meters (328 ft; sea turtles) Following detection within zone, animal must be observed exiting or additional period of 15 or 30 minutes
Ramp-Up Procedures	Required for arrays only, no minimum duration required
Shutdown Procedures	Shutdown required for marine mammals and sea turtles detected within defined shutdown zones; Exception for certain delphinids; Re-start allowed following clearance period of 15 or 30 minutes
Vessel Strike Avoidance Measures	Vigilant watch by PSOs and crew; vessel speeds reduced when assemblages of marine mammals observed near the research vessel; maintain a minimum separation distance between species of concern; avoid vessel course changes in the vicinity of marine mammals.

3.3.1 Proposed Shutdown and Buffer Zones

The Permits Division will require, and the NSF and L-DEO will implement, shutdown and buffer zones around the R/V *Langseth* to minimize any potential adverse effects of the sound from the airgun array on MMPA and ESA-listed species. The NSF and L-DEO included mitigation and monitoring measures for sea turtles as part of its proposed action. The shutdown zones are areas within which occurrence of a marine mammal or sea turtle triggers a shutdown of the airgun array, to reduce exposure of marine mammals or sea turtles to sound levels expected to have adverse effects on the species or their habitats. These shutdown zones are based upon modeled sound levels at various distances from the R/V *Langseth*, and correspond to the respective species sound threshold for ESA harm (e.g., injury) and harassment. The buffer zone means an area beyond the shutdown zone monitored for the presence of marine mammals and sea turtles that may enter the shutdown zone.

3.3.1.1 Ensonified Area

Since the NMFS 2018 *Revisions to Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing* (NOAA 2018), we recognize that ensonified area/volume can be more technically challenging to predict because of the duration component in the new thresholds. As a result, 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 from PTS. 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 and this may result in PTS overestimates. However, when more sophisticated three-dimensional modeling methods are not available, these tools offer the best way to predict appropriate isopleths. 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 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 NSF's environmental assessment (LGL 2023) and L-DEO's IHA application and Permits Division's proposed IHA and possible renewal (88 FR 56964-56993).

For behavioral harassment, the L-DEO conducted modeling on behalf of the NSF and UTIG. 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). Using this model, L-DEO estimated the distances shown in Table 3 and Table 4 for the proposed MCS and OBS refraction surveys. The L-DEO model results are used to determine the 160 dB re: 1 μPa at 1 meter (rms) and 175 dB re: 1 μPa at 1 meter (rms) radii for a single 40 cubic inch airgun array and 36-airgun array within the survey area's intermediate (100-1,000 meters deep [328-

3,280.8 feet]) and deep waters (greater than 1,000 meters [3,280.8 feet]). For Level B harassment under the MMPA, and behavioral responses under the ESA, NMFS has historically relied on an acoustic threshold of 160 dB re: 1 μPa (rms) for impulsive sound sources. These values are based on mysticete behavioral response observations, but are used for all marine mammals species. This constitutes harassment under the ESA. Also, 175 dB re: 1 μPa at 1 meter (rms) corresponds to the behavioral disturbance threshold for sea turtles (constituting harassment under the ESA). This is based on data from McCauley et al. (2000b) that reported an increased swimming speed and increasingly erratic behavior for both green and loggerhead turtles at received levels of 175 dB re: 1 μPa (rms).

Table 3. Predicted Distances to which Sound Levels of 160 dB re: 1 μPa at 1 meter (rms) for Impulsive Sources will be Received from the Single Airgun, the 2-Airgun Array, and the 36-Airgun Array in Intermediate and Deep Water Depths for Marine Mammals during the Proposed MCS and OBS Refraction Surveys off Puerto Rico

Source	Volume (in^3)	Water Depth (m)	Predicted Distance to Threshold (160 dB re: 1 μPa [rms]) (m)
1 Airgun Tow Depth: 12 m	40	100-1,000	647
		>1,000	431
2 Airguns Tow Depth: 3 m	90	100-1,000	657
		>1,000	438
36 Airguns Tow Depth: 12 m	6600	100-1,000	10,100
		>1,000	6,733

in^3=cubic inches; m=meters

Table 4. Predicted Distances to Which Sound Levels of 175 dB re: 1 μPa at 1 meter (rms) will be Received from the Single Airgun, the 2-Airgun Array, and the 36-Airgun Array in Intermediate and Deep Water Depths for Sea Turtles During the Proposed MCS and OBS Refraction Surveys off Puerto Rico

Source	Volume (in^3)	Water Depth (m)	Predicted Distance to Threshold (175 dB re: 1 μPa at 1 meter [rms]) (m)
1 Airgun Tow Depth: 12 m	40	100-1,000	116
		>1,000	77

Source	Volume (in^3)	Water Depth (m)	Predicted Distance to Threshold (175 dB re: 1 µPa at 1 meter [rms]) (m)
2 Airguns Tow Depth: 3 m	90	100-1,000	117
		>1,000	78
36 Airguns Tow Depth: 12 m	6,600	100-1,000	2,796
		>1,000	1,864

in^3=cubic inches; m=meters

3.3.1.2 Establishment of Proposed Shutdown and Buffer Zones

As noted above, a shutdown zone is a defined area within which occurrence of an animal triggers a mitigation action intended to reduce the potential for certain outcomes (e.g., auditory injury and disruption of critical behaviors). In addition, the buffer zone means an area beyond the shutdown zone monitored for the presence of marine mammals and sea turtles that may enter the shutdown zone. Shutdown and buffer zones for marine mammals and sea turtles are in Table 1 and Table 2. The shutdown zones are based on the radial distance from any element (the edges) of the airgun array (rather than being based on the center of the airgun array or around the vessel itself). With certain exceptions (described below), if a marine mammal or sea turtle appears within, enters, or appears on course to enter this zone, the airgun array will be powered-down or shut down, depending on the circumstance.

The shutdown zone for marine mammals is intended to be precautionary meaning it will be expected to contain sound exceeding the injury criteria for all cetacean hearing groups (based on the dual criteria of the SEL_{cum} and peak SPL), while also providing a consistent, reasonably observable zone within which PSOs will typically be able to conduct effective observations. Additionally, a 500-meter (1,640.4 foot) shutdown zone for the high-energy survey, and a 100-meter (328 feet) for the low-energy survey are expected to minimize the likelihood that marine mammals will be exposed to levels likely to result in more severe behavioral responses. Although significantly greater distances may be observed from an elevated platform under good conditions, the Permits Division believes that 500 meters (1,640.4 feet) is likely regularly attainable for PSOs using the naked eye during typical conditions. For the high-energy survey, 150 meters (492.16 feet) is a practicable shutdown zone for PSOs to implement shutdowns for sea turtles, as is 100 meters (328 feet) for the low-energy survey. This zone is sufficiently large to prevent sea turtles from exposure to sound levels that could result in the onset of PTS in hearing because of auditory injury and, therefore, harm under the ESA.

NSF's draft environmental analysis and L-DEO's IHA application have detailed descriptions of the modeling for the R/V *Langseth*'s airgun arrays, as well as the resulting isopleths to behavioral thresholds for the various marine mammal hearing groups and sea turtles (Table 3 and Table 4). Predicted distances to PTS threshold isopleths for the proposed MCS and OBS refraction surveys, which vary based on marine mammal hearing group and sea turtle thresholds, were calculated based on modeling performed by L-DEO using the NUCLEUS software program and the NMFS User Spreadsheet (https://www.fisheries.noaa.gov/action/user-manual-optional-spreadsheet-tool-2018-acoustic-technical-guidance; Table 5). NSF and L-DEO presented the PTS threshold distances based on a 50-meter shot interval used during the MCS reflection surveys because they are more conservative than the 400-meter shot interval used in the OBS seismic refraction surveys. For a discussion on how we evaluated and adopted the NSF and L-DEO's analysis, see Section 10.3.

Table 5. PTS Threshold Distances for Different Marine Mammal Hearing Groups and Sea Turtles for the 36-Airgun Array Based on a Speed of 7.6 kilometers per hour (4.1 knots) and a Shot Interval of 50 meters (164 feet)

Threshold	Low Frequency Cetaceans (m)	Mid Frequency Cetaceans (m)	High Frequency Cetaceans (m)	Sea Turtles (m)
Source – 36-Airgun Array, 50-meter shot interval				
SEL_{cum}	**320.2**	0	1.0	**15.4**
Peak SPL_{flat}	38.9	**13.6**	**268.3**	10.6

m=meters

3.3.1.3 Shutdown Procedures

The shutdown of the airgun array requires the immediate deactivation of all individual elements of the airgun array. Any PSO on duty will have the authority to delay the start of seismic survey activities or to call for shutdown of the airgun array if a marine mammal is detected within the applicable shutdown zone. The operator must also establish and maintain clear lines of communication directly between PSOs on duty and crew controlling the airgun array to ensure that shutdown commands are conveyed swiftly while allowing PSOs to maintain watch. When the airgun array is active (i.e., anytime 1 or more airgun is active, including during ramp-up) and a marine mammal (excluding specific non-ESA-listed delphinid species) appears within or enters the shutdown zone and/or a marine mammal is detected acoustically within the shutdown zone, the airgun array must be shut down. When shutdown is called for by a PSO, the airgun array must be immediately deactivated and any dispute regarding a PSO shutdown must be resolved only following deactivation. Additionally, shutdown will occur whenever PAM alone (without visual sighting) confirms the presence of marine mammals in the shutdown zone. (Note that PAM is required for the high-energy survey, but not the low-energy survey.) If the acoustic PSO cannot confirm presence within the shutdown zone, visual PSOs would be notified but shutdown is not required.

Following a shutdown, airgun array activity will not resume until the marine mammal has cleared the shutdown zone. These conditions apply to both the high and low-energy surveys. The animal will be considered as having cleared the shutdown zone if:

- It is visually observed to have departed the shutdown zone; or
- It has not been seen within the shutdown zone after a clearance period of
  - 15 minutes in the case of small odontocetes, or
  - 30 minutes in the case of mysticetes and all other odontocetes, with no further observation of the marine mammal(s).

This shutdown procedure requirement would be in place for all marine mammals, with the exception of small delphinids under certain circumstances. As described above, auditory injury is extremely unlikely to occur for mid-frequency cetaceans (e.g., sperm whales and most delphinids), as this group is relatively insensitive to sound produced at the predominant frequencies in an airgun pulse while also having a relatively high threshold for the onset of auditory injury (i.e., PTS).

Visual PSOs will use best professional judgement in making the decision to call for a shutdown if there is uncertainty regarding identification (i.e., whether the observed marine mammal[s] belongs to 1 of the delphinid genera for which shutdown is waived or 1 of the species with a larger shutdown zone).

Shutdown of the airgun array will also be required upon visual observation of a marine mammal species for which MMPA authorization has not been granted, or a marine mammal species for which authorization has been granted but the authorized number of takes are met, that is observed approaching, or observed within MMPA Level A and Level B harassment zones.

In addition to the shutdown procedure described above, during the high-energy survey, the Permits Division's MMPA IHA will require the airgun array be shut down at a distance of 1,500 meters (4,921.3 feet) when:

- All beaked whales;
- Dwarf and pygmy sperm whales (*Kogia* spp.);
- Any large whale (defined as a sperm whale or any mysticete [baleen whale]) species with a calf (defined as an animal less than two-thirds the body size of an adult observed to be in close association with an adult) is observed at any distance; and
- An aggregation of 6 or more large whales is observed at any distance.

No buffer zone is required for the extended 1,500-meter (4,921.3 feet) zone. For the low-energy survey, these same conditions apply, except the shutdown will be implemented at a distance of 500 meters (1,640 feet).

The NSF and L-DEO will implement a shutdown at a distance of 150 meters (492.1 feet) for ESA-listed sea turtles during the high-energy surveys, and 100 meters (328 feet) during the low-energy surveys. The airgun array will be shut down if a sea turtle is seen approaching or within the shutdown zone. Following a shutdown for ESA-listed sea turtles, the airgun array will not resume until the ESA-listed sea turtle has cleared the shutdown zone. The animal is considered to have cleared the shutdown zone if:

- It is visually observed to have left the shutdown zone; and
- It is not been seen within the shutdown zone for 15 minutes.

More details on shutdown procedures are in Appendix A, which contains the Permits Division's proposed IHA and possible renewal (Section 17).

3.3.2 Pre-Start Clearance and Ramp-Up Procedures

The procedures in this section apply to both the low- and high-energy surveys, with the following exception: PAM is not required for the low-energy survey. A 30-minute pre-start clearance observation period ensures no protected species are observed within the buffer zone and shutdown zone (or extended shutdown zone) prior to the beginning of ramp-up. During pre-start clearance is the only time observations of protected species in the buffer zone will prevent operations (i.e., the beginning of ramp-up). Ramp-up (sometimes referred to as "soft-start") means the gradual and systematic increase of emitted sound levels from an airgun array. The intent of ramp-up is to warn protected species of pending seismic survey actions (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 an increase in total airgun array volume until all operational airguns are activated and the full volume is achieved, is required at all times as part of the activation of the airgun array. Ramp-up 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. Two PSOs will be required to monitor during ramp-up.

Operators must adhere to the following pre-start clearance and ramp-up requirements:

- Thirty minutes of pre-start clearance observation of the shutdown and buffer zone is required prior to ramp-up for any shutdown of longer than 30 minutes (e.g., when the airgun array is shutdown during transits from 1 trackline to another). This pre-start clearance period may occur during any vessel activity (e.g., transit).
    - If any marine mammal is observed within or approaching the shutdown or buffer zone during the 30 minute pre-start clearance period, ramp-up may not begin until the animal(s) has been observed exiting the shutdown zone or until an additional time period has elapsed with no further sightings (i.e., 15 minutes for small odontocetes, and 30 minutes for mysticetes and all other odontocetes).
- The operator must notify a designated PSO of the planned start of ramp-up as agreed upon with the lead PSO.

    - The notification time must not be less than 60 minutes prior to the planned ramp-up in order to allow the PSOs time to monitor the shutdown zone and buffer zone for 30 minutes prior to the initiation of ramp-up (pre-start clearance).
    - One of the PSOs conducting pre-start clearance observations must be notified again immediately prior to initiating ramp-up procedures and the operator must receive confirmation from the PSO to proceed.
- Ramp-ups must be scheduled so as to minimize the time spent with the airgun array activated prior to reaching the designated run-in.
- Ramp-up may not be initiated if any marine mammal is within the applicable shutdown zone or buffer zone.
    - If a marine mammal is observed within the applicable shutdown zone or the buffer zone during ramp-up, a shutdown must be implemented as though the full airgun array were operational.
    - Ramp-up may not begin until the animal(s) has been observed exiting the shutdown or buffer zones or until an additional period has elapsed with no further sightings (15 minutes for small odontocetes, and 30 minutes for mysticetes and all other odontocetes.
- Ramp-up must begin by activating a single airgun of the smallest volume in the airgun array and must continue in stages by doubling the number of active airguns at the commencement of each stage, with each stage of approximately the same duration. Duration must not be less than 20 minutes. The operator must provide information to the PSO documenting the appropriate procedures were followed;
- PSOs must monitor the shutdown and buffer zones during ramp-up.
    - Ramp-up may not be initiated or must cease and the airgun array must be shutdown upon detection of a marine mammal within the applicable shutdown zone.
    - Once ramp-up has begun, detections 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.
    - Ramp-up may occur at times of poor visibility, including nighttime, if appropriate PAM has occurred with no detections in the 30 minutes prior to beginning ramp-up where operational planning cannot reasonably avoid such circumstances. Ramp-up may occur at night and during poor visibility if the shutdown and buffer zone have been continually monitored by PSOs for 30 minutes prior to ramp-up. Airgun array activation may only occur at times of poor visibility where operational planning cannot reasonably avoid such circumstances.
- If the airgun array is shutdown 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 acoustic and/or visual

monitoring and no acoustic or visual detections of marine mammals have occurred within the applicable shutdown 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., Beaufort sea state 4 or greater), ramp-up is required, but if the shutdown period was brief and constant observation was maintained, pre-start clearance watch of 30 minutes is not required; and

- Testing of the airgun array involving all airguns 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-start clearance (visual monitoring for 30 minutes).

Ramp-up procedures will not be required for ESA-listed sea turtles if they are not observed within the shutdown zone.

More details on pre-start clearance and ramp-up procedures are in Appendix A (Section 17), which contains the Permits Division's proposed IHA and possible renewal.

3.3.3 Vessel-Based Visual Mitigation Monitoring

Visual monitoring requires the use of trained PSOs to scan the ocean surface visually for the presence of marine mammals or sea turtles. The area to be scanned visually includes primarily the shutdown zones, but also the buffer zone, to implement the conservation measures discussed above.

The NSF and L-DEO must use at least 5 dedicated, trained, NMFS-approved PSOs. The PSOs must have no tasks other than to conduct observational effort, record observational data, and communicate with and instruct relevant vessel crew with regard to the presence of marine mammals and sea turtles and mitigation requirements. The PSO resumes shall be provided to NMFS for approval as part of the IHA application process.

At least 1 of the visual and 2 of the acoustic PSOs aboard the vessel must have a minimum of 90 days at-sea experience working in those roles, respectively, during a deep penetration (i.e., high-energy) seismic survey, with no more than 18 months elapsed since the conclusion of the at-sea experience. One visual PSO with such experience shall be designated as the lead for the entire PSO team. The lead PSO shall serve as the primary point of contact for the vessel operator and ensure all PSO requirements detailed in the MMPA IHA and the ITS are met. To the maximum extent practicable, experienced PSOs will be on duty with PSOs that have appropriate training but who have not yet gained relevant field experience.

During seismic survey activities (e.g., any day in 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 2 visual PSOs must be on duty conducting visual observations at all times during daylight hours (i.e., from 30 minutes prior to sunrise through 30 minutes following sunset) and 30 minutes prior to and during nighttime ramp-ups of the airgun array. Visual monitoring of the shutdown and buffer zones must begin no less than 30 minutes prior to ramp-up and must continue until 1 hour after use of the airgun array ceases or until 30 minutes past sunset. Visual PSOs shall coordinate to ensure 360-degree visual coverage around the vessel from the most appropriate observation posts, and shall conduct visual observations using binoculars and the naked eye while free from distractions and in a consistent, systematic, and diligent manner. Visual PSOs will systematically scan around the research vessel with Big-Eye reticle binoculars (25 x 150), handheld reticle binoculars (e.g., 7 x 50 Fujinon), and with the naked eye. PSOs will also have night vision devices (ITT F500 Series Generation 3 binocular-image intensifier or equivalent) during darkness, if necessary. At a minimum, the night vision device should feature automatic brightness and gain control, bright light protection, infrared illumination, and optics suited for low-light situations.

Visual PSOs will immediately communicate all observations to the on-duty acoustic PSO(s), including any determination by the PSO regarding species identification, distance, and bearing and the degree of confidence in the determination. Any observations of marine mammals and sea turtles by crewmembers will be relayed to the PSO team. During good conditions (e.g., daylight hours, Beaufort sea state of 3 or less), visual PSOs will conduct observations when the airgun array is not operating 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 PSOs may be on watch for a maximum of 4 consecutive hours followed by a break of at least 1 hour between watches and may conduct a maximum of 12 hours of observation per 24-hour period. Combined observational duties (visual and acoustic, but not at the same time) may not exceed 12 hours per 24-hour period for any individual PSO.

For data collection purposes, 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 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 shutdown was implemented, the length of time before any subsequent ramp-up of the airgun array. If required mitigation is not implemented, PSOs shall record a description of the circumstances. At a minimum, the following information must be recorded:

- Vessel name and call sign.
- PSO names and affiliations.
- Dates of departures and returns to port with port name.
- Date and participants for PSO briefings.
- Dates and times (Greenwich Mean Time) of survey effort and times corresponding with PSO effort.
- Vessel location (latitude/longitude) when survey effort began and ended and vessel location at beginning and end of visual PSO duty shifts.

- Vessel heading and speed at beginning and end of visual PSO duty shifts and upon any line change.
- Environmental conditions while on visual survey (at beginning and end of PSO 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 PSO shift change or as needed as environmental conditions changed (e.g., vessel traffic, equipment malfunctions).
- 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-start clearance, ramp-up, shutdown, testing, shooting, ramp-up completion, end of operations, streamers, etc.).

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

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

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

Mitigation and monitoring will be recorded in a standardized format and data will be entered into an electronic database. The accuracy of the data entry will be verified by computerized data validity checks as data are entered and by subsequent manual checking of the database. These procedures will allow initial summaries of the data to be prepared during and after the seismic survey activities, and will facilitate transfer of the data to statistical, graphical, and other programs for further processing and archiving.

More details on monitoring can be found in Appendix A (Section 17), which contains Permits Division's proposed IHA and possible renewal.

3.3.4 Passive Acoustic Monitoring

For the high-energy surveys only, the Permits Division will require the use of PAM. PAM uses trained personnel, herein referred to as acoustic PSOs, to operate underwater recording equipment (hydrophones) and detect the presence of marine mammals. PAM involves acoustically detecting marine mammals, regardless of distance from the airgun array, because visual localization of animals is not always be possible. PAM is intended to further support visual monitoring (during daylight hours) in maintaining a shutdown zone around the airgun array that is clear of marine mammals. In cases where visual monitoring is not effective (e.g., due to weather, nighttime), PAM may be used to allow certain activities to occur, as further detailed below.

The PAM system will consist of hardware (i.e., towed hydrophone streamer) and software (i.e., Pamguard). The "wet end" of the PAM system consists of a towed hydrophone streamer connected to the research vessel by a tow cable. The steel reinforced tow cable is approximately 250 meters (820.2 feet) long and the detachable hydrophone array is approximately 25 meters (82 feet) long. The hydrophones are fitted along the last 10 meters (32.8 feet) of towed hydrophone streamer with a depth gauge (with 100 meter [328.1 feet] capacity) attached to the free end. The hydrophone streamer is typically towed at a depth of less than 20 meters (65.6 feet). The towed hydrophone streamer will be deployed from a winch located on the stern deck; however, the deployment and connection to the research vessel may change depending upon weather conditions and configuration of the airgun array. The "dry end" of the PAM system consists of a cable on deck that would connect the tow cable to the electronics unit in the main computer laboratory where the PAM station is located. The acoustic signals received by the towed hydrophone streamer are amplified, conditioned, digitized, and processed by Pamguard software. The PAM system can detect marine mammal vocalizations at frequencies from 10 hertz (Hz) to 250 kHz. The hydrophone array will consist of 2 low-frequency hydrophones (10 Hz-24 kHz), 2 mid-frequency hydrophones (200 Hz to 200 KHz), and 2 high-frequency hydrophones (2-200 kHz).

The PAM system must be monitored by a minimum of 1 on-duty acoustic PSO beginning at least 30 minutes prior to ramp-up and at all times (day and night) during the use of the airgun array. When both acoustic and visual PSOs are on-duty, all detections must be immediately communicated to the remainder of the on-duty PSO team for potential verification of visual observations by the acoustic PSO or of acoustic detections by visual PSOs. An acoustic PSO may be on watch for a maximum of 4 consecutive hours followed by a break of at least 1 hour between watches and may conduct a maximum of 12 hours of observation per 24-hour period of any individual PSO. Combined observational duties (acoustic and visual but not at the same time) may not exceed 12 hours of observation per 24-hour period for any individual PSO. All PSOs are expected to rotate through the acoustic and visual positions, although the most experienced with acoustics will be on duty at the PAM system more frequently.

The R/V *Langseth* will use a towed PAM system, which must be monitored by a minimum of 1 on-duty acoustic PSO beginning at least 30 minutes prior to ramp-up and at all times during use of the airgun array.

At least 2 acoustic PSOs aboard the research vessel must have a minimum of 90 days at-sea experience working in that role during deep penetration or high-energy seismic surveys, with no more than 18 months elapsed since the conclusion of their at-sea experience.

When a vocalizing marine mammal is detected while visual monitoring is in progress, the acoustic PSO will contact the visual PSO immediately to alert them to the presence of marine mammals (if they have not already been visually sighted) and to allow for the implementation of mitigation measures, if necessary. The information regarding the vocalization will be entered into an onboard database. The acoustic detection could also be recorded for further analysis.

The following information must be recorded if any marine mammal is detected while using the PAM system:

- An acoustic encounter identification number, and whether the detection was linked with a visual sighting.
- Date and time when first and last heard.
- Types and nature of sounds heard (e.g., clicks, whistles, creaks, burst pulses, continuous, sporadic, strength of signal).
- Any additional information recorded such as water depth of the hydrophone array, bearing of the animal to the vessel (if determinable), species or taxonomic group (if determinable), spectrogram screenshot, and any other notable information.

Seismic survey activities may continue for 30 minutes when the PAM system malfunctions or is damaged, while the PAM operator diagnoses the issue. If the diagnosis indicates that the PAM system must be repaired to solve the problem, operations may continue for an additional 10 hours without PAM during daylight hours only under the following conditions:

- Beaufort sea state is less than or equal to 4.

- No marine mammals (excluding delphinids) detected solely by PAM in the applicable shutdown zone in the previous 2 hours.
- NMFS is notified via email as soon as practicable with the time and location in which operations began occurring without an active PAM system.
- Operations with an active airgun array, but without an operating PAM system, do not exceed a cumulative total of 10 hours in any 24-hour period.

3.3.5 Vessel Strike Avoidance Measures

Vessel strike avoidance measures are intended to minimize the potential for collisions with marine mammals. Permits Division notes that these requirements do not apply in any case where compliance will create an imminent and serious threat to a person or vessel or to the extent that a vessel is restricted in its ability to maneuver and, because of the restriction, cannot comply. These vessel strike avoidance measures include the following:

- The vessel operator (R/V *Langseth*) and crew must maintain a vigilant watch for all marine mammals and slow down or stop or alter course of the vessel, as appropriate and regardless of vessel size, to avoid striking any marine mammal during seismic survey activities as well as transits. A single marine mammal at the surface may indicate the presence of submerged animals near the vessel; therefore, precautionary measures should be exercised when an animal is observed. A visual observer aboard the vessel must monitor a vessel strike avoidance zone around the vessel (specific distances detailed below). Visual observers monitoring the vessel strike avoidance zone may either be third-party PSOs or crew members, but crew members responsible for these duties would 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 North Atlantic right whale, 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 *Langseth*) must maintain a minimum separation distance of 100 meters (1,640.2 feet) from large whales (i.e., all baleen whales and sperm whales). The following vessel avoidance measures would be taken if a large whale is within 100 meters (328.1 feet) of the vessel:
  - The vessel (R/V *Langseth*) would reduce speed and shift the engine to neutral, when feasible, and would not engage the engines until the whale has moved outside of the vessel's path and the minimum separation distance has been established.
  - If the vessel is stationary, the vessel would not engage engines until the whale(s) has moved out of the vessel's path.
- The vessel must, to the maximum extent practicable, 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 (e.g., attempt to remain parallel to the animal's source, avoid excessive speed or abrupt changes in direction until the animal has left the area). If marine mammals are sighted within the relevant separation distance, the vessel must reduce speed and shift the engine to neutral, not engaging the engines until the animal(s) are clear of area. This does not apply to any vessel towing gear or any vessel that is navigationally constrained.

3.3.6 Reporting

In order to issue an IHA for an activity, section 101(a)(5)(D) of the MMPA states that Permits 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 IHAs 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 while conducting the seismic survey activities. Effective reporting is critical both to compliance of the MMPA IHA as well as ensuring that the most value is obtained from the required monitoring.

Monitoring and reporting requirements prescribed by Permits Division will contribute improved understanding of 1 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.

NSF and L-DEO must submit a draft comprehensive report to the Permits Division within 90 days of the completion of the high-energy and low-energy seismic surveys or expiration of the IHA, whichever comes sooner. The report will describe the seismic survey activities that were conducted. The report will provide full documentation of methods, results, and interpretation pertaining to all monitoring and will summarize the dates and locations of seismic survey activities, and all marine mammal sightings (dates, times, locations, activities, associated seismic survey activities). The report will also include estimates of the number and nature of marine mammal exposures that occurred within estimated harassment zones based on PSO observations, including an estimate of those that were not detected, in consideration of both the characteristics and behaviors of the species of marine mammals that affect detectability, as well as the environmental factors that affect detectability.

The draft report shall also include geo-referenced time-stamped vessel tracklines for all periods during which the airgun arrays 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). 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 Permits Division. The report must summarize the data collected as described above and in the IHA. 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) and actions to minimize additional harm to live-stranded (or milling) marine mammals can be found in Appendix A (Section 17), which contains Permits Division's proposed IHA and possible renewal (Section 17).

4 POTENTIAL STRESSORS

The proposed action involves multiple activities, each of which can create stressors. Stressors are any physical, chemical, or biological entity or change in the environment that may affect an ESA-listed species or their critical habitat. During consultation, we deconstructed the proposed action to identify stressors that are reasonably certain to result from the proposed activities. These can be categorized as pollution (e.g., exhaust, fuel, oil, trash, OBS anchors), vessel strikes, acoustic and visual disturbance (research vessel, multi-beam echosounder, sub-bottom profiler, pingers, acoustic Doppler current profiler, OBSs, and seismic airgun array), and entanglement in towed seismic equipment (hydrophone streamers). Section 4 of OPR-2021-02539 (NMFS 2022b; https://doi.org/10.25923/wetp-dt20) provides a detailed overview of the acoustic stressors that will not be repeated here. The opinion, entitled, "Biological opinion on the Lamont-Doherty Earth Observatory's Marine Geophysical Survey by the R/V *Marcus G. Langseth* off Western Mexico in the Eastern Tropical Pacific 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" covers an action similar to that considered in this opinion.

The proposed action includes several conservation measures described in Section 3.3 designed to minimize effects that may result from acoustic stressors and vessel strikes. While we consider all of these measures important and expect them to be effective in minimizing the effects of potential stressors, they do not completely eliminate the identified stressors. Nevertheless, we treat them as part of the proposed action and fully consider them when evaluating the effects of the proposed action (Section 10).

5 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). Action means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by Federal agencies in the United States or upon the high seas (50 CFR 402.02).

The proposed marine seismic surveys will occur within an area bounded by ~17–21°North, ~63.6–68.5°West. Representative survey tracklines are shown in Figure 1. As described further in this document, some deviation in actual tracklines, including the order of survey operations, could occur because of data quality, inclement weather, or mechanical issues with the research vessel and/or equipment.

The surveys are proposed within the Exclusive Economic Zones (EEZ) of Puerto Rico, U.S. Virgin Islands, British Virgin Islands, and the Dominican Republic, in-water depths ranging from ~100–8,400 m. The low-energy survey is also proposed to extend into the territorial waters of Puerto Rico with the closest approach of the lines to land is within ~3 kilometers on the southwestern flank of Puerto Rico. The survey (tracklines or ensonified area) will not take place in the territorial waters of any other country (British Virgin Islands, or the Dominican Republic). The closest approach of the high-energy survey lines to land is ~8 kilometers to Puerto Rico (within the territorial waters of Puerto Rico [9 nautical miles]), ~13 kilometers to the British Virgin Islands, 42 kilometers to Dominican Republic, and 68 kilometers to the U.S. Virgin Islands.

Acquisition of wide-angle reflection/refraction seismic data using OBSs will occur along 3 major transects (Central-Central South, East, and West). MCS data will be acquired along transects MCS 1-3 and along transects A1-4. MCS West, Central, and East coinciding with the OBS profiles north of the island. Thus, those transects will be acquired twice (once with OBS and once with MCS). The Central South line will only be acquired once during OBS refraction surveys.

The action area includes the survey tracklines and the adjacent area ensonified by the airgun array during the seismic survey and the path of the vessel transit to and from the survey area (discussed in more detail in the Ensonified Area section of the Exposure Analysis). An array of land seismometers are planned to be deployed on Puerto Rico on properties along PR-149 to connect the Central and Central South OBS marine profiles. The land-based seismic research activities are not expected to have any effects on the marine environment and, therefore, are not analyzed in this consultation.

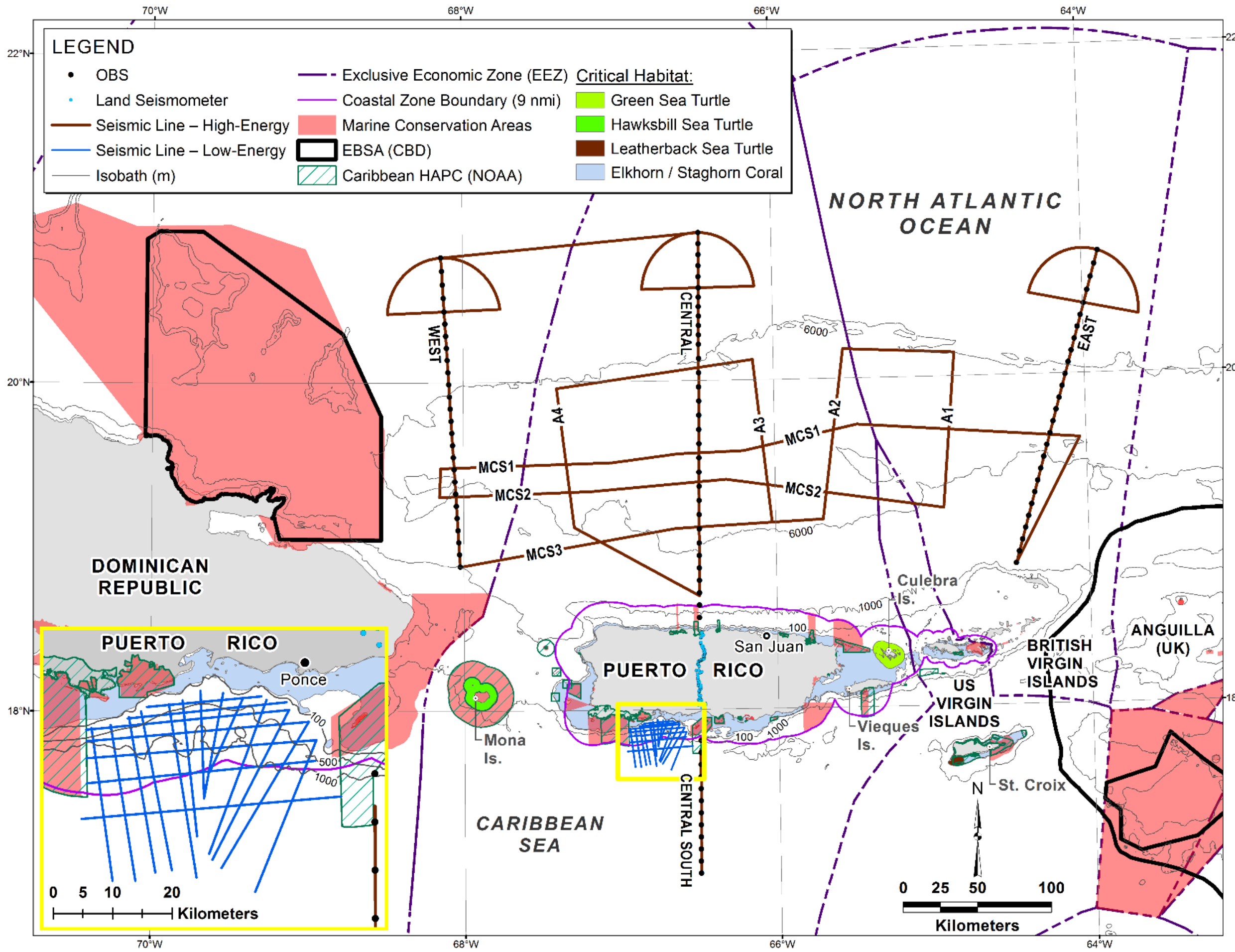

Figure 1. Map of proposed seismic surveys (low-energy survey shown in inset) near Puerto Rico with OBS deployments, marine conservation areas, and critical habitat

6 Endangered Species Act-Listed Species and Designated Critical Habitat Present in the Action Area

This section identifies the ESA-listed resources that potentially occur within the action area (Section 5) and may be affected by the proposed actions (Table 6). These ESA-listed species and 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 (Section 4).

Table 6. Threatened and endangered species, designated and proposed critical habitat that may be affected by the proposed action

Species	ESA Status	Critical Habitat	Recovery Plan
Marine Mammals – Cetaceans			
Blue Whale (*Balaenoptera musculus)*	E – 35 FR 18319	-- --	07/1998 11/2020 - First Revision
Fin Whale (*Balaenoptera physalus)*	E – 35 FR 18319	-- --	75 FR 47538 07/2010
Sei Whale (*Balaenoptera borealis*)	E – 35 FR 18319	-- --	12/2011
Sperm Whale (*Physeter macrocephalus*)	E – 35 FR 18319	-- --	75 FR 81584 12/2010
Marine Reptiles			
Green Turtle (*Chelonia mydas*) – North Atlantic DPS	T – 81 FR 20057	63 FR 46693 88 FR 46572 (Proposed)	FR Not Available 10/1991 – U.S. Atlantic
Green Turtle (*Chelonia mydas*) – South Atlantic DPS	T – 81 FR 20057	-- --	-- --
Hawksbill Turtle (*Eretmochelys imbricata)*	E – 35 FR 8491	63 FR 46693 Atlantic	57 FR 38818 Atlantic
Olive Ridley Turtle (*Lepidochelys olivacea*) All other populations	E – 43 FR 32800	-- --	-- --
Leatherback Turtle (*Dermochelys coriacea*)	E – 35 FR 8491	44 FR 17710 Atlantic – not in action area	63 FR 28359 10/1991 – U.S. Caribbean, Atlantic, and Gulf of Mexico
Loggerhead Turtle (*Caretta caretta*) – Northwest Atlantic Ocean DPS	T – 76 FR 58868	79 FR 39855 – not in action area	74 FR 2995 12/2008 – Northwest Atlantic
Fishes			
Giant Manta Ray (*Manta birostris*)	T – 83 FR 2916	-- --	-- --

Species	ESA Status	Critical Habitat	Recovery Plan
Nassau Grouper (*Epinephelus striatus*)	T – 81 FR 42268	87 FR 62930 (Proposed)	2018 -- Outline
Oceanic Whitetip Shark (*Carcharhinus longimanus*)	T – 83 FR 4153	-- --	9/2018- Outline
Scalloped Hammerhead Shark (*Sphyrna lewini*) – Central and Southwest Atlantic DPS	T – 79 FR 38213	-- --	-- --
Invertebrates			
Elkhorn Coral (*Acropora palmata*)	T – 79 FR 53851	73 FR 72210	80 FR 12146
Staghorn Coral (*Acropora cervicornis*)	T – 79 FR 53851	73 FR 72210	80 FR 12146
Boulder Star Coral *(Orbicella franksi)*	T – 79 FR 53851	85 FR 76262 (Proposed)	-- --
Lobed Star Coral (*Orbicella annularis*)	T – 79 FR 53851	85 FR 76302 (Proposed)	-- --
Mountainous Star Coral (*Orbicella faveolata*)	T – 79 FR 53851	85 FR 76302 (Proposed)	-- --
Rough Cactus Coral *(Mycetophyllia ferox)*	T – 79 FR 53851	85 FR 76302 (Proposed)	-- --
Pillar Coral (*Dendrogyra cylindrus*)	T – 79 FR 53851 (Proposed E – 88 FR 59494)	88 FR 54026	-- --
Queen Conch (*Alger gigas*)	T – 87 FR 67853 (Proposed)	-- --	-- --

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

7 Species and Critical Habitat Not Likely to be Adversely Affected

This section identifies the ESA-listed and proposed species and designated and proposed critical habitat under NMFS jurisdiction that may occur within the action area (as described in Section 5) but 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 and proposed species and designated and proposed critical habitat that may occur within the action area.

NMFS uses 2 criteria to identify the ESA-listed species or designated critical habitat that are not likely to be adversely affected by the proposed actions, 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 1 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. An ESA-listed species or designated critical habitat that co-occurs with a stressor of the action but is not likely to respond to the stressor is also not likely to be adversely affected by the proposed actions. We applied these criteria to the ESA-listed species and designated critical habitats in Section 6 and we summarize our results below.

We reach a "may affect, not likely to be adversely affected" finding for species or critical habitat when the action’s 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 response of the individual or critical habitat 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 a species or critical habitat is likely to be exposed to a stressor, but the response would not rise to the level of constituting an adverse effect.

Discountable effects relate to the exposure of species or critical habitat to a stressor. For an effect to be discountable, we must conclude that the likelihood of exposure is extremely 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 critical habitat. This same decision model applies to individual stressors associated with the proposed actions, such that some stressors may be determined as not likely to adversely affect ESA-listed species or critical habitat because any effects associated with the stressors were found to be wholly *beneficial, insignificant*, or *discountable*.

In Section 7.1, we evaluate the proposed action’s stressors (Section 4) that are not likely to adversely affect any ESA-listed or proposed species or designated or proposed critical habitat. We also identify ESA-listed or proposed species and designated or proposed critical habitat that are not likely to be adversely affected by all stressors from the proposed action (Section 7.2 to 7.3).

7.1 Stressors Not Likely to Adversely Affect Listed or Proposed Species or Proposed and Designated Critical Habitat

Stressors that may affect, but are not likely to adversely affect the ESA-listed or proposed cetaceans, sea turtles, fishes, invertebrates, and designated or proposed critical habitat considered in this opinion (see Table 6) include pollution, vessel strike, vessel noise and visual disturbance, gear entanglement and interaction, and acoustic noise from a sub-bottom profiler, multi-beam echosounder, acoustic Doppler current profiler, and OBS acoustic release. The following sections describe how we reached our effects determinations for these stressors.

7.1.1 Pollution

Pollution in the form of vessel exhaust, fuel or oil spills or leaks, and trash or other debris resulting from the use of vessels as part of the proposed action could result in impacts to ESA-listed marine mammals, sea turtles, and fishes.

Exhaust (i.e., air pollution, including carbon dioxide, nitrogen oxides, and sulfur oxides) from the research vessel will be emitted during the entirety of the proposed actions during all vessel transit and operations, and could affect air-breathing ESA-listed species such as marine mammals and sea turtles. The R/V *Langseth* uses marine fuel oil, which is considered a low sulfur fuel oil because its sulfur content is between 0.10 and 1.50% mass concentration (https://www.marineinsight.com/guidelines/a-guide-to-marine-gas-oil-and-lsfo-used-on-ships/#Sulfur_Content_in_Marine_Gas_Oil). It is unlikely that vessel exhaust resulting from the operation of the R/V *Langseth* will have a measurable impact on ESA-listed marine mammals or sea turtles given the relatively short duration of the proposed action (~45 days), the brief amount of time that whales and sea turtles spend at the surface, and the various regulations to minimize air pollution from vessel exhaust, such as the NSF's compliance with the Act to Prevent Pollution from Ships (33 U.S.C. §§ 1901-1905). For these reasons, the effects that may result from vessel exhaust on ESA-listed marine mammals and sea turtles are considered insignificant.

Discharges into the water from the R/V *Langseth* in the form of wastewater or leakages of fuel or oil are possible, though effects of any spills to ESA-listed marine mammals, sea turtles, and fishes considered in this opinion will be minimal, if they occur at all. The potential for fuel or oil leakages is extremely unlikely to occur and thus discountable.

The research vessel used during the NSF-funded high-energy seismic survey has spill-prevention plans, which will allow a rapid response to a spill in the event 1 occurs. In addition to this, NSF has never had a fuel or oil spill over many years of conducting similar surveys. The R/V *Langseth* is a UNLOS-designated vessel, meaning that it must adhere to UNLOS Research Vessel Safety Standards, which include requirements for pollution prevention (UNLOS 2021). Further, given the experience of the researchers and vessel operators in conducting activities in the action area, it is extremely unlikely that spills or discharges of pollutants will occur. Thus, we find that the risk from this potential stressor on ESA-listed cetaceans, sea turtles, fishes, listed and proposed invertebrates, and designated or proposed critical habitat is discountable.

Wastewater from the vessel will be treated in accordance with U.S. Coast Guard standards (33 C.F.R. §151 and §159). In addition, given the large size of the action area, the dilution of discharged wastewater, and oceanographic conditions that promote mixing, ESA-listed species are not likely to be exposed to concentrations of contaminants that could lead to adverse responses.

Trash or other debris resulting from the proposed action may affect ESA-listed marine mammals, sea turtles, and fishes. Any marine debris (e.g., plastic, paper, wood, metal, glass) that might be released would be accidental. The NSF follows standard, established guidance on the handling and disposal of marine trash and debris during the seismic surveys (UNLOS 2021). The gear used in the proposed action may also result in marine debris. The OBSs will be released from the attached anchor and float to the surface for retrieval, leaving the anchor behind as debris on the ocean floor. There will be a total of 41 OBS anchors left behind. The OBS anchors will be made of steel. These OBSs will be placed in waters greater than 6,000 meters deep, far deeper than where ESA-listed corals occur, so there will be no effects to ESA-listed corals as a result of the anchors. Although these anchors can be considered debris, we do not believe they pose an entanglement risk or other hazard to ESA-listed marine mammals, sea turtles, or fishes. The small amount of debris created by the anchors because of the proposed action compared to the relative size of the available habitat used by ESA-listed species is insignificant. Because the potential for accidental release of trash is extremely unlikely to occur, we find that the effects from this potential stressor on ESA-listed marine mammals, sea turtles, and fishes are discountable. The marine debris created by the OBSs will be minor, thus, we find that the effects from this potential stressor on ESA-listed marine mammals, sea turtles, and fishes are insignificant.

Therefore, we conclude that pollution by vessel exhaust, wastewater, fuel or oil spills or leaks, and trash or other debris may affect, but is not likely to adversely affect ESA-listed species because the effects are either insignificant or discountable, and will not be analyzed further.

7.1.2 Vessel Strikes

Vessel traffic associated with the proposed action carries the risk of vessel strikes of ESA-listed marine mammals, sea turtles, and fishes. In general, the probability of a vessel collision and the associated response depends, in part, on the size and speed of the vessel. The R/V *Langseth* has a length of 235 feet (72 meters) and the operating speed during seismic data acquisition is typically approximately 9.3 kilometers per hour (5 knots) during the OBS seismic refraction survey, and 7.6 kilometers per hour (4.1 knots) during the MCS seismic reflection survey. When not towing seismic survey gear, the R/V *Langseth* typically transits at 18.5 kilometers per hour (10 knots). Because of these slow speeds, the amount of noise produced by the propulsion system and the probability of vessel strike of large whales is reduced (Kite-Powell et al. 2007; Vanderlaan and Taggart 2007). 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 (Laist et al. 2001; Jensen and Silber 2004; Vanderlaan and Taggart 2007; Conn and Silber 2013).

Much less is known about vessel strike risk for sea turtles, but it is considered an important injury and mortality risk within the action area (Lutcavage et al. 1997). To our knowledge, there is little systematic evidence quantifying sea turtle vessel strikes, but there are some sources. Ataman et al. (2021) cataloged injuries on nesting female loggerhead sea turtles in southeastern Florida and found that, of 60 individuals whose injuries could be identified, 75% were from vessel strikes. Based on behavioral observations of sea turtle avoidance of small vessels, green turtles may be susceptible to vessel strikes at speeds as low as 3.7 kilometers per hour (2 knots) (Hazel et al. 2007). If an animal is struck by a vessel, responses can include death, serious injury, and/or minor, nonlethal injuries, with the associated response depending on the size and speed of the vessel, among other factors (Lutcavage et al. 1997; Hazel et al. 2007).

Each of the ESA-listed fish species considered in this opinion are thought to spend at least some time in the upper portions of the water column where they may be susceptible to vessel strike. Despite these species' use of the upper portion of the water column for at least some of their life history, in most cases, we would anticipate the ESA-listed fishes considered in this opinion would be able to detect vessels or other in-water devices and avoid them. Fish are able to use a combination of sensory cues to detect approaching vessels, such as sight, hearing, and their lateral line (for nearby changes in-water motion). A study on fish behavioral responses to vessels showed that most adults exhibit avoidance responses to engine noise, sonar, depth finders, and fish finders (Jørgensen et al. 2004), reducing the potential for vessel strikes. Misund (1997) found that fish ahead of a ship showed avoidance reactions at ranges of 50-350 meters (160-490 feet). When the vessel passed over them, some fish responded with sudden escape responses that included movement away from the vessel laterally or through downward compression of the school. In an early study conducted by Chapman and Hawkins (1973), the authors observed avoidance responses of herring from the low-frequency sounds of large vessels or accelerating small vessels. Avoidance responses quickly ended within 10 seconds after the vessel departed. Conversely, Rostad (2006) observed that some fish (likely schools of herring) are attracted to different types of drifting and stationary vessels (e.g., research vessels) of varying sizes, noise levels, and habitat locations, as well as moving commercial vessels. While we are not aware of studies specifically focusing on ESA-listed fishes' reactions to vessels, we cannot rule out either occurrence during the proposed action—that ESA-listed fishes may not avoid the vessel, and thus be susceptible to vessel strike.

For ESA-listed corals, if vessel strike did occur, it would most likely mean that the vessel ran aground. Numerous species of ESA-listed corals do occupy fairly shallow water depths as shallow as 0 meters to 20-25 meters (65-82 feet) while others occupy depths up to approximately 90 meters [295.3 feet]), and the vessel transit portion of the action falls into this depth range. In 2005, in the Gulf of Mexico, a vessel did run aground on a coral reef during an NSF seismic survey. NSF has had no incidents since then. The use of nautical charts and depth finders for navigation minimize the potential for accidental groundings, including in habitats occupied by listed corals, making it extremely unlikely to occur. Therefore, we believe the effects of accidental grounding of vessels (i.e., vessel strike) to ESA-listed corals because of the proposed action will be discountable.

Several conservation measures proposed by the Permits Division and/or NSF and L-DEO will minimize the risk of vessel strike to marine mammals and sea turtles, such as the use of PSOs, and ship crew keeping watch while in transit. In addition, the overall level of vessel activity associated with the proposed action is low relative to the large size of the action area, further reducing the likelihood of a vessel strike of an ESA-listed species.

While vessel strikes of marine mammals, sea turtles, and fishes during seismic survey activities are possible, we are not aware of any definitive case of a marine mammal, sea turtle, or fish being struck by a vessel associated with NSF seismic surveys. The R/V *Langseth* will be traveling at generally low speeds, reducing the probability of a vessel strike for marine mammals (Kite-Powell et al. 2007; Vanderlaan and Taggart 2007). Personnel on the vessel will maintain watch at all times while in transit. Our expectation of vessel strike being extremely unlikely to occur is due to the hundreds of thousands of kilometers the R/V *Langseth* has traveled without a reported vessel strike, general expected movement of marine mammals and sea turtles away from or parallel to the R/V *Langseth*, as well as the generally slow movement of the R/V *Langseth* during most of its travels (Holst and Smultea 2008b; Hauser and Holst 2009; Holst 2010). In addition, adherence to observation and avoidance procedures is also expected to avoid vessel strikes of marine mammals and sea turtles. All factors considered, we have concluded vessel strike of ESA-listed species by the research vessel is extremely unlikely to occur and thus discountable. Therefore, we conclude that vessel strike may affect, but is not likely to adversely affect ESA-listed species and will not be analyzed further.

7.1.3 Acoustic Noise from the Sub-Bottom Profiler, Multibeam Echosounder, Acoustic Doppler Current Profiler, and Acoustic Release Transponders

Sounds emitted by the sub-bottom profiler, multi-beam echosounder, acoustic Doppler current profiler, and OBS acoustic release transponders have the potential to affect ESA-listed cetaceans, sea turtles, and fishes.

Unlike vessels, which produce sound as a byproduct of their operations, multi-beam echosounders, sub-bottom profilers, 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. The OBS have an acoustic release transponder that transmits a signal to the instrument at a frequency of 8-11 kHz and a response is received at a frequency of 11.5-13 kHz (operator selectable) to activate and release the instrument. The transmitting beam pattern is 55°. The sound source level is approximately 93 dB.

We do not expect masking of communication will occur to an appreciable extent in cetaceans, sea turtles, and fishes due to the sub-bottom profiler, multi-beam echosounder, acoustic Doppler current profiler, and acoustic release transponders's signal directionality, low duty cycle, and brief period when an individual could be within their beam. These factors were considered when Behavioral responses to the sub-bottom profiler, multi-beam echosounder, acoustic Doppler current profiler, and acoustic release transponders are likely to be similar to airgun noise if received at the same levels. However, given the movement and speed of the research vessel and remote location of OBSs, 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 transponders would result in no more than 1 or 2 brief ping exposures of any individual cetacean, sea turtle, fish, or prey species if any exposure were to occur. Boebel et al. (2006) and Lurton and DeRuiter (2011) concluded that sub-bottom profilers, multi-beam echosounders, acoustic Doppler current profilers, and acoustic release transponders similar to those to be used during the proposed seismic survey activities presented a low risk for auditory damage or any other injury.

In addition, we do not expect hearing impairment such as temporary threshold shifts (TTS) and other physical effects if the animal is in the area because 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. Sea turtles generally do not possess a hearing range that includes frequencies emitted by the sub-bottom profiler, multi-beam echosounder, acoustic Doppler current profiler, and acoustic release transponders; therefore, ESA-listed sea turtles are not expected to detect these sounds even if they are exposed and are not expected to respond to them.

The ESA-listed fish species potentially exposed in this action are elasmobranchs and Nassau grouper. Data for fishes suggest they are capable of only detecting sounds from approximately 20 Hz to 1 kHz with the highest sensitivity to sounds at lower ranges (Ladich and Fay 2013). The active acoustic equipment proposed for use during the proposed action are outside the functional hearing range of ESA-listed fishes potentially exposed during this action. Therefore, ESA-listed fishes are not expected to detect or respond to sounds emitted by the sub-bottom profilers, multi-beam echosounders, acoustic Doppler current profilers, and acoustic release transponders used in this action. We find the probability of adverse effects to ESA-listed cetaceans, sea turtles, and fishes from this potential stressor to be extremely unlikely to occur. We are unable to quantify the level of exposure to these sound sources, but do not expect any exposure at levels sufficient to cause more than 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 transponders. In terms of potential effects from these sound sources on ESA-listed species' prey, like zooplankton, studies of adverse effects on zooplankton from these sources have not been documented. In addition, these sources are regularly used in prey mapping zooplankton species (Parra et al. 2019), to no apparent ill effect.

We find that the risk from this potential stressor on ESA-listed cetaceans, sea turtles, and fishes is insignificant. Therefore, we conclude that the sub-bottom profiler, multi-beam echosounder, acoustic Doppler current profiler, and acoustic release transponders may affect, but are not likely to adversely affect ESA-listed species.

7.1.4 Operational Noise and Visual Disturbance of Vessel and Equipment

The research vessel associated with the proposed action may cause visual or auditory disturbances to ESA-listed species that spend time near the surface or in the upper parts of the water column, such as marine mammals, sea turtles, and fishes, which may generally disrupt their behavior. 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 2003a; NRC 2005a), 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). Other ESA-listed species such as sea turtles and fishes are often considered less sensitive to anthropogenic sound, but given that much less is known about how they use sound, the impacts of anthropogenic sound are difficult to assess (Popper et al. 2014b; Nelms et al. 2016). Nonetheless, depending on the circumstances, exposure to anthropogenic sounds may result in auditory injury, changes in hearing ability, masking of important sounds, or behavioral responses, as well as other physical and physiological responses (see Section 10.4).

Studies have shown that vessel operations can result in changes in the behavior of marine mammals, sea turtles, and fishes (Patenaude et al. 2002; Richter et al. 2003; Hazel et al. 2007; Smultea et al. 2008a; Holt et al. 2009; Luksenburg and Parsons 2009; Noren et al. 2009). In many cases, particularly when responses are observed at great distances, it is thought that animals are likely responding to sound more than the visual presence of vessels (Evans et al. 1992; Blane and Jaakson 1994; Evans et al. 1994). At close distances, animals may not differentiate between visual and acoustic disturbances created by vessels and simply respond to the combined disturbance. Nonetheless, it is generally not possible to distinguish responses to the visual presences of vessels from those to the sounds associated with those vessels. We consider the effects to marine mammals, sea turtles, and fishes from the visual presence of vessels associated with the proposed action to be insignificant.

Sounds emitted by large vessels can be characterized as low frequency, continuous, or tonal and sound pressure levels at a source will vary according to speed, burden, capacity, and length (Richardson et al. 1995a; Kipple and Gabriele 2007; McKenna et al. 2012). Vessel noise levels could vary 5-10 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 49-463 kilometers (75.1-250 nautical miles) away.

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

All fish species can detect vessel noise due to its low-frequency content and their hearing capabilities. Data for elasmobranch fishes suggest they are capable of detecting sounds from approximately 20 Hz to 1 kHz with the highest sensitivity to sounds at lower ranges (Myrberg 2001; Casper et al. 2003; Casper and Mann 2006; Casper and Mann 2009; Casper et al. 2012; Ladich and Fay 2013). Therefore, ESA-listed fishes could be exposed to a range of vessel noises, depending on the source and context of the exposure. In the near field, fish are able to detect water motion, as well as visually locate an oncoming vessel. In these cases, most fishes located in close proximity that detect the vessel visually or via sound and motion in the water would be capable of avoiding the vessel or move away from the area affected by vessel sound. Thus, fish are more likely to react to vessel noise at close range than to vessel noise emanating from a greater distance.

Certain herbivorous reef fishes are beneficial to coral reefs because they consume macroalgae that can outcompete corals due to fast growth. Because of the relationship between reef fishes and reef-building hard corals (e.g., elkhorn coral, mountainous star coral, lobed star coral), impacts to reef fish from vessel noise could have secondary effects to ESA-listed corals. In studies that examine reef fish response to vessel noise, there have been a variety of responses observed. In some species of damselfish (Pomacentridae spp.), several responses have been noted, from a startle response, increased mortality as a result of predation (Simpson et al. 2016), to increased cortisol levels (Ferrier-Pagès et al. 2021). Other studies point to the possibility of fish habituating to vessel noise, showing limited response after a week of vessel sound exposure (Nedelec et al. 2016b) or minimal differences in cortisol levels between reef fishes at quiet and noisy sites (Staaterman et al. 2020). However, noise habituation in reef fishes has not been uniformly observed, with some species of reef fishes experiencing detrimental effects because of vessel noise (Ferrier-Pagès et al. 2021). Holland et al. (2021) used a portable multibeam echosounder operating at 38 kHz (similar to that proposed for use by NSF), with no apparent dispersal or disturbance of the reef fish that were the subject of the survey.

The contribution of vessel noise by the R/V *Langseth* is likely small in the overall regional sound field. Brief interruptions in communication via masking are possible, but unlikely given the habits of marine mammals and fish to move away from vessels, either as a result of engine noise, the physical presence of the vessel, or both (Mitson and Knudsen 2003; Lusseau 2006). Also, as stated, sea turtles are most likely to habituate and are shown to be less affected by vessel noise at distances greater than 10 meters (32.8 feet) (Hazel et al. 2007). In addition, during research operations, the R/V *Langseth* will be traveling at slow speeds, reducing the amount of noise produced by the propulsions system (Kite-Powell et al. 2007; Vanderlaan and Taggart 2007). The distance between the research vessel and observed marine mammals and sea turtles, per avoidance protocols, will also minimize the potential for acoustic disturbance from engine noise. Because the potential acoustic interference from engine noise will be undetectable or so minor that it cannot be meaningfully evaluated, we find that the risk from this potential stressor is insignificant. Therefore, we conclude that acoustic interference from engine noise may affect, but is not likely to adversely affect ESA-listed marine mammals, sea turtles, fishes, or corals, and will not be analyzed further.

7.1.5 Gear Interaction

There is a variety of gear proposed for use during the action that might entangle, strike, or otherwise interact with ESA-listed species in the action area.

Towed gear from the seismic survey activities pose a risk of entanglement to ESA-listed marine mammals and sea turtles. The towed hydrophone streamer could come in direct contact with ESA-listed species, and sea turtle entanglements have occurred in towed gear from the seismic survey vessel. A NSF-funded seismic survey off the coast of Costa Rica during 2011 recovered a dead olive ridley turtle (*Lepidochelys olivacea*) in the foil of towed seismic equipment; it is unclear whether the sea turtle became lodged in the foil pre- or post-mortem (Spring 2011). However, entanglement is highly unlikely due to the towed hydrophone streamer design, as well as observations of sea turtles investigating the towed hydrophone streamer and not becoming entangled and on operations in regions of high sea turtle density without entanglements occurring (Holst et al. 2005b; Holst et al. 2005a; Hauser 2008; Holst and Smultea 2008a). The towed hydrophone streamer is rigid and, as such, will not encircle, wrap around, or in any other way entangle any of the marine mammals considered during this consultation. We expect the taut cables will prevent entanglement. Furthermore, marine mammals are expected to avoid areas where the airgun array is actively being used, meaning they will also avoid towed gear. We are not aware of any entanglement events with ESA-listed marine mammals or sea turtles with the towed gear proposed for use in this action.

We do not expect ESA-listed marine mammals or sea turtles to be at the ocean bottom, so the concerns about equipment strike would primarily be as they are being deployed, and dropping to the ocean floor. We expect an ESA-listed marine mammal or sea turtle to perceive the disturbance and be able to detect the OBSs, exhibit avoidance behavior, and move out of the way.

ESA-listed fish species in the action area (Nassau grouper, giant manta rays, scalloped hammerheads and oceanic whitetip sharks) could be entangled or struck by equipment used during the seismic survey. ESA-listed giant manta rays can occur near the surface when feeding (10 meters), but can also dive to depths of between 200 and 450 meters, and even up to 1,000 meters. ESA-listed scalloped hammerheads occur over continental and insular shelves, as well as adjacent deep waters. The OBSs will operate at or near the ocean floor. The towed hydrophone array, the PAM hydrophone (both towed near the surface), and the towed airgun array (towed at 12 meters below the surface) pose similar risks to ESA-listed fishes species. However, we consider the possibility of equipment entanglement or strike to be remote because of fishes' ability to detect the equipment moving through the water and move out of the way.

Although the towed hydrophone streamer or PAM array could come in direct contact with an ESA-listed species, entanglements are extremely unlikely to occur. 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 likelihood of adverse effects to ESA-listed species to be discountable. Therefore, gear interactions may affect, but are not likely to adversely affect any ESA-listed species, and will not be analyzed further in this opinion.

7.1.6 Stressors Considered Further

The only potential stressor that is likely to adversely affect some ESA-listed species within the action area is sound fields produced by the seismic airgun array. This stressor and sound sources associated with seismic survey activities and the ESA-listed species that may be adversely affected are further analyzed and evaluated in Section 10.

7.2 Species Not Likely to be Adversely Affected

There are a number of ESA-listed species, as well as designated and proposed critical habitat, that could be in the action area and possibly be exposed to the stressors associated with the proposed action. As discussed previously, most of the stressors associated with the proposed action are not likely to adversely affect any of the listed species in the action area but acoustic sources (i.e., sound fields produced by the seismic airguns and the other equipment used in the survey) may result in adverse effects for some ESA-listed species.

7.2.1 Blue Whale, Fin Whale, and Sei Whale

Fin, sei, and blue whales are offshore, deepwater species. The action does occur in deep water (up to 8,400 meters deep), so there is some potential for overlap. Only a few comprehensive cetacean surveys around Puerto Rico have been conducted. The first field surveys were carried out by NOAA Fisheries aboard the *Oregon II* from January to March 1995 (Roden and Mullin 2000) and by NMFS using both acoustic and visual techniques throughout the U.S. Caribbean in February and March 2001 (Swartz et al. 2002); neither of these surveys observed blue, fin, or sei whales. There are no records of blue, fin, or sei whales in the action area in the Ocean Biodiversity Information System Spatial Ecological Analysis of Megavertebrate Populations (OBIS SEAMAP) database.

Records indicate blue whales are not regular inhabitants of the Caribbean (Lesage et al. 2017). In the Atlantic, the blue whale is considered an occasional visitor in U.S. Atlantic EEZ waters (Hayes et al. 2018). Blue whales have been tracked acoustically through the Navy's Sound Surveillance System in subtropical waters north of the West Indies and are thought to have a broad longitudinal distribution in tropical and warm temperature latitudes during the winter months (Hayes et al. 2020).

Fin and sei whales have only been observed in Puerto Rico north of Mona Island and south of Cayo Ratones, Salinas (Lesage et al. 2017). In an examination of cetacean sightings in the insular shelf waters of Puerto Rico from the late 1950s to 1989, fin and sei whales were sighted a total of 2 and 3 times, respectively; most of these sightings occurred during winter and early spring (Mignucci-Giannoni 1998). Others have noted a likely seasonal presence of fin whales in the region. Fin whales are thought to spend the winter at southern latitudes, and likely breed from December to January (Mignucci-Giannoni 1998).

In the U.S. Atlantic EEZ, it is likely that fin whales undergo migrations into Canadian waters, open ocean, and potentially subtropical or tropical regions (Hayes et al. 2021). Data from the Navy's Sound Surveillance System have indicated fin whales to be largely distributed in the deep ocean (Hayes et al. 2021).

In the Atlantic, the general pattern of sei whale distribution is offshore but animals occasionally move to shallower nearshore waters in the northeastern U.S. (Hayes et al. 2021). The distribution of these animals in more southern waters is not known but they are likely rare. Sei whale movement patterns are not well understood, but it is likely they follow prey abundance. By relying on historic whaling records, sei whales were landed from April to October at northern latitudes in the Atlantic (e.g., Norway, Scotland, Nova Scotia) (Prieto et al. 2012).

There is a lack of information regarding the presence of blue, fin, and sei whales in the region, and it is not clear if this is due to actual rarity of these species, or a lack of recent, systematic surveys. If blue, fin, and sei whales are present in the region generally, the available information indicates that these whales would spend the winter in the area. The proposed action will take place in October, so it is extremely unlikely that these species will be present at the time of the seismic survey activities. Given the overall rarity of blue, fin, and sei whales in the region, and the timing of the action, we conclude that the proposed seismic survey is not likely to adversely affect blue, fin, or sei whales because any effects would be discountable. These species will not be considered further.

7.2.2 ESA-Listed Elasmobranchs

ESA-listed elasmobranchs (giant manta rays, oceanic whitetip sharks, and Central and Southwest Atlantic DPS scalloped hammerhead shark) may occur in the action area and be affected by sound fields generated by airguns and echosounders.

Elasmobranchs, like all fish, have an inner ear capable of detecting sound and a lateral line capable of detecting water motion caused by sound (Hastings and Popper 2005; Popper and Schilt 2009). Data for elasmobranch fishes suggest they are capable of detecting sounds from approximately 20 Hz to 1 kHz with the highest sensitivity to sounds at lower ranges (Myrberg 2001; Casper et al. 2003; Casper and Mann 2006; Casper and Mann 2009; Casper et al. 2012; Ladich and Fay 2013). However, unlike most teleost fish, elasmobranchs do not have swim bladders (or any other air-filled cavity), and thus are unable to detect sound pressure (Casper et al. 2012). Particle motion is presumably the only sound stimulus that can be detected by elasmobranchs (Casper et al. 2012). Given their assumed hearing range, elasmobranchs are anticipated to be able to detect the low frequency (10-500 Hz; (Hildebrand 2009a)) sound from an airgun array if exposed. However, the limited duration of the proposed action's low-frequency acoustic stressors will likely minimize the effect this stressor has on elasmobranchs. Furthermore, although some elasmobranchs have been known to respond to anthropogenic sound, in general elasmobranchs are not considered particularly sensitive to sound (Casper et al. 2012).

There have been no studies examining the direct effects of exposure to specific anthropogenic sound sources in any species of elasmobranchs (Casper et al. 2012). However, several elasmobranch species, including the oceanic silky shark (*Carcharhinus falciformis*) and coastal lemon shark (*Negaprion brevirostris*), have been observed withdrawing from pulsed low-frequency sounds played from an underwater speaker (Myrberg et al. 1978; Klimley and Myrberg 1979). Lemon sharks exhibited withdrawal responses to pulsed low to mid-frequency sounds (500 Hz to 4 kHz) raised 18 dB re: 1 μPa at an onset rate of 96 dB re: 1 μPa per second to a peak amplitude of 123 dB re: 1 μPa received level from a continuous level, just masking broadband ambient sound (Klimley and Myrberg 1979). In the same study, lemon sharks withdrew from artificial sounds that included 10 pulses per second and 15-7.5 decreasing pulses per second.

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

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

Popper et al. (2014b) concluded that the relative risk of fishes with no swim bladders exhibiting a behavioral response to low-frequency active sonar was low, regardless of the distance from the sound source. The authors did not find any data on masking by sonar in fishes, but concluded that, if it were to occur, masking will result in a narrow range of frequencies being masked (Popper et al. 2014b). Popper et al. (2014b) also concluded that injury for fish with no swim bladders exposed to low frequency active sonar is unlikely because no damage was found after exposure to higher intensity impulsive signals.

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

The precise expected response of ESA-listed elasmobranchs to low-frequency acoustic energy is not completely understood due to a lack of sufficient experimental and observational data for these species. However, given the signal type and level of exposure to the low frequency signals used in seismic survey activities, we do not expect adverse effects (including significant behavioral adjustments, TTS, permanent threshold shifts [PTS], injury, or mortality). The most likely response of ESA-listed elasmobranchs exposed to seismic survey activities, if any, will be minor temporary changes in their behavior including increased swimming rate, avoidance of the sound source, or changes in orientation to the sound source, none of which would likely result in adverse effects to the individual. If these behavioral reactions were to occur, we would not expect them to result in fitness impacts such as reduced foraging or reproduction ability.

Therefore, the potential effect of seismic survey activities on the elasmobranch species (giant manta ray, oceanic whitetip shark, and Central and Southwest Atlantic DPS scalloped hammerhead shark) listed under the ESA is insignificant. We conclude that the proposed seismic survey activities in the action area are not likely to adversely affect these elasmobranch species because any effects would be insignificant, and these species will not be considered further.

7.2.3 Olive Ridley Sea Turtles

Olive ridley sea turtles are regarded as infrequent nesters in Puerto Rico (Eckert and Eckert 2019). There have been some reports of olive ridleys sighted in northern Puerto Rico over the years, but these are not common occurrences. In January 2020, a female was observed laying a clutch on Playa Abacoa, on the north side of Puerto Rico, with hatchlings emerging in March (del Pilar González-García et al. 2021). The proposed action will take place in fall, and last for about a month, so we do not expect the timing of the action to overlap with the expected presence of olive ridley nesting or hatchling emergence, should it occur at all. Due to the overall rarity of olive ridley sea turtles in the action area, and the timing of the action, we conclude that the proposed seismic survey is not likely to adversely affect olive ridley sea turtles because any effects would be discountable. This species will not be considered further in this opinion.

7.2.4 Loggerhead Sea Turtle

Loggerhead hatchlings use floating mats of *Sargassum* while adults and juveniles may be present along the shelf edge and in shallow habitats such as estuaries, reefs, and natural and artificial hard bottom. Limited loggerhead nesting has been reported on the east coast of the main island of Puerto Rico and on Culebra Island, but is apparently not frequent (Eckert and Eckert 2019).

Stranding and nesting data from Puerto Rico Department of Natural and Environmental Resources indicate that this species can occasionally be found along the eastern coast of the main island of Puerto Rico, including nesting on some beaches (Eckert and Eckert 2019), but nesting and stranding events involving the species do not occur frequently. Therefore, because of the rarity of loggerhead sea turtles around Puerto Rico and the lack of nesting, stranding and sighting data indicating they are present in the action area, effects of the action to this species are extremely unlikely to occur and are, therefore, discountable. Thus, we believe the action is not likely to adversely affect the Northwest Atlantic Ocean DPS of loggerhead sea turtle.

7.2.5 Nassau Grouper

The Nassau grouper's confirmed distribution currently includes "Bermuda and Florida (USA), throughout the Bahamas and Caribbean Sea" (Hill and Sadovy de Mitcheson 2013). There are known, current spawning aggregation-sites in Puerto Rico (i.e., Bajo de Sico, which is approximately 10 miles south of Desecheo Island). Nassau grouper are in the region broadly, and thus may be exposed to sound from the seismic airguns.

Nassau groupers spawn once a year in large aggregations, in groups of a few dozen to thousands spawning at once. Nassau groupers move in groups towards the spawning aggregation-sites parallel to the coast or along the shelf edge at depths between 20 and 33 (65.6 meters to 108.3 meters). Spawning runs occur in late fall through winter (i.e., a month or 2 before spawning is likely in November to February) (NMFS 2013b).

Spawning aggregation-sites are located near significant geomorphological features, such as reef projections (as close as 50 meters [164 feet] to shore) and close to a drop-off into deep water over a wide depth range (six to 60 meters [19.7-197 feet]). Sites are usually several hundred meters in diameter, with soft corals, sponges, stony coral outcrops, and sandy depressions. Nassau groupers stay on the spawning site for up to 3 months (NMFS 2013b).

Fertilized eggs are transported offshore by ocean currents. Thirty-five to forty days after hatching, larvae recruit from the oceanic environment to demersal habitats (at a size of about 32 millimeters [4.8 inches] total length). Juveniles inhabit macroalgae, coral clumps, and seagrass beds, and are relatively solitary. As they grow, they occupy progressively deeper areas and offshore reefs, where they may form schools of up to 40 individuals. When not spawning, adults are most commonly found in waters less than 1 100 meters deep (NMFS 2013b). Nassau grouper have been found in waters as deep as 130 meters (426 feet).

We do not expect the proposed action to overlap with Nassau grouper spawning. The seismic activities will take place in waters deeper than where we expect Nassau grouper to occur, mostly in waters greater than 1,000 meters deep. Some portions of the seismic survey would take place in waters between 100 and 1,000 meters deep, but the overall ensonified area in these depths is limited compared to the amount of effort in deeper water (Table 10 and Table 11). The closest point of approach to Puerto Rico from the high-energy survey is 22 kilometers; for the low-energy survey, it is 2.5 kilometers.

We believe that the high-energy survey is far enough away from the areas where Nassau grouper would be found that there would be minimal effects from the noise produced by the airguns. The low-energy survey is potentially closer to Nassau grouper habitat; however, the low-energy survey is using only 2 airguns, creating a much smaller ensonified area. It is possible that sound from the airguns could extend into Nassau grouper habitat, but it would likely not be at levels that would cause a measurable effect to Nassau grouper.

We conclude that the proposed seismic survey activities in the action area are not likely to adversely affect Nassau grouper because any effects would be insignificant, and this species will not be considered further.

7.2.6 ESA-Listed Corals

ESA-listed corals that are in the action area and may be exposed to sound from the seismic airguns include elkhorn, staghorn, boulder star, lobed star, mountainous star, rough cactus, and pillar corals (proposed for listing change to endangered). For ESA-listed corals, we describe how the corals can detect sound or water particle motion, because these species do not have auditory sensing organs in the same way as ESA-listed marine mammals, sea turtles, or fishes. Information on the sound detection capabilities of ESA-listed corals is scarce, and there is a lack of information on the effects of sound on marine invertebrates broadly. For these reasons, there are no thresholds for sound exposure for ESA-listed corals that could cause harm, injury, or other responses.

The proposed action will take place in waters deeper than where we expect ESA-listed corals to be found (more than 100 and up to 8,400 meters). However, the ensonified area created by the airguns could enter into coral habitat. The distances to the 160 and 175 dB thresholds that NSF provided as part of its proposed action are for marine mammal and sea turtle harassment, so the ensonified area that is used in other parts of this consultation is not applicable here. The sound from the airguns extend out further than those distances, and thus it is possible that ESA-listed corals could be exposed to sound levels above ambient noise and experience effects.

Coral larvae are covered in cilia, which could aid in sound detection in that the cilia are sensitive to particle motion or water movements (Budelmann 1992a; Budelmann 1992b; Mackie and Singla 2003). Sound detection for marine invertebrates is thought to be in the low frequency range (Nedelec et al. 2016a). In many common coral reef species, sound detection and generation is expected to fall in the range of 1 Hz to 200 kHz, with most between 1 Hz and 100 kHz (Ferrier-Pagès et al. 2021). Seismic airguns are regarded as generating low-frequency sounds (Ruppel et al. 2022).

There is a lack of information on the effects of noise on corals. However, there is some evidence available. Mountainous star coral (*Orbicella faveolata*) larvae orient selectively towards reefs, showing a particular sensitivity to natural low-frequency (25-1,000 Hz) soundscapes pre-settlement (Vermeij et al. 2010; Lillis et al. 2016). It is possible that, in some cases, excessive noise could affect coral recruitment. It has been theorized that the hydro-acoustic force from seismic airguns could cause skeletal and tissue damage to Scleractinian corals (i.e., stony corals, which include the ESA-listed Atlantic-Caribbean corals) but at higher energy levels (~260 dB re 1μ Pa) than would in the proposed action (Hastings 2008).

We are aware of 1 study that examined the effects of airguns on corals. Heyward et al. (2018) examined corals before and after a 3-D seismic airgun survey with a total discharge volume of 2,055 cubic inches, which took place in mostly shallow waters (40-60 meters deep). The seismic airgun survey took place directly on and around the reef. Predominant coral species were of the plating/foliaceous variety (e.g., *Montipora* spp., *Pachyseris* spp., *Leptoseris* spp., various Pectinidae and others), with fewer *Acropora* species. Because we do not know if different species of coral react differently to airgun noise, it is difficult to directly compare the results of this study to the ESA-listed Atlantic-Caribbean corals exposed during the proposed action. In the absence of other information, this is the best available information and we use results from this study as a surrogate for the ESA-listed species in the action area.

During the study, the survey resulted in a maximum received sound exposure level of 204 dB re $1\mu Pa^2 \cdot s$, and a received zero-to-peak pressure of 226 dB re 1μPa. No detectable effect on the soft tissues or skeletal integrity of the Scleractinian corals, primarily plate corals in families Agaricidae and Acroporidae was observed. In addition, no effects were detected as measured by coral mortality, skeletal damage or visible signs of stress immediately after and up to 4 months following the 3-D marine seismic survey (Heyward et al. 2018).

Because of the important trophic interactions between reef fishes and reef-building corals, detrimental impacts to reef fishes (e.g., prolonged abandonment of habitat, increased stress response) could in turn negatively impact coral reefs. Miller and Cripps (2013) conducted visual surveys on coral reefs before and after a 3-D seismic airgun survey and found no detectable effect of the seismic survey on the abundance of fishes on the reef. Wardle et al. (2001a) examined the reactions of reef fishes to a survey using 3 150 cubic inch airguns by using a video recorder. Observed fish gave an involuntary sudden bending of the body ("C-start), but then continued as before the airgun blast. No fish showed any signs of moving away from the reef. However, Paxton et al. (2017) found that reef fish abundance declined by 78% during the seismic airgun survey which approached the reef at distances between 0.7 and 7.9 kilometers. The study period did not extend beyond the conclusion of the seismic airgun survey, so the authors were not able to present the duration of the decline in fish abundance, or when the reef fish returned. Given the results of other studies examining fish reaction to airguns, we think it is unlikely that the reef fish in the Paxton et al. (2017) study abandoned the study area permanently, and it is more likely that the displaced fish returned after a few days (Engås et al. 1996a).

The Heyward et al. (2018) study examined the effects of a seismic airgun survey that took place directly on and around a coral reef, and detected no effects to the corals. The proposed action would take place at some distance away from any ESA-listed corals in the action area, so we believe that, while the corals in this proposed action could be exposed to sound from the airguns above ambient noise levels, it will not be at sound levels as high as in the Heyward et al. 2018 study. If exposed, the ESA-listed corals in the proposed action will experience a limited amount of sound from the airgun. The proposed action will take place over the course of 22 days, and many of those days of seismic airgun activity will occur at farther distances from where ESA-listed corals occur. The majority of the high-energy tracklines are well over 100 kilometers from shore. The low-energy tracklines are closer to shore, but at 5 kilometers away or more. Even if the ESA-listed corals exposed to the sound from airgun activities did experience detrimental effects, we believe that the limited duration and intensity of the sound would make those effects too small to be meaningfully measured, and thus insignificant.

Any exposure to sound sources of ESA-listed corals would be temporary and brief, and, because of the distance, likely less intense than the sound exposure in the Heyward et al. (2018) study in which no detectable effects to corals were observed. Exposure to sound sources is not expected to create sustained conditions that would prevent coral larvae from settling. During the Paxton et al. (2017) study, exposed reef fishes abandoned the area, but the airguns approached the reefs much closer (0.7 kilometers) than the airguns will during the proposed action, so we consider the likelihood of abandonment to be less. As stated above, the limited amount of time the seismic survey will be in close proximity to ESA-listed coral habitat will minimize the duration of exposure for reef fishes in the area. Any displacement of reef fish that might occur is expected to be temporary. Because of this, we expect that any effects that the ESA-listed corals might experience as a result of reef fish displacement would be too small to be meaningfully measured, and thus insignificant.

In conclusion, we determine that NSF's action may affect, but is not likely to adversely affect ESA-listed elkhorn, staghorn, boulder star, lobed star, mountainous star, rough cactus, or pillar corals.

7.2.7 Queen Conch

On September 8, 2022, NMFS proposed the queen conch for listing as threatened and published a status review for queen conch (Horn et al. 2022).

The queen conch is distributed throughout the Caribbean Sea, the Gulf of Mexico, and around Bermuda. In U.S. waters, it is found in Puerto Rico, the U.S. Virgin Islands, and Florida. As conch develop they use different habitat types including seagrass beds, sand flats, algal beds, and rubble areas from a few centimeters deep to approximately 30 meter (Brownell and Stevely 1981). Queen conch nursery areas primarily occur in back reef areas (i.e., shallow sheltered areas, lagoons, behind emergent reefs or cays) of medium seagrass density, at depths between 2-4 meters, with strong tidal currents of at least 50 centimeters/second (Stoner 1989), and frequent tidal water exchanges (Stoner and Waite 1991; Stoner et al. 1996). Seagrass is thought to provide both nutrition and protection from predators (Ray and Stoner 1996; Stoner and Davis 2010). Queen conch are herbivores and primarily feed on macroalgae and seagrass detritus (Creswell 1994; Ray and Stoner 1996).

The proposed action involves the placement of OBSs; however, that activity would take place several kilometers from shore, in-water depths (> 1,000 m) greater than where we expect to find queen conch. Given its habitat preference, the location of activities causing impacts to its habitat, we believe that there would be no effect on the habitat for queen conch. However, the sound emanating from the proposed seismic activities (above ambient noise levels) could reach areas where queen conch occur.

As with ESA-listed corals, there are no thresholds for sound exposure for queen conch that could cause harm, injury, or other measurable effects. We are not aware of any studies documenting the effects of elevated sound levels to queen conch. Because of the distance from the seismic survey sounds source to queen conch habitat, we expect that any exposure that might occur from the airgun array would be minimal.

Any exposure to sound sources within the sound detection and generation range of queen conch would be temporary and brief, a few days at most. As a result, effects to ESA-listed invertebrates from seismic airguns used during the proposed actions are insignificant and are not likely to adversely affect the queen conch in the action area.

7.3 Critical Habitat Not Likely to be Adversely Affected

The action area includes proposed and designated critical habitat. There is designated critical habitat for leatherback sea turtle and hawksbill sea turtle in the region (St. Croix, U.S. Virgin Islands; and Mona and Monita Islands, Puerto Rico, respectively). However, these units are not in the action area (i.e., the survey area or any of the vessel transit path, see Figure 1) and will not be discussed further.

7.3.1 Proposed Critical Habitat for Nassau Grouper

In 2022, NMFS proposed to designate critical habitat for the Nassau grouper. Specific occupied areas proposed for designation as critical habitat contain 2,353.19 square kilometers of aquatic habitat located in waters off the coasts of southeastern Florida, Puerto Rico, Navassa, and the U.S. Virgin Islands.

There are 19 units within the proposed critical habitat, 6 in Puerto Rico, and 1 within the action area: the Southwest unit, which overlaps with the low-energy seismic airgun survey. It includes all waters from the southwestern shoreline of Puerto Rico, between Playa Tres Tubos just south Mayaqüez and Punta Ballena in Guanica, extending offshore to depths of about 10 meter and, near La Parguera, to depths of about 15 meters. There is no proposed critical habitat within the area of the high-energy survey on the north side of Puerto Rico.

Within the geographic area occupied by this ESA-listed species, critical habitat consists of specific areas on which are found those physical and biological features essential to the conservation of each species. The features essential to the conservation of Nassau grouper include those that support recruitment and development habitat, and spawning habitat. These are described in more detail as follows.

1. Recruitment and development habitat. Areas from nearshore to offshore necessary for recruitment, development, and growth of Nassau grouper containing a variety of benthic types, consisting of the following:
    a. Nearshore shallow subtidal marine nursery areas
        i. Substrate that consists of unconsolidated calcareous medium to very coarse sediment (not fine sand) and shell and coral fragments and may also include cobble, boulders, whole coral and shells, or rubble mounds, to support larval settlement and provide shelter from predators during growth and habitat for prey.
    b. Intermediate hardbottom and seagrass areas
        i. Close proximity to the nearshore shallow subtidal marine nursery areas that protect growing fish from predation as they move from nearshore nursery areas into deeper waters and provide habitat for prey. The areas include seagrass interspersed with areas of rubble, boulders, shell fragments, or other forms of cover; inshore patch and fore reefs that provide crevices and holes; or substrates interspersed with scattered sponges, octocorals, rock and marcoalgal patches, or stony corals.
    c. Offshore linear and patch reefs
        i. Close proximity to intermediate hardbottom and seagrass areas that contain multiple benthic types, for example, coral reef, colonized hardbottom, sponge habitat, coral rubble, rocky outcrops, or ledges, to provide shelter from predation during maturation and habitat for prey.
    d. Structures supporting movement corridors
        i. Structures between the subtidal nearshore area and the intermediate hardbottom and seagrass area and the offshore reef area including overhangs, crevices, depressions, blowout ledges, holes, and other types of formations of varying sizes and complexity to support juveniles and adults as movement corridors that include temporary refuge that reduce predation risk as Nassau grouper move from nearshore to offshore habitats.
2. Spawning habitat: marine sites used for spawning and adjacent waters that support movement and staging associated with spawning.

The low-energy, 2-airgun seismic survey will take place on the south side of Puerto Rico, within the vicinity of the Southwest unit. The R/V *Langseth* will transit through the proposed critical habitat to get to the survey site. The features pertaining to recruitment and development habitat broadly include substrate, sediment types, and structures that support larval settlement, provide shelter from predators, habitat for prey species, and movement corridors that provide refuge. We do not expect the vessel transit to result in any stressors that would impact substrate in the proposed critical habitat. As described elsewhere, we consider the possibility of vessel grounding and emergency anchoring to be extremely unlikely, and the low-energy survey will not involve the placement of any OBSs. Thus, we find the effects from the action on the PBF of recruitment and development habitat to be discountable.

Essential features for the spawning habitat include marine sites used for spawning and adjacent waters that support movement and staging associated with spawning. The sound from the airgun array during seismic operation could create a disturbance in the habitat that hinders the use of the waters that support movement and staging associated with spawning.

The tracklines for the low-energy survey occur in waters deeper than 100 meters, beyond the 15 meter depth contour of the proposed critical habitat. However, the airgun operations will occur near the critical habitat, and it is possible that sound emanating from the 2 airguns could extend into the proposed critical habitat at a level above ambient noise, affecting the quality of the spawning habitat and adjacent waters that support movement and staging associated with spawning.

The 2-airgun survey would take place over the course of 3 days, and so any disturbance created by the proposed action would be limited in duration. As stated earlier, the closest point of approach by the low-energy survey is 2.5 kilometers, and the ensonified area for the 2-airgun survey is limited (i.e., less than 2.5 kilometers, and thus not expected to enter the proposed critical habitat). Any disturbance to Nassau grouper spawning habitat posed by the noise from the airguns would be unable to be meaningfully detected, and thus insignificant. Therefore, we the effects of NSF's proposed action may affect, but are not likely to adversely affect the proposed critical habitat for Nassau grouper.

7.3.2 Designated Critical Habitat for Atlantic-Caribbean Corals

Designated critical habitat for pillar coral, lobed star coral, mountainous star coral, boulder star coral, and rough cactus coral are found in the action area off the coasts of Florida, Puerto Rico, and the U.S. Virgin Islands (Table 7). The proposed PBFs for pillar coral, lobed star coral, mountainous star coral, boulder star coral, and rough cactus coral are the following:

1. Substrate with presence of crevices and holes that provide cryptic habitat, the presence of microbial biofilms, or presence of crustose coralline algae.
2. Reefscape (all the visible features of an area of reef) with no more than a thin veneer of sediment and low occupancy by fleshy and turf microalgae.
3. Marine water with levels of temperature, aragonite saturation, nutrients, and water clarity that have been observed to support any demographic function.
4. Marine water with levels of anthropogenically-introduced (from humans) chemical contaminants that do not preclude or inhibit any demographic function.

The proposed action does not include any stressors that might alter the temperature, aragonite saturation, nutrients, and water clarity that have been observed to support any demographic function for the Atlantic-Caribbean corals (PBF #3). Stressors that introduce chemical contaminants into the marine waters (PBF #4) like pollution that may occur during the vessel activities associated with the action were considered in Section 7.1.1, where we determined that the effects from pollution were discountable. Our analysis will focus on stressors that may affect substrate (PBF #1) and cause sedimentation (PBF #2).

Table 7. Locations and descriptions of the designated critical habitat units for 5 species of Caribbean corals within the action area

Species	Critical Habitat Unit Name	Location	Geographic Extent	Water Depth Ranges (m)	Area (approximate, rounded) km^2
Lobed Star Coral (*Orbicella annularis*)	OANN-2	Puerto Rico	All Islands	0.5-20	2,100
Mountainous Star Coral (*Orbicella faveolata*)	OFAV-2	Puerto Rico	All Islands of Puerto Rico	0.5-90 m	5,500
Boulder Star Coral (*Orbicella franksi*)	OFRA-2	Puerto Rico	All Islands of Puerto Rico	0.5-90 m	5,500
Pillar Coral (*Dendrogyra cylindrus*)	DCYL-2	Puerto Rico	All Islands	1-25 m	2,800
Rough Cactus Coral (*Mycetophyllia ferox*)	MFER-2	Puerto Rico	All Islands of Puerto Rico	5-90 m	5,000

Vessel transit will be the primary activity in the proposed critical habitat. Other aspects of the proposed action that may cause impacts to substrate and/or sedimentation include vessel grounding.

Vessel grounding could result in significant damage to substrate and reefscape. There is 1 reported instance of a vessel grounding during an NSF survey in 2005, involving the R/V *Maurice Ewing* grounding on a reef off the northern Yucatan Peninsula in the southern Gulf of Mexico. NSF has been conducting seismic airgun surveys since 2003, and this is the only vessel grounding that has occurred. The vessel would use designated channels of sufficient depth to navigate safely. The required vessel operation practices encourage vessel operators' safe navigation, thus minimizing potential impacts to benthic habitats. The use of nautical charts and depth finders for navigation minimize the potential for accidental groundings, including in the proposed critical habitats, making it extremely unlikely to occur, and thus discountable. Therefore, we determine that the effects of NSF's proposed action may affect, but are not likely to adversely affect the critical habitat for ESA-listed Atlantic-Caribbean corals.

7.3.3 Designated Critical Habitat for Elkhorn and Staghorn Coral

Critical habitat for elkhorn and staghorn corals was designated in 2008. The PBF essential to the conservation of Atlantic *Acropora* species is substrate of suitable quality and availability in-water depths from the mean high water line to 30 meters (98 feet) in order to support successful larval settlement, recruitment, and reattachment of fragments. "Substrate of suitable quality and availability" means consolidated hard bottom or dead coral skeletons free from fleshy macroalgae or turf algae and sediment cover. Areas containing this feature have been identified in 4 locations within the jurisdiction of the U.S.; the Puerto Rico area, comprises approximately 3,582 square kilometers (1,383 square miles) of marine habitat and falls within the action area. The critical habitat for elkhorn and staghorn coral largely overlaps with the proposed critical habitat for the ESA-listed Atlantic-Caribbean corals discussed in Section 7.3.2. Vessel transit would be the primary activity that will occur in the critical habitat.

The stressors associated with vessel activity (pollution, vessel strikes) may affect elkhorn and staghorn coral critical habitat. However, these stressors were considered in Section 7.1 and were found to be discountable and insignificant. Therefore, we determine that the effects of NSF's proposed action may affect, but are not likely to adversely affect the designated critical habitat for ESA-listed elkhorn and staghorn corals.

7.3.4 Proposed Critical Habitat for North Atlantic Ocean DPS Green Sea Turtle

On July 19, 2023, critical habitat was proposed for 6 DPSs of green sea turtle; proposed critical habitat for the North Atlantic DPS overlaps with the action area (88 FR 46572). Proposed critical habitat for the South Atlantic DPS green turtle does not overlap with the action area. There is also designated critical habitat for green sea turtle around Culebra, Puerto Rico, but it is not in the action area and will be not considered. The features essential to the conservation of the DPS are reproductive, migratory, benthic foraging/resting, and surface-pelagic foraging/resting (*Sargassum*). There are 3 essential features that overlap with the action area: reproductive, migratory, and benthic foraging/resting.

- Reproductive: From the mean high water line to 20 meters depth, sufficiently dark and unobstructed nearshore waters adjacent to nesting beaches designated as critical habitat by USFWS, to allow for the transit, mating, and internesting of reproductive individuals and the transit of post-hatchlings.
- Migratory: From the mean high water line to 20 meters depth (North Atlantic DPS), sufficiently unobstructed waters that allow for unrestricted transit of reproductive individuals between benthic foraging/resting and reproductive areas.
- Benthic Foraging/Resting: From the mean high water line to 20 meters depth, underwater refugia and food resources (i.e., seagrasses, macroalgae, and/or invertebrates) of sufficient condition, distribution, diversity, abundance, and density necessary to support survival, development, growth, and/or reproduction.

The proposed critical habitat in Puerto Rico identified as North Puerto Rico Island, including Punta Salinas, Escambrón, and Arrecifes Isla Verde Natural Reserve are in the action area, which includes San Juan as the port-of-call for the vessel during the high-energy survey. The R/V *Langseth* will transit through the proposed critical habitat. None of the survey tracklines are within the proposed critical habitat. There is North Atlantic DPS green sea turtle critical habitat proposed elsewhere in Puerto Rico (e.g., on the south side of the island in Guayama and Maunabo), but it is not in the action area for the low-energy survey (which is near Ponce and Guanica). As discussed earlier, designated critical habitat for green sea turtles around Culebra Island and its surrounding islands and cays are also outside the action area (both survey areas and areas of vessel transit).

The proposed action will not involve any work that creates obstructions or structures in waters adjacent to nesting beaches in the action area. There will be no lights installed or continuously operated. Thus, there will be no effect on the ability of reproductive individuals to transit, mate, or internest, or for post-hatchlings to transit the area.

The high-energy survey will take place on the north side of Puerto Rico and take a total of 36 days. That portion of the proposed action will use San Juan to port, and involve limited travel in and out of the port, because the airgun survey is taking place offshore. Vessel transit associated with the proposed action will only occur in the proposed critical habitat for a few days at most. Any disturbance created by the vessel activity for the proposed action will be temporary and limited in geographic area, affecting only a small fraction of the proposed critical habitat as a whole. Thus, vessel activity would not create conditions that will obstruct the migratory essential feature. Any disturbance posed by vessel transit would be unable to be meaningfully detected, and thus insignificant.

The proposed action will not impact any food resources. We do not expect any impacts to seagrasses or algae from the airgun noise. OBSs would not be placed in seagrass beds. Any placement of OBSs would occur in waters deeper than 20 meters that are not in the proposed critical habitat. Therefore, there will be no effect on the benthic foraging/resting PBF.

Because there would either be no effect or insignificant effects to the portion of the PBFs present in the action area, we determine that the effects of NSF’s proposed action may affect, but are not likely to adversely affect the proposed critical habitat for North Atlantic DPS green turtle.

8 Status of Species Likely to be Adversely Affected

This section identifies and examines the status of ESA-listed sperm whales and North Atlantic and South Atlantic DPS green, hawksbill, and leatherback sea turtles that are expected to be adversely affected by acoustic stressors from the airgun array are discussed in more detail in Section 10. 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. One factor affecting the range-wide status of cetaceans and sea turtles and aquatic habitat at large is climate change. The localized effects of climate change in the action area are discussed in the Environmental Baseline (Section 9).

8.1 Sperm Whale

The sperm whale is a widely distributed species found in all major oceans. Sperm whales were first listed under the precursor to the ESA, the Endangered Species Conservation Act of 1969, and remained on the list of threatened and endangered species after the passage of the ESA in 1973 (35 FR 18319, December 2, 1970).

8.1.1 Life History

The social organization of sperm whales is characterized by females remaining in the geographic area in which they were born and males dispersing more broadly. Females group together and raise young. For female sperm whales, remaining in the region of birth can include very large oceanic ranges over which the whales need to successfully forage and nurse young whales. Male sperm whales are mostly solitary, disperse more widely, and can mate with multiple female populations throughout a lifetime.

The average lifespan of sperm whales is estimated to be at least 50 years (Whitehead 2009b). They have a gestation period of 1 to 1 and a half years, and calves nurse for approximately 2 years. Sexual maturity is reached between 7 and thirteen years of age for females with an average calving interval of 4 to 6 years. Male sperm whales reach full sexual maturity in their twenties. Sperm whales have a strong preference for waters deeper than 1,000 meters (3281 feet; Watkins 1977; Reeves and Whitehead 1997), although Berzin (1971) reported that they are restricted to waters deeper than 300 meters (984 feet). While deep water is their typical habitat, sperm whales are occasionally found in waters less than 300 meters (984 feet) in depth (Clarke 1956; Rice 1989). Sperm whales have been observed near Long Island, New York, in-water between 40-55 meters deep (131.2 to 180.4 feet; Scott and Sadove 1997). When they are found relatively close to shore, sperm whales are usually associated with sharp increases in topography where upwelling occurs and biological production is high, implying the presence of a good food supply (Clarke 1956). Such areas include oceanic islands and along the outer continental shelf. They winter at low latitudes, where they calve and nurse, and summer at high latitudes, where they feed primarily on squid; other prey includes octopus and demersal fish (including teleosts and elasmobranchs).

Sperm whales are widely distributed in the Caribbean and are common in the deep-water passages between islands and along continental slopes (CH2M Hill 2018). Sperm whales inhabit the deep ocean near Puerto Rico from January through about August. There have been 7 documented sperm whale sightings around Puerto Rico from 1994-2014 (Rodriguez et al. 2019) The first sighting reports 1 individual traveling, and the other 2 sightings were of a mother and its calf swimming at the surface, with occasional breaching. In 1 of these sightings (10 September, 2014), the adult female of the pair had a distinctive mark close to the melon area. The picture was also sent to the Guadeloupe Sperm Whale Project for possible identification, however no match was obtained (Rodriguez et al. 2019). This is the only sighting reported in this note which slightly differs from the seasonality proposed by Mignucci-Giannoni et al. (2000), late fall to early winter, and gives insight into how little we know about this species in Puerto Rican waters (Rodriguez et al. 2019). Two of the sightings occurred within the Mona Channel and the other sighting off the insular slope along the south coast of Lajas. Mignucci-Giannoni et al. (2000) suggested that the waters south of Vieques may be important nursing grounds for some marine mammal species, including sperm whales, and may be part of the calving grounds for this species.

8.1.2 Population Dynamics

The sperm whale is the most abundant of the large whale species, with a global population of between 300,000 and 450,000 individuals (Whitehead 2009b). The higher estimates may be approaching population sizes prior to commercial whaling, the reason for ESA listing.

There are 6 recognized stocks of sperm whales that exist in U.S. waters: California/Oregon/Washington (N= 1,997, N_{min}= 1,270), Hawaii (N= 5,707; N_{min}= 4,486), Northern Gulf of Mexico (N= 1,180, N_{min}= 983), North Pacific (no reliable population estimate at this time), North Atlantic (N= 4,349; N_{min}= 3,451), and Puerto Rico and the U.S. VIRGIN ISLANDS (insufficient population data) (Carretta et al. 2022; Hayes et al. 2022; Muto 2022). Sperm whales have been observed in Puerto Rico and the Virgin Islands; in a summary of cetacean sightings in the region over 40 years, 43 sperm whales were sighted. According to the available data, sperm whales are rarely seen within the action area from April through September (Mignucci-Giannoni 1998).

The best abundance estimate available for the Puerto Rico and U.S. VIRGIN ISLANDS stock of sperm whales is unknown. A line-transect survey was conducted during January-March 1995 on NOAA Ship Oregon II, and was designed to cover a wide range of water depths surrounding Puerto Rico and the Virgin Islands. However, due to the bottom topography of the region and the size of the vessel, most waters surveyed were >200 meters (656 feet) deep. Eight sightings of sperm whales were made, 6 of which occurred in and near U.S. waters (Roden and Mullin 2000). Another line transect survey for humpback whales was conducted during February-March 2000 aboard NOAA Ship Gordon Gunter in the eastern and southern Caribbean Sea. A portion of the survey effort occurred in U.S. waters during transit, and 8 sightings of sperm whales were made in and near U.S. waters. During February-March 2001 a line transect survey was conducted in waters of the eastern Bahamas, eastern Dominican Republic, Puerto Rico and Virgin Islands. Five sightings of sperm whales were made near Puerto Rico and the Virgin Islands (in and near

U.S. waters). It was not possible to estimate abundance from these surveys using line-transect methods due to so few sightings.

There are no population estimates for sperm whales in the action area. The best available estimate for Northern Gulf of Mexico sperm whales is 1,665, based on 2003-2004 data, which are insufficient data to determine population trends (Waring et al. 2008).

Ocean-wide genetic studies indicate sperm whales have low genetic diversity, suggesting a recent bottleneck, but strong differentiation between matrilineally related groups (Lyrholm and Gyllensten 1998). Consistent with this, 2 studies of sperm whales in the Pacific indicate low genetic diversity (Mesnick et al. 2011; Rendell et al. 2012). Furthermore, sperm whales from the Gulf of Mexico, the western North Atlantic, the North Sea, and the Mediterranean Sea all have been shown to have low levels of genetic diversity (Engelhaupt et al. 2009). As none of the stocks for which data are available have high levels of genetic diversity, the species may be at some risk to inbreeding and 'Allee' effects, although the extent to which is currently unknown.

Sperm whales are widely distributed in the Caribbean and are common in the deep-water passages between islands and along continental slopes (CH2M Hill 2018). Sperm whales inhabit the deep ocean near Puerto Rico from January through about August.

8.1.3 Vocalization and Hearing

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

Long, repeated clicks are associated with feeding and echolocation (Whitehead and Weilgart 1991; Weilgart and Whitehead 1993; Goold and Jones 1995; Weilgart and Whitehead 1997; Miller et al. 2004). Creaks (rapid sets of clicks) are heard most frequently when sperm whales are foraging and engaged in the deepest portion of their dives, with inter-click intervals and source levels being altered during these behaviors (Miller et al. 2004; Laplanche et al. 2005).

Clicks are also used during social behavior and intragroup interactions (Weilgart and Whitehead 1993). When sperm whales are socializing, they tend to repeat series of group-distinctive clicks (codas), which follow a precise rhythm and may last for hours (Watkins and Schevill 1977). Codas are shared between individuals in a social unit and are considered to be primarily for intragroup communication (Weilgart and Whitehead 1997; Rendell and Whitehead 2004). Research in the South Pacific Ocean suggests that in breeding areas the majority of codas are produced by mature females (Marcoux et al. 2006). Coda repertoires have also been found to vary geographically and are categorized as dialects (Weilgart and Whitehead 1997; Pavan et al. 2000). For example, significant differences in coda repertoire have been observed between sperm whales in the Caribbean Sea and those in the Pacific Ocean (Weilgart and Whitehead 1997). Three coda types used by male sperm whales have recently been described from data collected over multiple years: these codas are associated with dive cycles, socializing, and alarm (Frantzis and Alexiadou 2008).

Our understanding of sperm whale hearing stems largely from the sounds they produce. The only direct measurement of hearing was from a young stranded individual from which auditory evoked potentials were recorded (Carder and Ridgway 1990). From this whale, responses support a hearing range of 2.5-60 kHz and highest sensitivity to frequencies between 5-20 kHz. Other hearing information consists of indirect data. For example, the anatomy of the sperm whale's inner and middle ear indicates an ability to best hear high-frequency to ultrasonic hearing (Ketten 1992). The sperm whale may also possess better low-frequency hearing than other odontocetes, although not as low as many baleen whales (Ketten 1992). Reactions to anthropogenic sounds can provide indirect evidence of hearing capability, and several studies have made note of changes seen in sperm whale behavior in conjunction with these sounds. For example, sperm whales have been observed to frequently stop echolocating in the presence of underwater pulses made by echosounders and submarine sonar (Watkins and Schevill 1975b; Watkins et al. 1985a). In the Caribbean Sea, Watkins et al. (1985a) observed that sperm whales exposed to 3.25-8.4 kHz pulses (presumed to be from submarine sonar) interrupted their activities and left the area. Similar reactions were observed from artificial sound generated by banging on a boat hull (Watkins et al. 1985a). André et al. (1997) reported that foraging whales exposed to a 10 kHz pulsed signal did not ultimately exhibit any general avoidance reactions: when resting at the surface in a compact group, sperm whales initially reacted strongly, and then ignored the signal completely. Thode et al. (2007) observed that the acoustic signal from the cavitation of a fishing vessel's propeller (110 dB re: 1 μPa^2-s between 250 Hz and 1 kHz) interrupted sperm whale acoustic activity and resulted in the animals converging on the vessel. Sperm whales have also been observed to stop vocalizing for brief periods when codas are being produced by other individuals, perhaps because they can hear better when not vocalizing themselves (Goold and Jones 1995). Because they spend large amounts of time at depth and use low frequency sound, sperm whales are likely to be susceptible to low frequency sound in the ocean (Croll et al. 1999). Nonetheless, sperm whales are considered to be part of the mid-frequency marine mammal hearing group, with a hearing range between 150 Hz and 160 kHz (NOAA 2018).

8.1.4 Status

The sperm whale is endangered as a result of past commercial whaling. Although the aggregate abundance worldwide is probably at least several hundred thousand individuals, the extent of depletion and degree of recovery of populations are uncertain. Commercial whaling is no longer allowed, however, illegal hunting may occur at biologically unsustainable levels (NMFS 2015a). Continued threats to sperm whale populations include ship strikes, entanglement in fishing gear, competition for resources due to overfishing, loss of prey and habitat due to climate change, and noise.

8.1.5 Critical Habitat

No critical habitat has been designated for the sperm whale.

8.1.6 Recovery Goals

See the 2010 Final Recovery Plan for the sperm whale (NMFS 2010a) for complete downlisting/delisting criteria for both of the following recovery goals:

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

8.2 Hawksbill Sea Turtle

The hawksbill turtle has a circumglobal distribution throughout tropical and, to a lesser extent, subtropical oceans. The species was first listed under the Endangered Species Conservation Act and listed as endangered under the ESA since 1973. We used information available in the 2007 and 2013 five-year reviews (NMFS and USFWS 2007b; NMFS and USFWS 2013b) to summarize the life history, population dynamics and status of the species.

8.2.1 Life History

Hawksbill sea turtles reach sexual maturity at 20-40 years of age. Females return to their natal beaches every 2 to 5 years to nest (an average of 3 to 5 times per season). Clutch sizes are large (up to 250 eggs). Sex determination is temperature dependent, with warmer incubation producing more females. Hatchlings migrate to and remain in pelagic habitats until they reach approximately 22-25 centimeters (9-10 inches) in straight carapace length. As juveniles, they take up residency in coastal waters to forage and grow. As adults, hawksbills use their sharp beak-like mouths to feed on sponges and corals. Hawksbill sea turtles are highly migratory and use a wide range of habitats during their lifetimes (Musick and Limpus 1997; Plotkin 2003). Satellite tagged turtles have shown significant variation in movement and migration patterns. Distance traveled between nesting and foraging locations range from a few hundred to a few thousand kilometers (Miller 1998; Horrocks et al. 2001).

8.2.2 Population Dynamics

The hawksbill has a circumglobal distribution throughout tropical and, to a lesser extent, subtropical waters of the Atlantic, Indian, and Pacific Oceans. In their oceanic phase, juvenile hawksbills can be found in *Sargassum* mats; post-oceanic hawksbills may occupy a range of habitats that include coral reefs or other hard bottom habitats, sea grass, algal beds, mangrove bays and creeks (Musick and Limpus 1997; Bjorndal and Bolten 2010).

Populations are distinguished generally by ocean basin and more specifically by nesting location. Our understanding of population structure is relatively poor. Genetic analysis of hawksbill sea turtles foraging off the Cape Verde Islands identified 3 closely-related haplotypes in a large majority of individuals sampled that did not match those of any known nesting population in the western Atlantic, where the vast majority of nesting has been documented (Monzón-Argüello et al. 2010). Hawksbills in the Caribbean seem to have dispersed into separate populations (rookeries) after a bottleneck roughly 100,000-300,000 years ago (Leroux et al. 2012).

Surveys at 88 nesting sites worldwide indicate that 22,004 – 29,035 females nest annually (NMFS and USFWS 2013a). In general, hawksbills are doing better in the Atlantic and Indian Ocean than in the Pacific Ocean, where despite greater overall abundance, a greater proportion of the nesting sites are declining. Throughout Puerto Rico, there are 20 nesting beaches for hawksbill sea turtles. There are 2 known hawksbill nesting beaches near the proposed action areas; Pinones on the north side of Puerto Rico (less than 25 crawls per year), closest to the high-energy airgun survey, and Caja de Muerto on the south side of the island (between 25 and 100 nest crawls per year), near the location of the low-energy, 2-airgun survey. In Puerto Rico, hawksbill nesting occurs from July to October.

From 1980-2003, the number of nests at 3 primary nesting beaches (Rancho Nuevo, Tepehuajes, and Playa Dos) increased 15% annually (Heppell et al. 2005); however, due to recent declines in nest counts, decreased survival at other life stages, and updated population modeling, this rate is not expected to continue (NMFS and USFWS 2013a).

8.2.3 Hearing

Sea turtles are low frequency hearing specialists, typically hearing frequencies from 30 Hz to 2 kHz, with a range of maximum sensitivity between 100-800 Hz (Ridgway et al. 1969; Lenhardt 1994; Bartol et al. 1999; Lenhardt 2002; Bartol and Ketten 2006). Piniak et al. (2012) found hawksbill turtle hatchlings capable of hearing underwater sounds at frequencies of between 50 Hz to 1.6 kHz (maximum sensitivity at 200-400 Hz). These hearing sensitivities are similar to those reported for 2 terrestrial species: pond and wood turtles. Pond turtles respond best to sounds between 200-700 Hz, with slow declines below 100 Hz and rapid declines above 700 Hz, and almost no sensitivity above 3 kHz (Wever and Vernon 1956). Wood turtles are sensitive up to about 500 Hz, followed by a rapid decline above 1 kHz and almost no responses beyond 3 or 4 kHz (Patterson 1966).

8.2.4 Status

Long-term data on the hawksbill sea turtle indicate that 63 sites have declined over the past 20-100 years (historic trends are unknown for the remaining 25 sites). Recently, 28 sites (68%) have experienced nesting declines, 10 have experienced increases, 3 have remained stable, and 47 have unknown trends. The greatest threats to hawksbill sea turtles are overharvesting of turtles and eggs, degradation of nesting habitat, and fisheries interactions. Adult hawksbills are harvested for their meat and carapace, which is sold as tortoiseshell. In addition, lights on or adjacent to nesting beaches are often fatal to emerging hatchlings and alters the behavior of nesting adults. The species' resilience to additional perturbation is low.

8.2.5 Critical Habitat

On September 2, 1998, NMFS established critical habitat for hawksbill sea turtles around Mona and Monito Islands, Puerto Rico (63 FR 46693). This critical habitat is not present within the action area.

8.2.6 Recovery Goals

See the 1992 Recovery Plan for the U.S. Caribbean, Atlantic and Gulf of Mexico (NMFS and USFWS 1993) and the 1998 Recovery Plan for the U.S. Pacific populations (NMFS and USFWS 1998) of hawksbill sea turtles, for complete down listing/delisting criteria for each of their respective recovery goals. The following items were the top recovery actions identified to support in the recovery plans:

1. Identify important nesting beaches.
2. Ensure long-term protection and management of important nesting beaches.
3. Protect and manage nesting habitat; prevent the degradation of nesting habitat caused by seawalls, revetments, sand bags, other erosion-control measures, jetties and breakwaters.
4. Identify important marine habitats; protect and manage populations in marine habitat.
5. Protect and manage marine habitat; prevent the degradation or destruction of important [marine] habitats caused by upland and coastal erosion.
6. Prevent the degradation of reef habitat caused by sewage and other pollutants.
7. Monitor nesting activity on important nesting beaches with standardized index surveys.
8. Evaluate nest success and implement appropriate nest-protection on important nesting beaches.
9. Ensure that law-enforcement activities prevent the illegal exploitation and harassment of sea turtles and increase law-enforcement efforts to reduce illegal exploitation.
10. Determine nesting beach origins for juvenile and sub adult populations.

8.3 Leatherback Sea Turtle

The leatherback sea turtle is unique among sea turtles for its large size, wide distribution (due to thermoregulatory systems and behavior), and lack of a hard, bony carapace. Leatherback turtles range from tropical to subpolar latitudes worldwide and are the largest living turtle, reaching lengths of 2 meters (6.5 feet) long, and weighing up to 907.2 kg (2,000 pounds). Leatherback turtles occur throughout marine waters, from nearshore habitats to oceanic environments (Shoop and Kenney 1992). Movements are largely dependent upon reproductive and feeding cycles and the oceanographic features that concentrate prey, such as frontal systems, eddy features, current boundaries, and coastal retention areas (Benson et al. 2011).

The species was first listed under the Endangered Species Conservation Act (35 FR 8491) and listed as endangered under the ESA since 1973. In the 2020 Five-Year Status Review, NMFS and U.S. Fish and Wildlife Service assessed the discreteness and significance of leatherback populations. After reviewing the best available information, the agencies identified 7 leatherback populations that meet the discreteness and significance criteria of the DPS Policy (Figure 2). Leatherback sea turtles in the action area that may be exposed to the action originate from the Northwest Atlantic DPS, and will be considered here.

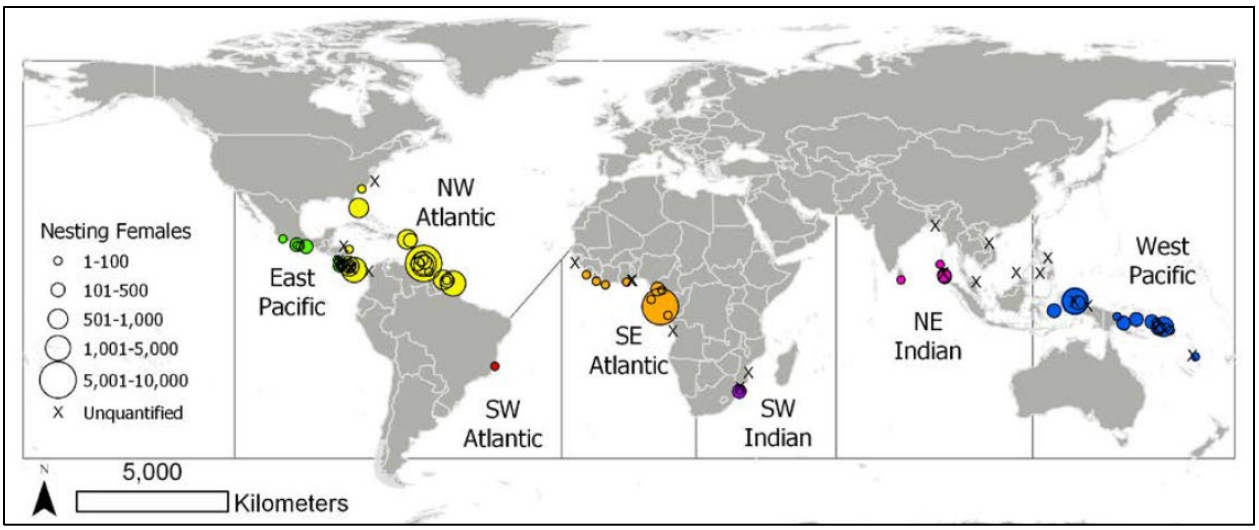

Figure 2. Map of Leatherback DPS boundaries and nesting beaches. From NMFS and USFWS 2020.

Leatherback sea turtles in the action area would belong to the Northwest Atlantic DPS. We used information available in the 5 year review (NMFS and USFWS 2013c) and (NMFS 2020b) and the critical habitat designation (77 FR 61573) to summarize the life history, population dynamics and status of the species.

8.3.1 Life History

The age of maturity for leatherback sea turtles has been difficult to ascertain, with estimates ranging from 5-29 years (Spotila et al. 1996; Avens et al. 2009). Females lay up to 7 clutches per season, with more than 65 eggs per clutch and eggs weighing >80 grams (Reina et al. 2002; Wallace et al. 2007). The number of leatherback hatchlings that make it out of the nest onto the beach (i.e., emergent success) is approximately 50% worldwide (Eckert et al. 2012). Females nest every 1 to 7 years. Natal homing, at least within an ocean basin, results in reproductive isolation between 5 broad geographic regions: eastern and western Pacific, eastern and western

Atlantic, and Indian Ocean. Leatherback sea turtles migrate long, transoceanic distances between their tropical nesting beaches and the highly productive temperate waters where they forage, primarily on jellyfish and tunicates. These gelatinous prey are relatively nutrient-poor, such that leatherbacks must consume large quantities to support their body weight. Leatherbacks weigh approximately 33% more on their foraging grounds than at nesting, indicating that they probably catabolize fat reserves to fuel migration and subsequent reproduction (James et al. 2005; Wallace et al. 2006). Sea turtles must meet an energy threshold before returning to nesting beaches. Therefore, their remigration intervals (the time between nesting) are dependent upon foraging success and duration (Hays 2000; Price et al. 2004).

8.3.2 Population Dynamics

Leatherback sea turtles are distributed in oceans throughout the world. Leatherbacks occur throughout marine waters, from nearshore habitats to oceanic environments (Shoop and Kenney 1992). Movements are largely dependent upon reproductive and feeding cycles and the oceanographic features that concentrate prey, such as frontal systems, eddy features, current boundaries, and coastal retention areas (Benson et al. 2011).

Analyses of mitochondrial DNA from leatherback sea turtles indicates a low level of genetic diversity, pointing to possible difficulties in the future if current population declines continue (Dutton et al. 1999). Further analysis of samples taken from individuals from rookeries in the Atlantic and Indian oceans suggest that each of the rookeries represent demographically independent populations (NMFS 2013a). Genetic diversity of the Northwest Atlantic DPS is moderate, with 6 mtDNA haplotypes (Dutton et al. 2013). In St. Croix, a unique haplotype occurs at high frequency. The Florida and Costa Rica nesting aggregations each possess 1 unique, low frequency haplotype (NMFS 2020b). St. Croix likely represents a broader Northern Caribbean subpopulation that includes multiple neighboring island nesting aggregations in the U.S. Virgin Islands and Puerto Rico, however sampling and analysis are required to determine extent of fine scale structuring (NMFS unpublished data).

Leatherbacks have nesting beaches in the Pacific, Atlantic, and Indian oceans. Detailed population structure is unknown, but is likely dependent upon nesting beach location. Leatherback sea turtle nesting activity occurs on beaches around the main island of Puerto Rico, with the highest amount of leatherback nesting taking place on beaches along the northeastern coast of the island. Leatherback nesting also occurs around offshore islands of Puerto Rico, including Culebra where a number of beaches are used by this species.

Recent information indicates that there are 788 nesting females in Puerto Rico (NMFS 2020b); there are 21 leatherback nesting sites throughout Puerto Rico (Eckert and Eckert 2019). In Puerto Rico, the number of nests varies annually, with a low of 1,187 nests in 2017, and a high of 2,167 nests in 2016 (NMFS and USFWS 2020). Nest trends at 3 beaches in Puerto Rico vary as well, with Culebra exhibiting a negative nesting trend from 1984-2017 (-3.7%), while Luquillo-Fajarado (1996-2017) and Maunabo (1999-2017) exhibiting positive nesting trends (4.2% and 7.7%, respectively).

8.3.3 Hearing

Little is known about sea turtle sound use and production. Nesting leatherback turtles have been recorded producing sounds (sighs, grunts or belch-like sounds) up to 1,200 Hz with maximum energy from 300-500 Hz, although these sounds are thought to be associated with breathing (Mrosovsky 1972; Cook and Forrest 2005). In addition, leatherback embryos in eggs and hatchlings have been recorded making low-frequency pulsed and harmonic sounds (Ferrara et al. 2014).

Piniak (2012) measured hearing of leatherback turtle hatchlings in-water an in air, and observed reactions to low frequency sounds, with responses to stimuli occurring between 50 Hz and 1.6 kHz in air between 50 Hz and 1.2 kHz in-water (lowest sensitivity recorded was 93 dB re: 1 μPa at 300 Hz).

8.3.4 Status

The leatherback turtle is an endangered species whose once large nesting populations have experienced steep declines in recent decades. The primary threats to leatherback turtles include fisheries bycatch, harvest of nesting females, and egg harvesting (Martínez et al. 2007). Because of these threats, once large rookeries are now functionally extinct, and there have been range-wide reductions in population abundance. Other threats include loss of nesting habitat due to development, tourism, and sand extraction. Lights on or adjacent to nesting beaches alter nesting adult behavior and are often fatal to emerging hatchlings as they are drawn to light sources and away from the sea. Plastic ingestion is common in leatherback turtles and can block gastrointestinal tracts leading to death. Climate change may alter sex ratios (as temperature determines hatchling sex), range (through expansion of foraging habitat), and habitat (through the loss of nesting beaches, because of sea-level rise). The species’ resilience to additional perturbation is low.

Coastal development is considered a significant threat, particularly at Playa Grande-El Paraiso (i.e., Dorado Beach, which is considered to be the most important nesting beach in Puerto Rico). Development reduces access to sea turtle nesting sites due to buildings and human presence. Urban development in Puerto Rico near leatherback nesting beaches is also an on-going concern, as is deforestation. Predation of leatherback eggs by feral dogs is a concern. In Playa California, Maunabo, Puerto Rico, more than 30% of the leatherback nests were depredated by stray dogs in 2012. Leatherback bycatch in coastal and artisanal fisheries is a threat throughout the Greater Caribbean (NMFS and USFWS 2020).

Overall, the DPS appears to be exhibiting a decrease in annual nesting activity, based on observations of significant declines in nesting activity at beaches where there has been historically a high abundance of nesting females (Trinidad and Tobago, Suriname, and French Guiana). Other metrics of productivity for the DPS are close to the species’ average, the decline in nesting activity puts the DPS at risk. While the estimated total index of nesting female abundance for the Northwest Atlantic population (20,659 females) is relatively high compared to the Pacific populations, this population faces clear and present threats that, along with a declining nest trend, place its continued persistence in question (NMFS and USFWS 2020).

8.3.5 Critical Habitat

On March 23, 1979, NMFS established critical habitat for leatherback sea turtles in waters adjacent to Sandy Point Beach, St. Croix, U.S. Virgin Islands (44 FR 17710). This critical habitat is not present within the action area.

8.3.6 Recovery Goals

See the 1992 Recovery Plans for the U.S Caribbean, Gulf of Mexico and Atlantic leatherback turtles for complete down listing/delisting criteria for their recovery goals(NMFS 1992). The following items were the top 5 recovery actions identified in the Leatherback Five-Year Action Plan:

1. Reduce fisheries interactions.
2. Improve nesting beach protection and increase reproductive output.
3. International cooperation.
4. Monitoring and research.
5. Public engagement.

8.4 Green Sea Turtle—North and South Atlantic Distinct Population Segments

The green sea turtle was listed under the ESA on July 28, 1978. On April 6, 2016, NMFS listed 11 DPSs of green sea turtles as threatened or endangered under the ESA. Eight DPSs are listed as threatened: Central North Pacific, East Indian-West Pacific, East Pacific, North Atlantic, North Indian, South Atlantic, Southwest Indian, and Southwest Pacific. Three DPSs are listed as endangered: Central South Pacific, Central West Pacific, and Mediterranean. The DPSs considered in this biological opinion that occur within the action area are the threatened North Atlantic and South Atlantic DPSs.

North Atlantic DPS green turtles nest in the action area, but South Atlantic DPS green turtles do not. However, South Atlantic DPS green turtles have been found in feeding aggregations near the action area (Lahanas et al. 1998), so we consider South Atlantic DPS individuals as likely to occur in the action area.

We used information available in the 2007 five-year review (NMFS and USFWS 2007a) and 2015 Status Review (Seminoff et al. 2015b) to summarize the life history, population dynamics and status of the species.

8.4.1 Life History

Age at first reproduction for females is 20-40 years. Green sea turtles lay an average of 3 nests per season with an average of 100 eggs per nest. The remigration interval (i.e., return to natal beaches) is 2-5 years. Nesting occurs primarily on beaches with intact dune structure, native vegetation and appropriate incubation temperatures during summer months. After emerging from the nest, hatchlings swim to offshore areas and go through a post-hatchling pelagic stage where they are believed to live for several years. During this life stage, green sea turtles feed close to the surface on a variety of marine algae and other life associated with drift lines and debris. Adult turtles exhibit site fidelity and migrate hundreds to thousands of kilometers from nesting beaches to foraging areas. Green sea turtles spend the majority of their lives in coastal foraging grounds, which include open coastlines and protected bays and lagoons. Adult green turtles feed primarily on seagrasses and algae, although they also eat jellyfish, sponges and other invertebrate prey.

8.4.2 Population Dynamics

Compared to other DPSs, the North Atlantic DPS exhibits the highest nester abundance, with approximately 167,424 females at 73 nesting sites, and available data indicate an increasing trend in nesting. The largest nesting site in the North Atlantic DPS is in Tortuguero, Costa Rica, which hosts 79% of nesting females for the DPS (Seminoff et al. 2015a). There are 4 green turtle nesting beaches throughout Puerto Rico, on the east and west sides of the island. Three of these beaches see fewer than 25 crawls per year, and 1 (Vieques) has between 100 and 500 crawls per year (Eckert and Eckert 2019).

The South Atlantic DPS has 51 nesting sites, with an estimated nester abundance of 63,332. The largest nesting site is at Poilão, Guinea-Bissau, which hosts 46% of nesting females for the DPS (Seminoff et al. 2015a). There are no nesting sites for South Atlantic DPS green turtle in the action area.

For the North Atlantic DPS, the available data indicate an increasing trend in nesting. There are no reliable estimates of population growth rate for the DPS as a whole, but estimates have been developed at a localized level. Modeling by Chaloupka et al. (2008) using data sets of 25 years or more show the Florida nesting stock at the Archie Carr NWR growing at an annual rate of 13.9%, and the Tortuguero, Costa Rica, population growing at 4.9%. Population growth information for North Atlantic DPS green turtles in Puerto Rico specifically is not known.

There are 51 nesting sites for the South Atlantic DPS, and many have insufficient data to determine population growth rates or trends. Of the nesting sites where data are available, such as Ascension Island, Suriname, Brazil, Venezuela, Equatorial Guinea, and Guinea-Bissau, there is evidence that population abundance is increasing.

The North Atlantic DPS has a globally unique haplotype, which was a factor in defining the discreteness of the population for the DPS. Evidence from mitochondrial DNA studies indicates that there are at least 4 independent nesting subpopulations in Florida, Cuba, Mexico and Costa Rica (Seminoff et al. 2015a). More recent genetic analysis indicates that designating a new western Gulf of Mexico management unit might be appropriate (Shamblin et al. 2015).

South Atlantic DPS individuals from nesting sites in Brazil, Ascension Island, and western Africa have a shared haplotype found in high frequencies. Green turtles from rookeries in the eastern Caribbean, however, are dominated by a different haplotype.

As juveniles, green turtles will make extensive movements to feeding areas far from their natal beaches. For example, North Atlantic DPS green turtles originating from nesting beaches in Florida and Mexico were identified on feeding grounds off Colombia (Vásquez-Carrillo et al. 2020). There is a known feeding area for juvenile green turtles near Culebra, Puerto Rico. Genetic analysis of individuals captured there shows them originating from nesting beaches in Mexico, Costa Rica, Florida, and Suriname (South Atlantic DPS) (Patrício et al. 2017).

8.4.3 Hearing

As with other sea turtle species, green sea turtles are low frequency hearing specialists, typically hearing frequencies from 30 Hz to 2 kHz, with a range of maximum sensitivity between 100-800 Hz (Ridgway et al. 1969; Lenhardt 1994; Bartol et al. 1999; Lenhardt 2002; Bartol and Ketten 2006). Piniak et al. (2016) found green sea turtle juveniles capable of hearing underwater sounds at frequencies of 50 Hz to 1,600 Hz (maximum sensitivity at 200-400 Hz). Hearing below 80 Hz is less sensitive but still possible (Lenhardt 1994). Other studies have similarly found greatest sensitivities between 200-400 Hz for the green turtle with a range of 100-500 Hz (Ridgway et al. 1969; Bartol and Ketten 2006).

8.4.4 Status

Historically, green turtles in the North Atlantic DPS were hunted for food, which was the principal cause of the population's decline. Apparent increases in nester abundance for the North Atlantic DPS in recent years are encouraging but must be viewed cautiously, as the datasets represent a fraction of a green sea turtle generation, up to 50 years. While the threats of pollution, habitat loss through coastal development, beachfront lighting, and fisheries bycatch continue, the North Atlantic DPS appears to be somewhat resilient to future perturbations.

Though there is some evidence that the South Atlantic DPS is increasing, there is a considerable amount of uncertainty over the impacts of threats to the South Atlantic DPS. The DPS is threatened by habitat degradation at nesting beaches, and mortality from fisheries bycatch remains a primary concern.

8.4.5 Critical Habitat

On September 2, 1998, NMFS established critical habitat for green sea turtles around Culebra, Mona, and Monito Islands, Puerto Rico (63 FR 46693). This critical habitat is not present within the action area. See Section 7.3.4 for a discussion of the proposed critical habitat for North Atlantic Ocean DPS green turtle that would change the current designation. There has been critical habitat proposed for the South Atlantic Ocean DPS green turtle around St. Thomas, St. John, and St. Croix, U.S. Virgin Islands (88 FR 46572). This proposed critical habitat is not present within the action area.

8.4.6 Recovery Goals

See the 1991 recovery plan for the Atlantic populations of green sea turtles for complete down-listing/delisting criteria for recovery goals for the species (NMFS and USFWS 1991a). Broadly, recovery plan goals emphasize the need to protect and manage nesting and marine habitat, protect and manage populations on nesting beaches and in the marine environment, increase public education, and promote international cooperation on sea turtle conservation topics.

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). 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 (sperm whale) and sea turtles (North Atlantic DPS and South Atlantic DPS of green turtle, leatherback turtle, and hawksbill turtle) in the action area. Some human activities are ongoing and appear to continue to affect marine mammal and sea turtle 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, vessel interactions (vessel strike), fisheries (fisheries interactions), pollution (marine debris, pollutants and contaminants, and hydrocarbons), aquatic nuisance species, anthropogenic sound (vessel sound and commercial shipping, aircraft, seismic surveys, marine construction, active sonar, 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 are likely to be adversely affected by the high-energy seismic survey activities considered in this consultation. This is important because, in some states or life history stages, or areas of their ranges, ESA-listed individuals 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 action.

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 (Powell 2017; Lynas et al.

2021). 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 affect ESA resources. NOAA's climate information portal provides basic background information on these and other measured or anticipated climate change effects (see https://www.climate.gov).

Over the last 150 years the world has warmed as humans have continued to add heat-trapping greenhouse gases to the atmosphere (Figure 3) (Hayhoe et al. 2018; IPCC 2022). This warming has triggered many changes in the earth's climate. Numerous independent lines of evidence have documented these changes, from the atmosphere to the ocean to the poles. This warming, primarily in response to human activities, is causing widespread effects in the physical environment, including more intense storms, melting glaciers, disappearing snow cover, shrinking sea ice, rising sea levels, changes in rainfall patterns, and shifting droughts (Wuebbles et al. 2017). Globally, surface temperatures have increased by 0.99° Celsius in recent decades (2001-2020) compared to the pre-industrial average from 1850-1900 (IPCC 2022). This warming has occurred over nearly the entirety of the earth's surface. Precipitation has also increased as the earth's atmosphere warms and contains more water vapor. But the changes in precipitation are uneven, with patterns of wetting and drying interspersed around the planet. As the earth warms, melting ice from land surfaces and expanding ocean volume has resulted in global mean sea levels to rise by 0.20 meters (0.65 feet) between 1901 and 2018 (IPCC 2022).

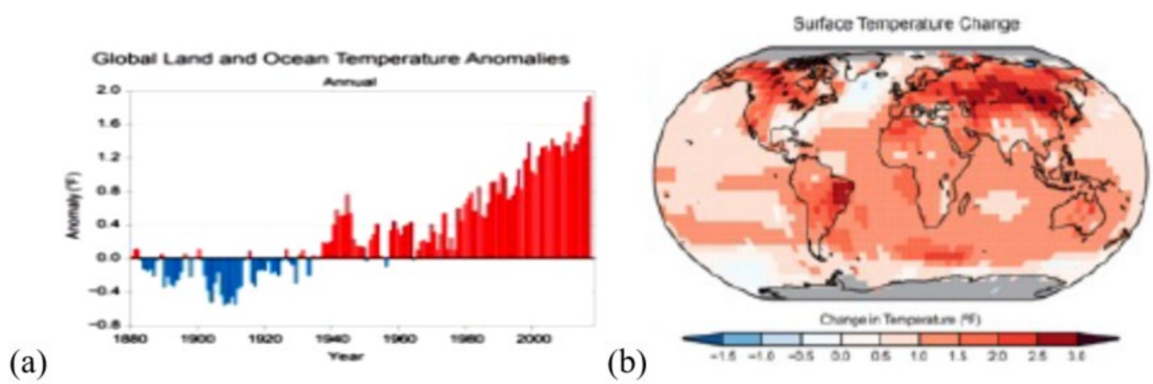

Figure 3. Global annual average temperature (a) Red bars show temperatures above the 1901-1960 average, and blue bars indicate temperatures below the average. (b) From 1986 -2016 global average surface temperature increased by 0.7° Celsius compared to 1901-1960 (Wuebbles et al. 2017) and by 0.99° Celsius from 2001-2020 compared to 1850-1900 (IPCC 2022).

Using the prior generation of global climate models (CMIP5-Coupled Model Intercomparison Project phase 5; Tebaldi et al. 2021), the annual mean temperature change within the Caribbean was compared against global mean warming targets of 1.5° Celsius, 2.0° Celsius and 2.5° Celsius above preindustrial levels for a climate forcing scenario corresponding to lower levels of greenhouse gas emissions (RCP4.5; Thomson et al. 2011). The comparison illustrates the projected temperature within the Caribbean intensifies above 2.0° Celsius including extreme changes in temperature.

For instance, the projected number of warm spells goes up drastically with additional warming - extension of 70 days from 1.5° Celsius to 2° Celsius global warming. A follow-up study used a set of regional climate model projections to better quantify climate change projections within the Caribbean for the same global warming targets (Campbell et al. 2021). The Caribbean islands were found to warm faster than the surrounding oceans by 0.5° Celsius to 1.5° Celsius, with the largest warming occurring during the cooler months. The regional climate model projections also indicate differential warming within the Caribbean with the largest warming occurring over the northern Caribbean. This is an indication that increased warming may favor more homogenous temperatures from south to north.

The rising concentrations of greenhouse gases in the atmosphere, now higher than any period in the last 800,000 years, have also affected the chemistry of the ocean, causing it to become more acidic. These large-scale changes in the earth's climate are in turn causing changes locally to Puerto Rico's climate and environment. PRCC (2022) notes that Puerto Rico is expected to warm faster than the global average, with increases in both mean and extreme temperatures. Concern for these threats led the Puerto Rico government to sign into law in 2019 the Climate Change Mitigation, Adaptation and Resilience Act requiring the island of Puerto Rico to reduce its greenhouse gas emissions over the course of the next 5 years by 50% (PRCC 2022).

Several of the most important threats contributing to the extinction risk of proposed and ESA-listed species, particularly those with a calcium carbonate skeleton such as corals and mollusks as well as species like ESA-listed sea turtles 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 proposed and 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, including in the Caribbean, and is predicted to increase considerably between now and 2100 (IPCC 2014).

Changes in the marine ecosystem caused by global climate change (e.g., ocean acidification, salinity, oceanic currents, DO 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 proposed and ESA-listed species including marine mammals, sea turtles, fish, and mollusks. 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).

McMahon and Hays (2006) predicted increased ocean temperatures will expand the distribution of leatherback turtles into more northern latitudes. The authors noted this is already occurring in the Atlantic Ocean and is likely to occur in the Pacific.

Similarly, climate-related changes in important prey species populations are likely to affect predator populations. 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).

Macleod (2009) estimated that, based upon expected shifts in-water temperature, 88% of cetaceans would be affected by climate change, 47% would be negatively affected, and 21% would be put at risk of extinction. Changes in core habitat area means some species are predicted to experience gains in available core habitat and some are predicted to experience losses (Hazen et al. 2012). Such range shifts could affect marine mammal and sea turtle foraging success as well as sea turtle reproductive periodicity (Pike 2013; Silber et al. 2017).

Genetic analyses and behavioral data suggest that sea turtle populations with temperature-dependent sex determination may be unable to evolve rapidly enough to counteract the negative fitness consequences of rapid global temperature change (Hays 2008 as cited in Newson et al. 2009). Altered sex ratios have been observed in sea turtle populations worldwide (Mazaris et al. 2008; Reina et al. 2008; Robinson et al. 2008; Fuentes et al. 2009). This does not yet appear to have affected population viabilities through reduced reproductive success, although average nesting and emergence dates have changed over the past several decades by days to weeks in some locations (Poloczanska et al. 2009). A fundamental shift in population demographics may lead to increased instability of populations that are already at risk from several other threats. In addition to altering sex ratios, increased temperatures in sea turtle nests can result in reduced incubation times (producing smaller hatchling), reduced clutch size, and reduced nesting success due to exceeded thermal tolerances (Fuentes et al. 2009; Fuentes et al. 2010; Fuentes et al. 2011; Azanza-Ricardo et al. 2017). Within the action area, sea level rise is affecting sea turtle nesting beaches (Gould et al. 2018).

9.2 Vessel Activity

Potential sources of adverse effects from Federal vessel operations in the action area include operations of NOAA vessels, anchor and propeller damage and accidental groundings. NOAA, including the National Ocean Servive and other line offices, conducts coral reef monitoring, benthic surveys, sediment sampling, and other scientific surveys in the action area. The National Ocean Service and the Southeast Fisheries Science Center lead the NOAA National Coral Reef Monitoring Program efforts that take place every 2 years at randomly selected sampling sites around Puerto Rico. NMFS OPR completed a programmatic ESA section 7 consultation for

NOAA's Coral Reef Conservation Program for coral restoration, monitoring, and other activities that receive some or all Coral Reef Conservation Program funding (NMFS 2022a) and also sometimes involve the use of a NOAA vessel.

NMFS and the United States Coast Guard completed an informal programmatic section 7 consultation for the Caribbean Marine Event Program for marine events in the United States Virgin Islands and Puerto Rico in December 2017. As a result of this consultation, the United States Coast Guard includes guidelines to avoid and minimize potential impacts of marine events, especially events involving motorized vessels such as speedboat races, to ESA-listed species and their habitat as permit conditions the event participants must follow. NMFS has also completed a national programmatic formal consultation with the United States Coast Guard to cover maintenance of Federal aids to navigation (ATONs) throughout Puerto Rico and the entire U.S, and recently completed reinitiation of this consultation. ATON maintenance requires the use of United States Coast Guard cutters and the consultation included requirements to minimize potential impacts of vessel operation and other actions associated with ATON maintenance on ESA-listed corals and their habitat. ATONs are present in some portions of the action area, particularly ports and navigation channels.

Through the ESA section 7 process, where applicable, NMFS will establish RPMs and/or Federal agencies will propose conservation measures for vessel operations to avoid or minimize adverse effects to proposed and ESA-listed species in the action area from vessel transit, anchoring, and other vessel operations. However, vessel operations do present the potential for some level of interaction with proposed and ESA-listed species in the action area.

Commercial and recreational vessel traffic can have adverse effects on sperm whales and ESA-listed sea turtles via propeller injuries and boat strike injuries (turtles), and accidental groundings, propeller scarring, and propeller wash (habitat for sea turtles). NMFS did not find records of vessel collisions with sperm whales but, because deeper waters of the action area include routes for shipping traffic, there is a possibility of vessel collision, some of which may be unreported. Puerto Rico Department of Natural and Environmental Resources stranding data indicate that 13 green sea turtles and 16 hawksbill sea turtles could be confirmed to have been impacted by boats in the action area from 1989-2009. The proliferation of vessels is associated with the proliferation and expansion of docks, the expansion and creation of port facilities, and the expansion and creation of marinas. The action area includes the east coast of Puerto Rico where port and marina expansion and dock construction occur and other areas around Vieques that are not federally managed. As part of the section 7 consultation for dock, port, and marina construction activities under the jurisdiction of the United States Army Corps of Engineers, NMFS also considers the impacts of vessel traffic from the operation of these facilities and any measures to avoid and minimize adverse impacts to sea turtles. Additionally, because the construction of many of these in-water facilities involves pile-driving, NMFS also considers the potential acoustic impacts of facility construction on marine mammals, sea turtles, and fish and any measures to avoid and minimize injurious and behavioral acoustic impacts to these animals.

Commercial and recreational vessel traffic in the action area is also associated with commercial and private diving activities. Anchoring of these vessels at reef sites can lead to impacts to habitat used by ESA-listed sea turtles.

9.3 Fisheries

Commercial whalers once targeted sperm whales. Once commercial whaling ended, the species was expected to rebuild; however, a study in the eastern Caribbean indicates that unit size, numbers of calves, and calving rates in a well-studied population have continued declining (Gero and Whitehead 2016).

Fishing gear currently used in the Caribbean, including Puerto Rico, includes gillnets, which have been shown to cause entanglement of sperm whales. Two were reported entangled in 2015 in the eastern Caribbean (Gero and Whitehead 2016). There are no reported entanglements of sperm whales in the action area, but the population in the eastern Caribbean is the same population that travels through the action area so entanglement due to fishing gear in and outside the action area could contribute to population declines. Stranding of sperm whales because of interactions with fisheries has not been reported in the action area and, given the artisanal nature of the fisheries in the action area in both Federal and Commonwealth waters, is not likely to occur.

Fishing gears used throughout the action area adversely affect threatened and endangered sea turtles. Based on stranding data from Commonwealth waters (PRDNER unpublished stranding data), net and hook-and-line gear have been documented as interacting with sea turtles in Puerto Rico. Illegal fishing targeting sea turtles accounted for 33% of reported sea turtle strandings around Vieques for the period from 1991–2008 with no incidental capture of sea turtles in fishing gear reported (PRDNER unpublished stranding data). All of the turtles affected by illegal fishing (i.e., harpooning) were hawksbills. Abandoned or lost fishing gear can also affect the quality of refuge and foraging habitat for green and hawksbill sea turtles as abandoned gear can lead to abrasion and breakage in hard bottom and coral reef habitats. They also have shading impacts on seagrass and macroalgae if the gear is large enough, such as traps and nets.

Fishery interaction remains a major threat to sea turtle recovery. Wallace et al. (2010) estimated that worldwide 447,000 sea turtles are killed each year from bycatch in commercial fisheries. Although sea turtle excluder devices and other bycatch reduction devices have significantly reduced the level of bycatch of sea turtles and other marine species in U.S. waters, mortality still occurs.

The fishery for Atlantic Highly Migratory Species is known to incidentally capture large numbers of leatherback and loggerhead sea turtles, particularly in the pelagic longline component. Pelagic longline, pelagic driftnet, bottom longline, and/or purse seine gear have all been documented taking sea turtles. Thousands of sea turtles have been caught in this fishery throughout the Atlantic since 1992, and a portion of these interactions occurred in the Caribbean. A subset of these animals were landed dead, and another subset likely experienced post-release mortality, a number which was substantial (NMFS 2004). A permanent prohibition on the use of driftnet gear in the swordfish fishery was published in 1999. NMFS reinitiated consultation on the pelagic longline component of this fishery (NMFS 2004) because the authorized number of incidental takes for loggerheads and leatherbacks sea turtles, species not likely to be adversely affected by the proposed actions under consultation in this opinion, were exceeded. The resulting biological opinion stated the long-term continued operation this sector of the fishery was likely to jeopardize the continued existence of leatherback sea turtles, but reasonable and prudent alternatives were identified allowing for the continued authorization of the pelagic longline fishing that would not jeopardize leatherback sea turtles. Reinitiation of consultation has been conducted again and a biological opinion issued in 2020 (NMFS 2020a); jeopardy to any species is not expected. In the U.S. Caribbean, commercial tuna and swordfish fishers primarily use pelagic longline, rod and reel, and handline gear (NMFS 2012). Longline vessels targeting Atlantic Highly Migratory Species in the Caribbean set fewer hooks per set, on average and fish deeper in the water column than the fleets in other areas (e.g., Northeast Distant).

The take authorized for the Puerto Rico fishery under the Puerto Rico Fishery Management Plan (FMP) (SERO 2020) using a 3 year time period is for the monitoring of anticipated take is noted in Table 8.

Table 8. Puerto Rico Fishery Management Plan anticipated fisheries take.

Species	Lethal Take	Non-Lethal Take
Sea Turtle- green*	6 individuals	0
Sea Turtle- hawksbill	6 individuals	0
***Up to 6 takes of green sea turtles, total, from any combination of the NA and SA DPSs**	**Additional nonlethal take of these species as a result of the effect to corals from the harvest of the herbivorous fish (loss of grazing capacity).	

Anticipated levels of take under the Spiny Lobster FMP (NMFS 2011) are 12 lethal takes of green and hawksbill sea turtles over 3 years and 9 lethal takes of leatherback sea turtles over 3 years. Informal Section 7 consultations were also completed for the Caribbean Coral and Queen Conch FMPs. NMFS concluded that implementation of the Coral and Queen Conch FMPs are not likely to adversely affect ESA-listed sea turtles.

Globally, 6.4 million tons of fishing gear is lost in the oceans every year (Wilcox et al. 2015). Marine mammal and sea turtle entanglement and bycatch is a global problem that every year results in the death of hundreds of thousands of animals worldwide. 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% of entanglement is caused by derelict fishing gear (Baulch and Perry 2014).

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. 2010). As with vessel strikes, entanglement or entrapment in fishing gear likely has the greatest impact on populations of ESA-listed species with the lowest abundance (e.g., Kraus et al. 2016). Nevertheless, all species of marine mammals may face threats from derelict fishing gear.

In addition to these direct impacts, cetaceans may also be subject to indirect impacts from fisheries. 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 (Garcia et al. 2003). However, the effects of fisheries on whales through changes in prey abundance remain largely unknown in the action area.

Directed harvest of sea turtles and their eggs for food and other products has existed for years and was a significant factor causing the decline of several species, including the green turtle, hawksbill turtle, leatherback turtle, and loggerhead turtle considered in this consultation. In the U.S., the harvest of nesting sea turtles and eggs is now illegal; however, poaching is a problem on some beaches (Ehrhart and Witherington. 1987). Nesting adults and eggs continue to be harvested legally and illegally in other nations (Benson et al. 2007; Benson et al. 2011). There has been a dramatic decrease in poaching of eggs and slaughter of nesting females due to the presence of sea turtle community groups since 2012, although it is possible some poaching is occurring undetected. However, inwater feeding areas still suffer from poaching. For example, in 2018, slaughtering of hawksbill was recorded in several keys off the south coast of Puerto Rico (C. Diez, Programa de Especies Protegidas-DRNA-PR, pers. comm. to P. Opay, NMFS SERO PRD, March 27, 2019; SERO 2020).

Several examples of sea turtle poaching in areas near the action area have occurred over the past 2 decades. In 2013, a man pled guilty to felony violation of the Lacey Act for illegal sale of sea turtle meat and carapaces from endangered hawksbill sea turtles and meat from a threatened green sea turtle, while knowing that the sea turtles had been taken in violation of the ESA. The illegal sales took place in 2009-2010 around Playa Añasco, Puerto Rico. The case resulted from a joint-undercover operation by the NOAA Office of Law Enforcement and the Federal Bureau of Investigation (U.S. DOJ 2013). In July 2013, 8 people were arrested in Puerto Rico on charges of selling endangered sea turtles for human consumption. An undercover operation revealed that the suspects were involved in selling the meat of 15 hawksbill turtles and 7 green turtles (Gannon 2013).

9.4 Pollutants

Coastal and stormwater runoff, marina and dock construction, dredging, PCB loading, and groundwater and other discharges can degrade marine habitats. The development of marinas and docks in inshore waters can negatively impact nearshore habitats. An increase in the number of docks built increases boat and vessel traffic. Fueling facilities at marinas can sometimes discharge oil, gas, and sewage into sensitive estuarine and coastal habitats. Although these contaminant concentrations do not likely affect the more pelagic waters where sperm whales are located, the species of sea turtles analyzed in this biological opinion travel between nearshore and offshore habitats and may be exposed to and accumulate these contaminants during their life cycles. There are studies on organic contaminants and trace metal accumulation in green and leatherback sea turtles (Aguirre et al. 1994). It is thought that dietary preferences were likely to be the main differentiating factor among species. Decreasing lipid contaminant burdens with turtle size were observed in green turtles, most likely attributable to a change in diet with age.

9.5 Aquatic Nuisance Species

Aquatic nuisance species are aquatic and terrestrial organisms, introduced into new habitats throughout the U.S. and other areas of the world that produce harmful impacts on aquatic ecosystems and native species (http://www.anstaskforce.gov). They are also referred to as invasive, alien, or non-indigenous species. Invasive species have been referred to as 1 of the top 4 threats to the world’s oceans (Raaymakers and Hilliard 2002; Raaymakers 2003; Terdalkar et al. 2005; Pughiuc 2010). Introduction of these species is cited as a major threat to biodiversity, second only to habitat loss (Wilcove et al. 1998). A variety of vectors are thought to have introduced non-native species including, but not limited to aquarium and pet trades, recreation, hull fouling, 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. Currently, there is little information on the level of aquatic nuisance species and the impacts of these invasive species may have on marine mammals and sea turtles in the action area through the duration of the project. The invasive lionfish (*Pterois volitans*) has no natural predators in the Atlantic Ocean, and has been found throughout Puerto Rico (Toledo-Hernández et al. 2014). Lionfish are considered a threat in part because they eat herbivorous reef fish that eat seagrass and algae. By depleting the reef fish, seagrass and algae can proliferate, harming coral reefs (Simnitt et al. 2020), which can be detrimental to hawksbill sea turtles which rely on coral reefs. While aquatic nuisance species can be a threat to ESA-listed species and their habitat, we are unable to quantify or specify the degree of impact in the action area. Therefore, the level of risk and degree of impact to ESA-listed marine mammals and sea turtles is unknown.

9.6 Disease

A disease known as fibropapillomatosis is a major threat to green turtles in some areas of the world. Fibropapillomatosis is characterized by tumorous growths, which can range in size from very small to extremely large, and are found both internally and externally. Large tumors can interfere with feeding and essential behaviors, and tumors on the eyes can cause permanent blindness (Foley et al. 2005). Fibropapillomatosis was first described in green turtles in the Florida Keys in the 1930s.

Puerto Rico has the most long-term data on fibropapillomatosis incidence in the Caribbean, with 24 years of information (Patrício et al. 2011; Patricio et al. 2017). Fibropapillomatosis tumors were officially reported in 1985 at several locations within the main coast of PR. A total of 840 cases of green turtles have been reported as stranding since 1985. From those, 268 (32%) had fibropapillomatosis tumors (Diez and Patrício 2016). Efforts to study fibropapillomatosis prevalence have been concentrated in the Culebra Archipelago (located 17 kilometers [10.5 miles] off the east coast of Puerto Rico), where there are 2 high density foraging aggregations of juvenile green turtles with high recapture rates, as informed by a long-term capture-mark-recapture program (1997-2014). Molecular studies and long distance tag recoveries indicate that these aggregations are mixed stocks from rookeries of the Wider Caribbean (Velez-Zuazo and Kelez 2010). From 2000 to the present, multifactorial studies have been conducted at 2 specific study sites within the Culebra Archipelago (i.e., Puerto Manglar and Tortuga Bay-Culebrita Island) to measure several aspects of fibropapillomatosis in immature green turtles. Captures ranged in size from 26.0-81.0 centimeters straight carapace length (10.2-31.9 inches; mean = 53.3 centimeters [21 inches]; standard deviation = 11.7 [4.6 inches], n = 765), indicating a juvenile and subadult aggregation (Patrício et al. 2011; Diez and Patrício 2016; Patricio et al. 2017).

Studies on blood chemistry and fibropapillomatosis pathology were published by Kang et al. (2008) and Page-Karjian et al. (2012). One of the most significant results of these studies was the presence of the virus in non-tumored turtles (Page-Karjian et al. 2012). Ongoing analyses on fibropapillomatosis dynamics at Culebra's aggregations indicate that smaller turtles (< 40 cm [15.7 inches] straight carapace length) do not exhibit fibropapillomatosis tumors and mid-sized turtles (~ 50-60 cm [19.7-23.6 inches] straight carapace length) are the most affected (Patrício et al. 2016). Over 15 years of fibropapillomatosis presence (2000 onwards), 59% of the turtles with fibropapillomatosis were only mildly affected, 36% moderately, and only 6% had severe fibropapillomatosis (Patrício et al. 2016). Additionally, a disease recovery rate of 31% was estimated after 1.5-4.0 years of tumor expression (Patrício et al. 2016). In summary, green turtles with fibropapillomatosis tumors are ubiquitous in the Greater Caribbean, but information on prevalence is scarce. Studies in Puerto Rico suggest that fibropapillomatosis is not currently a major threat to green turtle populations and that higher disease prevalence was potentially associated with human contamination.

9.7 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.

Derelict and illegal fishing traps are a prevalent problem in nearshore waters around Puerto Rico. These traps can cause physical damage to sensitive habitats, such as coral reefs, while trapping and killing target and non-target organisms, including endangered and protected species. In 2020, to combat this problem, the Ocean Foundation and Conservacion ConCiencia collaborated with the local fishing industry to remove derelict fishing gear, particularly lobster and fish traps, from waters around Eastern Puerto Rico including Culebra. During removal activities, valuable data on the location, weight of debris, cost of gear, disposal of gear, type of gear, and species captured by lost traps were recorded.

Throughout the Caribbean, there are threats to wildlife include habitat loss, degradation and alteration, and increasing levels of pollution. Marine debris is a threat to sea turtles hatchlings when emerging from the nest and entering the surrounding waters.

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 and sea turtles. The ingestion of marine debris has been documented to result in blockage or obstruction of the digestive tract, mouth, and stomach lining of various species and can lead to serious internal injury or mortality (Derraik 2002). In addition to interference with alimentary processes, plastics lodged in the alimentary tract could facilitate the transfer of pollutants into the bodies of whales and dolphins (Derraik 2002). Law et al. (2010b) presented a time series of plastic content at the surface of the western North Atlantic Ocean and Caribbean Sea from 1986 through 2008. More than 60% of 6,136 surface plankton net tows collected small, buoyant plastic pieces. Data on marine debris in 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 Atlantic Ocean, but we assume similar effects from marine debris documented within other ocean basins could also occur to species from marine debris.

Cetaceans are also impacted by marine debris, which includes: plastics, glass, metal, polystyrene foam, rubber, and derelict fishing gear (Baulch and Perry 2014). Over half of cetacean species (including sperm whales) are known to ingest marine debris (mostly plastic), with up to 31% of individuals in some populations containing marine debris in their guts, and marine debris is implicated as the cause of death for up to 22% of individuals found stranded on shorelines from 1 study looking at global trends (Baulch and Perry 2014). We are not aware of any specific instances of marine debris ingestion found in stranded sperm whales within the action area, but given the ubiquitous nature of marine debris within the Wider Caribbean region (Diez et al. 2019), it stands to reason that it poses a threat to sperm whales in the action area.

Ingestion of marine debris can be a serious threat to sea turtles. When feeding, sea turtles (e.g., leatherback turtles) can mistake debris (e.g., tar and plastic) for natural food items, especially jellyfish, which are a primary prey. Some types of marine debris may be directly or indirectly toxic, such as oil. Plastic ingestion is very common in leatherback turtles and can block gastrointestinal tracts leading to death (Mrosovsky et al. 2009). In 2016, Puerto Rico banned plastic bags from use by commercial establishments (food service exempted) (Diez et al. 2019). Other types of marine debris, such as discarded or derelict fishing gear and cargo nets, may entangle and drown sea turtles of all life stages, see Section 9.3 for more discussion on sea turtle entanglement in fishing gear in Puerto Rican fisheries.

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. 2010a). Microplastics have been found in sandy beaches on the north coast of Puerto Rico, including known sea turtle nesting beaches(Pérez-Alvelo et al. 2021). Additionally, plastic waste in the ocean chemically attracts hydrocarbon pollutants. Marine mammals, sea turtles, and fish can mistakenly consume these wastes containing elevated levels of toxins instead of their prey. It is expected that marine mammals and sea turtles may be exposed to marine debris within the action area, although the risk of ingestion or entanglement and the resulting impacts are uncertain at the time of this consultation.

9.8 Anthropogenic Sound

The ESA-listed species that occur in the action area are regularly exposed to several sources of natural and anthropogenic sounds. A wide variety of anthropogenic and natural sources contribute to ocean noise throughout the world's oceans. Anthropogenic sources of noise that are most likely to contribute to increases in ocean noise are vessel noise from commercial shipping and general vessel traffic, oceanographic research, oil, gas and mineral exploration, underwater construction, geophysical (seismic) surveys, Naval and other sources of sonar, and underwater explosions (Richardson et al. 1995d; Hatch and Wright 2007b).

Noise is of particular concern to marine mammals because many species use sound as a primary sense for navigating, finding prey, avoiding predators, and communicating with other individuals.

There is a large and variable natural component to the ambient noise level as a result of events such as earthquakes, rainfall, waves breaking, and lightning hitting the ocean as well as biological noises such as those from snapping shrimp, other crustaceans, fishes, and the vocalizations of marine mammals (Crawford and Huang 1999; Patek 2002; Hildebrand 2004b). However, several studies have shown that anthropogenic sources of noise have increased ambient noise levels in the ocean over the last 50 years (NRC 1994; Richardson et al. 1995d; NRC 2000; NRC 2003b; Jasny et al. 2005; NRC 2005b). Much of this increase is due to increased shipping as ships become more numerous and of larger tonnage (NRC 2003b). Commercial fishing vessels, cruise ships, transport boats, airplanes, helicopters and recreational boats all contribute sound into the ocean (NRC 2003b), as does military training and testing activities. Generally the most energetic regularly operated sound sources are seismic airgun arrays from approximately 90 vessels with typically 12-48 individual guns per array, firing about every 10 seconds (Hildebrand 2004b).

9.8.1 Seismic Surveys

Similar to the proposed action, offshore seismic surveys involve the use of high-energy sound sources operated in the water column to probe below the seafloor. Numerous seismic surveys have been conducted in the North Atlantic over the past several decades. Unlike other regions (e.g., Gulf of Mexico) where the large majority of seismic activity is associated with oil and gas development, seismic surveys conducted in the action area are primarily for scientific research, to identify possible seafloor or shallow-depth geologic hazards, and to better understand phenomena surrounding earthquake risk.

For past scientific research seismic surveys in the action area, NMFS issued authorizations for take of marine mammals and ESA-listed sea turtles. MMPA and ESA permits specify the conditions under which researchers can operate seismic sound sources, such as airguns, including mitigation measure to minimize adverse effects to protected species. Near the action area, other past seismic surveys include 1 in 2005 (off the coast of the Yucatan Peninsula, Mexico), which resulted in a no jeopardy determination.

9.8.2 Active Sonar

Active sonar emits high-intensity acoustic energy and receives reflected and/or scattered energy. A wide range of sonar systems are in use for both civilian and military applications. The primary sonar characteristics that vary with application are the frequency band, signal type (pulsed or continuous), rate of repetition, and source level. Sonar systems can be divided into categories, depending on their primary frequency of operation; low frequency for 1 kHz and less, mid frequency for 1-10 kHz; high frequency for 10-100 kHz; and very high frequency for greater than 100 kHz (Hildebrand 2004a). Low frequency systems are designed for long-range detection (Popper et al. 2014a). The effective source level of an low-frequency active array, when viewed in the horizontal direction, can be 235 dB re 1μPa-m or higher (Hildebrand 2004a). Signal transmissions are emitted in patterned sequences that may last for days or weeks. An example of a low-frequency active sonar system is the U.S. Navy Surveillance Underwater Towed Array Sensor System (SURTASS), discussed in more detail below. Mid-frequency military sonars include tactical anti-submarine warfare sonars, designed to detect submarines over several tens of kilometers, depth sounders and communication sonars. High-frequency military sonars includes those incorporated into weapons (torpedoes and mines) or weapon countermeasures (mine countermeasures or anti-torpedo devices), as well as side-scan sonar for seafloor mapping. Commercial sonars are designed for fish finding, depth sounding, and sub-bottom profiling. They typically generate sound at frequencies of 3-200 kHz, with source levels ranging from 150-235 dB re 1μPa-m (Hildebrand 2004a). Depth sounders and sub-bottom profilers are operated primarily in nearshore and shallow environments, however, fish finders are operated in both deep and shallow areas.

9.8.3 Vessel Sound and Commercial Shipping

Individual vessels produce unique acoustic signatures, although these signatures may change with vessel speed, vessel load, and activities that may be taking place on the vessel. Sound levels are typically higher for the larger and faster vessels. Peak spectral levels for individual commercial vessels are in the frequency band of 10-50 Hz and range from 195 dB re: μPa^2-s at 1 meter for fast-moving (greater than 20 knots) supertankers to 140 dB re: μPa^2-s at 1 meter for smaller vessels (NRC 2003b). Although large vessels emit predominantly low frequency sound, studies report broadband sound from large cargo vessels above 2 kHz, which may interfere with important biological functions of cetaceans (Holt 2008). At frequencies below 300 Hz, ambient sound levels are elevated by 15-20 dB when exposed to sounds from vessels at a distance (McKenna et al. 2013).

The action area is subject to commercial vessel traffic that would in turn be a source of anthropogenic noise. San Juan Harbor is Puerto Rico's principal port, with the majority of the Commonwealth's commerce coming through the port, including cargo and cruise ships. The Port of San Juan is 1 of the top 25 ports in the United States, measured by overall cargo tonnage. In 2020, the Port of San Juan handled 824 twenty foot equivalents of containerized cargo (TEU) domestically, 206 TEU imported, and 43 TEU exported (DOT 2022). The Port of Ponce is another important port in Puerto Rico. The Port of Ponce on the south coast of Puerto Rico, near the location of the low-energy survey, can accommodate post-Panamax vessels. Cruise ships will also transit between San Juan and Ponce.

There are approximately 11,000 supertankers worldwide, each operating approximately 300 days per year, each producing constant broadband noise at typical source levels of 198 dB (Hildebrand 2004b). However, the Port of San Juan cannot accommodate supertankers, and smaller tankers must be used to bring in petroleum products. In 2014, there were an estimated 180 tanker vessel calls (including those carrying petroleum products and liquid barges) (USACE 2018). Supertankers may still transit through the action area on their way to other ports.

Much of the increase in sound in the ocean environment over the past several decades is due to increased shipping, as vessels become more numerous and of larger tonnage (NRC 2003b; Hildebrand 2009b; McKenna et al. 2012). Shipping traffic constitutes a major source of low-frequency (five to 500 Hz) sound in the ocean (Hildebrand 2004a), particularly in the Northern Hemisphere where the majority of vessel traffic occurs. While commercial shipping contributes a large portion of oceanic anthropogenic noise, other sources of maritime traffic can also impact the marine environment. These include recreational boats, whale-watching boats, research vessels, and fishing vessels.

Vessel noise can result from several sources including propeller cavitation, vibration of machinery, flow noise, structural radiation, and auxiliary sources such as pumps, fans and other mechanical power sources. Kipple and Gabriele (2007) measured sounds emitted from 38 vessels ranging in size from 14-962 feet at speeds of 10 knots and at a distance of 500 yards from the hydrophone. Sound levels ranged from a minimum of 157 to a maximum of 182 dB re 1 μPa-m, with sound levels showing an increasing trend with both increasing vessel size and with increasing vessel speed. Vessel sound levels also showed dependence on propulsion type and horsepower. McKenna et al. (2012) measured radiated noise from several types of commercial ships, combining acoustic measurements with ship passage information from Automatic Identification System (AIS). On average, container ships and bulk carriers had the highest estimated broadband source levels (186 dB re 1 μPa, 20-1000 Hz), despite major differences in size and speed. Differences in the dominant frequency of radiated noise were found to be related to ship type, with bulk carrier noise predominantly near 100 Hz while container ship and tanker noise was predominantly below 40 Hz. The tanker had less acoustic energy in frequencies above 300 Hz, unlike the container and bulk carrier.

Sound emitted from large vessels, such as shipping and cruise ships, is the principal source of low frequency noise in the ocean today, and marine mammals are known to react to or be affected by that noise (Richardson et al. 1995c; Foote et al. 2004; Hildebrand 2005; Hatch and Wright 2007a; Holt et al. 2008; Melcon et al. 2012; Anderwald et al. 2013; Kerosky et al. 2013; Erbe et al. 2014; Guerra et al. 2014; May-Collado and Quinones-Lebron 2014; Williams et al. 2014). Several studies have demonstrated short-term effects of disturbance on humpback whale behavior (Hall 1982; Baker et al. 1983; Krieger and Wing 1984; Bauer and Herman 1986), but the long-term effects, if any, are unclear or not detectable. Carretta et al. (2001) and Jasny et al. (2005) identified the increasing levels of anthropogenic noise as a habitat concern for whales and other cetaceans because of its potential effect on their ability to communicate. Significant changes in odontocete behavior attributed to vessel noise have been documented up to at least 5.2 kilometers away from the vessel (Pirotta et al. 2012).

Commercial shipping traffic is a major source of low frequency (5-500 Hz) human generated sound in the world's oceans (Simmonds and Hutchinson 1996; NRC 2003b). The radiated noise spectrum of merchant ships ranges from 20-500 Hz and peaks at approximately 60 Hz. Ross (Ross 1976) estimated that between 1950 and 1975 shipping had caused a rise in ambient ocean noise levels of 10 dB; based on his estimates, Ross predicted a continuously increasing trend in ocean ambient noise of 0.55 dB per year. Chapman and Price (2011) recorded low frequency deep ocean ambient noise in the Northeast Pacific Ocean from 1976-1986 and reported that the trend of 0.55 dB per year predicted by Ross (1976) persisted until at least around 1980; afterward, the increase per year was significantly less, about 0.2 dB per year.

9.9 Military Activities

The military uses sound to test the systems of Navy vessels as well as for naval operations; the Navy's Atlantic Fleet Testing and Training area includes Puerto Rico. Many researchers have described behavioral responses of marine mammals to the sounds produced by helicopters and fixed-wing aircraft, boats and ships, as well as dredging, construction, geological explorations, etc. (Richardson et al. 1995d). Most observations have been limited to short-term behavioral responses, which included cessation of feeding, resting, or social interactions. Smultea et al. (2008b) documented a recognized "stress behavioral reaction" by a group of sperm whales in response to small aircraft fly-bys. The group ceased forward movement, moved closer together in a parallel flank-to-flank formation, and formed a fan-shaped semi-circle with the lone calf remaining near the middle of the group. In-air noise levels from aircraft can be problematic for marine life, and that sound can also extend into water. Other military installations in Puerto Rico that use aircraft which could create in-water noise include the Puerto Rico Air National Guard Muñiz Air Base and the U.S. Coast Guard Air Station Borinquen.

9.10 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 Atlantic Ocean, Gulf of Mexico, and the Caribbean Sea, some of which extend into portions of the action area for the proposed action. Marine mammals and sea turtles 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 and sea turtles in the action area from a variety of research activities. There have been numerous research permits issued since 2009 under the provisions of both the MMPA and ESA authorizing scientific research on marine mammals and sea turtles, including for research in the action area.

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

Authorized research on sea turtles includes close approach, capture, handling and restraint, tagging, blood and tissue collection, lavage, ultrasound, imaging, antibiotic (tetracycline) injections, captive experiments, laparoscopy, and mortality. Most research activities involve authorized sublethal "takes," with some resulting mortality.

9.11 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, incidental bycatch, and entanglement), whereas others result in more indirect (e.g., fishing that affects prey availability), or nonlethal (e.g., vessel noise) 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 on ESA-listed resources in the action area to be the status and trends of those species. A thorough review of the status and trends of each species is discussed in the Status of Species Likely to be Adversely Affected (Section 8). As noted in Section 8, some of the species considered in this consultation are experiencing increases in population abundance, some are declining, and for others, their status remains unknown. Taken together, this indicates that the environmental baseline is impacting species in different ways. The species experiencing increasing population abundances are doing so despite the potential negative impacts of the activities described of the environmental baseline. Therefore, while the environmental baseline may slow their recovery, recovery is not being prevented. For the species that may be declining in abundance, it is possible that the suite of conditions described in the environmental baseline is limiting their recovery. However, it is also possible that their populations are at such low levels (e.g., due to historical commercial whaling) that even when the species' primary threats are removed, the species may not be able to achieve recovery. At small population sizes, species may experience phenomena such as demographic stochasticity, inbreeding depression, and Allee effects, among others, that cause their limited population size to become a threat in and of itself.

10 Effects of the Action

Section 7 regulations define "effects of the action" as all consequences to 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 CFR §402.02).

This effects analysis section is organized following the stressor, and exposure and response assessment framework described in Section 2. In this section, we further describe the probability of individuals of ESA-listed cetaceans (sperm whale) and sea turtles (hawksbill turtle, North Atlantic and South Atlantic DPS of green turtle, and leatherback turtle) in the action area being exposed to airgun noise based on the best scientific and commercial evidence available, and the probable responses of those individuals (given their probable exposures) based on the available evidence. For any responses that would be expected to reduce an individual's fitness (i.e., growth, survival, annual reproductive success, or lifetime reproductive success), the assessment will consider the risk posed to the viability of the population(s) those individuals comprise and to the ESA-listed species those populations represent. For this consultation, we are particularly concerned about behavioral and stress-related physiological disruptions and potential unintentional mortality that may result in animals that fail to feed, reproduce, or survive because these responses are likely to have population-level consequences. The purpose of this assessment and, ultimately, of this consultation, is to determine if it is reasonable to expect the proposed action to have effects on ESA-listed species that could appreciably reduce their likelihood of surviving and recovering in the wild.

10.1 Stressors Remaining to be Considered

During consultation, we determined that sound fields produced by the airgun array will likely adversely affect ESA-listed species by introducing acoustic energy into the marine environment. This stressor and the likely effects on ESA-listed species are discussed in the Exposure and Response Analyses (Sections 10.3 and 10.4).

10.2 Mitigation to Minimize or Avoid Exposure

As described in the Description of the proposed actions (Section 3), the NSF and L-DEO's proposed action and Permits Division's proposed IHA and possible renewal requires monitoring and conservation measures that include the use of shutdown and buffer zones, shutdown procedures, pre-start clearance and ramp-up procedures, vessel-based visual monitoring with NMFS-approved PSOs, PAM, vessel strike avoidance measures, seasonal restrictions, and additional conservation measures considered to minimize or avoid exposure of ESA-listed species. The Permits Division's conservation measures to minimize or avoid exposure are described in more detail in the draft IHA in Appendix A (Section 17).

10.3 Exposure 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. This 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 subpopulation(s) those individuals represent. 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 array.

In this section, we quantify the likely exposure of ESA-listed species to sound from the airgun array. For this consultation, the NSF, L-DEO, and Permits Division estimated exposure to the sounds from the airgun array that would result in ESA "harm" and "harassment" of ESA-listed cetaceans and sea turtles.

Section 3 of the ESA defines take 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 May 1, 2023, NMFS adopted as final, the previous interim policy 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."

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

Our exposure analysis relies on 2 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 low- and high-energy seismic survey (e.g., active acoustic sound source specifications, area or volume of water that would 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 and by regulation, 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 Exposure Estimates for ESA-Listed Cetaceans

As discussed in the Status of Species Likely to be Adversely Affected (Section 8), the only ESA-listed cetacean species that is likely to be adversely affected by the proposed actions is the sperm whale. Sperm whales are classified in the mid-frequency hearing group (NOAA 2018).

The NSF and L-DEO applied acoustic thresholds to determine at what point during exposure to the airgun array cetaceans are harmed and harassed. An estimate of the number of cetaceans that would be exposed to sounds from the airgun array is included in NSF's draft environmental assessment/analysis (LGL 2023).

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 sperm whales 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 IHA and request for comments and possible renewal, the Permits Division stated that they did not expect sound emanating from non-airgun sources to exceed levels produced by the airgun array. Therefore, the Permits 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 OBS acoustic release transponders 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 take of ESA-listed species (Section 7.1.3).

In this section, we describe the NSF, L-DEO, and Permits Division's analytical methods to estimate the number of ESA-listed cetacean species that might be exposed to the sound field.

10.3.1.1 ESA-Listed Cetacean Occurrence—Density Estimates

We reviewed available cetacean densities and group dynamics with the NSF, L-DEO, and the Permits Division and agreed on densities that constituted the best available scientific information for each ESA-listed cetacean species. The Permits Division adopted these estimates for use in their proposed IHA and we have adopted them for our ESA exposure analysis for sperm whales. The NSF, L-DEO, and the Permits Division also calculated exposure of blue, fin and sei whales during the seismic surveys. However, based on our review of the available information, we concluded that these 3 ESA-listed whales were not likely to be present in the action area, and thus are not likely to be adversely affected by the actions (Section 7.2.1).

The NSF and L-DEO used habitat-based stratified cetacean densities for the North Atlantic Ocean for the U.S. Navy Atlantic Fleet Testing and Training Area from Roberts et al. (2023). The habitat-based density models were produced by the Duke University Marine Geospatial Ecology Laboratory and represent the best available information regarding cetacean densities in the seismic survey area. The density data from Roberts et al. (2023) incorporates aerial and vessel line-transect survey data from NMFS Science Centers and other organizations and updates prior habitat-based cetacean density models (i.e., Roberts et al. 2016). The Roberts et al. (2016) model was comprised of 8 physiographic and 16 dynamic oceanographic and biological covariates, and controls for the influence of sea state, group size, availability bias, and perception bias on the probability of making a sighting. Roberts et al. (2023) updated Roberts et al. (2016)

by expanding the model to utilize over 2.8 million linear kilometers (1.74 million miles) of survey effort collected between 1992-2020, yielding density maps for over 30 species and multi-species guilds. More information on this density model is available online at: https://seamap.env.duke.edu/models/Duke/AFTT/. The habitat-based density models consisted of 5 kilometer (2.7 nautical mile) by 5 kilometer GIS raster grid cells. Densities in the grid cells for the U.S. Navy Atlantic Fleet Testing and Training Area overlapping the seismic survey area (plus a 40-kilometer [21.6 nautical mile] buffer) were averaged for each species for each of 2 water depth categories (intermediate and deep water depths) to determine monthly mean density values for each species. If available, the mean monthly density was chosen for each species for the month of October; if a monthly density was not available for a species, whatever available density was used (e.g., an annual estimate).

Data sources and density calculations are described in detail in NSF's draft environmental assessment/analysis (LGL 2023) and L-DEO's IHA application. There is uncertainty about the representativeness of the density data and the assumptions used to estimate exposures. For some cetacean species that are part of the IHA application, the densities derived from past surveys may not be precisely representative of the densities that would be encountered during the seismic survey activities. Density estimates for sperm whales are found in Table 9. The approach used here is based on the best available data.

The number of sperm whales that can be exposed to the sounds from the airgun array on 1 or more occasions is estimated for the seismic survey area using expected seasonal density of animals in the area (Table 9). Summing exposures along all of the tracklines yields the total exposures of sperm whale for the proposed actions of the 2-airgun and 36-airgun array configurations for the seismic survey activities and Permits Division's proposed issuance of an IHA and possible renewal.

Table 9. Densities used for calculating exposure of ESA-listed sperm whales

Species	Density (#/km^2) in Intermediate Water (100-1,000 meters)	Density (#/km^2) in Deep Water (> 1,000 meters)	Source
Sperm Whale	0.005312	0.006623	(Roberts et al. 2023)

10.3.1.2 Total Ensonified Area for ESA-Listed Cetaceans

As noted in Section 3, the high-energy, 36-airgun survey will consist of 2,565 kilometers (1,385 nautical miles) tracklines of two-dimensional MCS seismic reflection data and 1,505 kilometers (813 nautical miles) tracklines of OBS refraction data across the Puerto Rico Trench. The low-energy, 2-airgun survey will consist of 560 line kilometers (302 nautical miles) of MCS seismic reflection data to examine the seismogenic structures south of the island. All of the tracklines for the high-energy survey will take place in-water depths greater than 1,000 meters (3,280 feet); a small portion of the ensonified area coming from these deepwater tracklines will enter into waters less than 1,000 meters (3,280 feet) deep. For the low-energy survey, 43% of the survey effort will occur in intermediate water depths (100–1000 meters [328-3,280 feet]), and 57% will occur in deep water (>1000 meters [3,280 feet]). Details on LDEO's approach to modeling the ensonified area emanating from these tracklines are presented in Sections 3.3.1 and 3.3.3 and are further discussed in NSF's draft environmental assessment/analysis (LGL 2023) and L-DEO's IHA application. NSF used LDEO's model to determine radial distances from the airgun array to the 160 dB re: 1 μPa [rms] behavioral disturbance threshold for cetaceans within intermediate and deep water depths as shown in Table 3.

For the high-energy survey, the daily ensonified area (for the 160 dB re: 1 μPa [rms] behavioral disturbance threshold) for the MCS reflection survey tracklines is estimated to be approximately 89.7 square kilometers (25.6 square nautical miles) for intermediate water depths and 2,254.5 square kilometers (657.3 square nautical miles) for deep water. For the high-energy survey, the daily ensonified area (for the 160 dB re: 1 μPa [rms] behavioral disturbance threshold) for OBS refraction survey tracklines is estimated to be approximately 89.7 square kilometers (25.6 square nautical miles) for intermediate water depths, and 2,793.1 square kilometers (814.3 square nautical miles) for deep water. For the low-energy survey, the daily ensonified area (for the 160 dB re: 1 μPa [rms] behavioral disturbance threshold) for the MCS reflection survey tracklines is estimated to be approximately 100.9 square kilometers (29.4 square nautical miles) for deep water and 114.1 square kilometers (33.3 square nautical miles) for intermediate depths. These areas were calculated by using the radial distances from the airgun array to the predicted isopleths corresponding to the 160 dB re: 1 μPa (rms) threshold (Table 3), along a planned trackline that will be surveyed in 1 day (approximately 182 kilometers [113.09 miles] during the MCS survey and 222 kilometers [137.9 miles] during the OBS survey). The daily ensonified area is multiplied by the total number of survey days (13 days for the high-energy MCS survey, 3 days for the low-energy MCS survey, and 7 days for the high-energy OBS survey). The product is multiplied by 1.25 to account for an additional 25% contingency (e.g., potential delays) to allow for additional airgun array operations such as testing of the sound source or re-surveying tracklines with poor data quality. This also considers uncertainties in the density estimates used to estimate take.

This provides an estimate of the total area (square kilometers) expected to be ensonified to the behavioral disturbance thresholds for cetaceans (which includes TTS and ESA harassment). The total area ensonified at 160 dB re: 1 μPa (rms) for the high-energy MCS survey is 1,457.2 square kilometers (424.9 square nautical miles) and 36,635.0 square kilometers (10,681.1 square nautical miles) for intermediate and deep waters, respectively, when accounting for overlap and using endcaps (Table 10). Also, when accounting for the same criteria, the total area ensonified at 160 dB re: 1 μPa (rms) for the high-energy OBS survey is 784.6 square kilometers (228.8 square nautical miles) and 24,439.6 square kilometers (7,125.4 square nautical miles) for intermediate and deep waters, respectively (Table 10).

Table 10. 160 dB re: 1 µPa (rms) Harassment Isopleths, Trackline Distance, Ensonified Area, Number of Survey Days, Percent Increase, and Total Ensonified Areas During the National Science Foundation and Lamont-Doherty Earth Observatory's High-Energy Seismic Survey off Puerto Rico

Criteria (Water Depth)	Daily Trackline Distance (km)	Daily Ensonified Area (km^2)*	Survey Days	Ensonified Area (km^2)	Total Ensonified Area with 25% Increase (km^2)*
Sound Source – 36-Airgun Array MCS					
160 dB re: 1 µPa (rms) (greater than 1,000 m)	182	2,254.5	13	29,308.5	36,635.0
160 dB re: 1 µPa (rms) (100-1,000 m)	182	89.7	13	1,166.1	1,457.2
Sound Source – 36-Airgun Array (OBS)					
160 dB re: 1 µPa (rms) (greater than 1,000 m)	222	2,793.1	7	19,551.7	24,439.6
160 dB re: 1 µPa (rms) (100-1,000 m)	222	89.7	7	627.9	784.6

km=kilometers, km^2=square kilometers.
* Including endcaps and accounting for overlap

By applying the same methodology to the low-energy survey, we get an estimate of the total area (square kilometers) expected to be ensonified to the behavioral disturbance thresholds for cetaceans (which includes TTS and ESA harassment). The total area ensonified at 160 dB re: 1 µPa (rms) for the low-energy MCS survey is 378.4 square kilometers (110.3 square nautical miles) and 427.9 square kilometers (124.8 square nautical miles) for intermediate and deep waters, respectively, when accounting for overlap and using endcaps (Table 11).

Table 11. 160 dB re: 1 µPa (rms) Harassment Isopleths, Trackline Distance, Ensonified Area, Number of Survey Days, Percent Increase, and Total Ensonified Areas During the

National Science Foundation and Lamont-Doherty Earth Observatory's Low-Energy Seismic Survey off Puerto Rico

Criteria (Water Depth)	Daily Trackline Distance (km)	Daily Ensonified Area (km^2)*	Survey Days	Ensonified Area (km^2)	Total Ensonified Area with 25% Increase (km^2)*
Sound Source – 36-Airgun Array MCS					
160 dB re: 1 µPa (rms) (greater than 1,000 m)	182	100.9	3	302.7	378.4
160 dB re: 1 µPa (rms) (100-1,000 m)	182	114.1	3	342.3	427.9

km=kilometers, km^2=square kilometers.
* Including endcaps and accounting for overlap

In addition to the ensonified area noted above, based on the small anticipated isopleths for ESA harm (in this case considered to be received sound levels exceeding the marine mammal threshold for PTS as shown in Table 5) and in consideration of the conservation measures (i.e., shutdown and buffer zones, shutdown procedures, pre-start clearance and ramp-up procedures, vessel-based visual monitoring by NMFS-approved PSOs, vessel strike avoidance measures, seasonal restrictions, and additional conservation measures), we do not expect take in the form of ESA harm for sperm whales.

10.3.1.3 Cetacean Exposures as a Percentage of Population

Sperm whales of all age classes are likely to be exposed during the seismic survey activities. Given that the low- and high-energy seismic survey will be conducted in fall (October), we expect that most animals will be in or migrating to/from their feeding grounds north of the action area. Sperm whales are expected to be feeding, traveling, or migrating in the action area and some females may have young-of-the-year accompanying them. Mature male sperm whales are generally expected to be further north in the higher latitudes of the Atlantic Ocean. Therefore, we expect a juvenile male and female bias to sperm whale exposure. For sperm whales, exposure of adult males is expected to be lower than other age and sex class combinations because male sperm whales are generally solitary and may migrate toward the northern portion of their range (poleward of about 40-50° latitude). For sperm whales, these individuals can be exposed to the seismic survey activities while they are transiting through the action area.

It should be noted that the exposure numbers by ESA harassment are expected to be conservative for several reasons. First, estimated exposure was increased by 25%, in the form of the ensonified area over the operational seismic survey days, increasing the total ensonified area. This accounts for the possibility of additional seismic survey activities associated with airgun array testing and repeat coverage of any areas where initial data quality is sub-standard, and in recognition of the uncertainties in the density estimates used to estimate exposures as described above. Additionally, cetaceans are 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 and harassment. However, the extent to which cetaceans (sperm whales) would move away from the sound source is difficult to quantify and is not accounted for in the exposure estimates. Last, due to the range of each of these species compared to the relatively small size of the action area and the relatively short duration of the seismic survey activities, the potential for exposure is reduced.

The population abundance estimates of cetacean species (i.e., sperm whale) considered in this consultation represent the total number of individuals that make up a given stock or the total number estimated within a particular study or survey area. NMFS's stock abundance estimates for most species represent the total estimate of individuals within the geographic area, if known, that comprises the stock. For most species of cetaceans, stock abundance estimates are based on sightings within the U.S. EEZ; however, for some species, this geographic area may extend beyond U.S. waters. Survey abundance estimates may be used for other species. All managed stocks in this region are assessed in NMFS's U.S. Atlantic stock assessment report (Hayes et al. 2022). The percentage of exposure for each population of ESA-listed cetacean in the action area is summarized in the section below. Exposure estimates were derived from multiplying the highest intermediate and deepwater densities (Table 9) by the total ensonified area with a 25% increase (Table 10 and Table 11).

Sperm Whale – The estimated exposure of the regional population (approximately 4,349 individuals) of sperm whales is 482 individuals to behavioral harassment and/or TTS, which is approximately 11.1% of the stock or regional population.

10.3.2 Exposure Estimates of ESA-Listed Sea Turtles

As discussed in the Status of Species Likely to be Adversely Affected (Section 8), there are 4 ESA-listed sea turtle species or populations that are likely to be adversely affected by the proposed actions: the North Atlantic DPS and South Atlantic DPS of green turtle, hawksbill turtle, and leatherback turtle.

10.3.2.1 ESA-Listed Sea Turtle Occurrence—Density Estimates

We reviewed available sea turtle densities presented by the NSF and L-DEO to determine which densities constituted the best available scientific information for the 4 ESA-listed sea turtle species likely to be adversely affected by the seismic survey activities.

The L-DEO used a similar method to calculate exposure for sea turtles as that for marine mammals. For sea turtles, the L-DEO used the 175 dB threshold to create a buffer in GIS representing the ensonified area within each of the water depth categories (intermediate and deep water).

Overall, there is a lack of density and abundance information for sea turtles in the action area. The L-DEO was not able to generate exposure estimates for hawksbill sea turtles because there were no density data available for this species. The L-DEO calculated exposure estimates for olive ridley and loggerhead sea turtles, but we determined these species are not common in the area, and are not likely to be exposed to the proposed action (Sections 7.2.3 and 7.2.4). The sources used by L-DEO for calculating exposure of leatherback and green sea turtles involved applying densities from other parts of the North Atlantic Ocean (e.g., southeast Florida) in coastal areas that do not reflect the environment where the proposed airgun surveys will take place. In addition, this density estimate does not account for the 2 DPSs of green turtle that are present in the action area.

Upon further examination, we were not able to find density data for these sea turtle species either. Although we do not have current information on density specific to the action area, we know that these sea turtle species are present in the region, and that there is a likelihood of exposure to the proposed seismic activities. In the absence of better information, we rely on a surrogate to estimate exposure of leatherback, green, and hawksbill sea turtles, that is, the area within the 175 dB re: 1 µPa (rms) isopleth is where sea turtles are likely to be adversely affected.

The sound source (i.e., airgun array) is in motion during the survey. The R/V *Langseth* moves at 8.3 kilometers per hour (4.5 knots) during the three-dimensional seismic survey (slight slower for the two-dimensional survey [7.8 kilometers per hour; 4.2 knots]). For the high-energy survey, the distance to the 175 dB re: 1 µPa (rms) is 2,796 meters (9,173.2 feet) in intermediate depth water, and 1,864 meters (6,115.5 feet) in deep water. For the low-energy survey, the distance to the 175 dB re: 1 µPa (rms) is 117 meters (383.9 feet) in intermediate depth water, and 78 meters (255.9 feet) in deep water. Given the average vessel speed, and distance to the 175 dB re: 1 µPa (rms) in different water depths, it would take the R/V *Langseth* as much as 20 minutes[1] to move past a stationary point. This means that a sea turtle in the ensonified area will be exposed to the sound from the airgun multiple times. Therefore, the extent of take for sea turtles includes the amount of time the individual is in the 175 dB re: 1 µPa (rms) ensonified area.

We are relying on the extent of the ensonified area corresponding to behavioral thresholds as a surrogate to estimate sea turtle exposure. The 175 dB re: 1 µPa (rms) exclusion zone represents the distance to which sound at a potentially adverse level for sea turtles will extend from the source. If a leatherback, green, or hawksbill sea turtle were within this exclusion zone during

[1] For example, when the R/V *Langseth* is surveying in intermediate depth waters, the distance to the 175 dB threshold is 2.7 kilometers. During the three-dimensional portion of the seismic survey, the vessel moves at 7.8 kilometers per hour, meaning it would take approximately 20 minutes for the vessel to travel 2.7 kilometers, or for a stationary sea turtle to be out of the 175 dB ensonified area. For the R/V *Langseth* to travel 1.8 kilometers (i.e., the distance to the 175 dB threshold in deep water) during the two-dimensional portion of the survey (8.3 kilometers per hour), it would take about 13 minutes.

operations of the airgun array, it would be exposed to the stressor (i.e., the sound field produced by the airguns).

10.3.2.2 Total Ensonified Area for ESA-Listed Sea Turtles

Sections 3 and 10.3.1.2 detail the total trackline distances for both the MCS and OBS surveys in intermediate and deep water. Details on LDEO's approach to modeling the ensonified area emanating from these tracklines are presented in Sections 3.3.1 and are further discussed in NSF's draft environmental assessment/analysis (LGL 2023). NSF used LDEO's model to determine radial distances from the airgun array to the 175 dB re: 1 μPa [rms] behavioral disturbance threshold within intermediate and deep water depths as shown in Table 4.

The daily ensonified area (for the 175 dB re: 1 μPa [rms] behavioral disturbance threshold) for the high-energy MCS reflection survey tracklines is estimated to be approximately 38.7 square kilometers (11.3 square nautical miles) for intermediate water depths and 604.8 square kilometers (176.3 square nautical miles) for deep water. The daily ensonified area (for the 175 dB re: 1 μPa [rms] behavioral disturbance threshold) for the low-energy MCS reflection survey tracklines is estimated to be approximately 20.0 square kilometers (5.8 square nautical miles) for intermediate water depths and 17.7 square kilometers (5.2 square nautical miles) for deep water. The daily ensonified area (for the 175 dB re: 1 μPa [rms] behavioral disturbance threshold) for OBS refraction survey tracklines is estimated to be approximately 38.7 square kilometers (11.3 square nautical miles) for intermediate water depths, and 753.9 square kilometers (219.8 square nautical miles) for deep water. The same steps for estimating the total ensonified zone for the 160 dB re: 1 μPa (rms) behavioral disturbance threshold for cetaceans, including the 25% increase, were applied to get the total ensonified zone for the 175 dB re: 1 μPa [rms] behavioral disturbance threshold for sea turtles. The total area (square kilometers) expected to be ensonified to the 175 dB re: 1 μPa [rms] behavioral disturbance threshold for sea turtles (which includes TTS and behavioral harassment) is presented in Table 12.

Table 12. 175 dB re: 1 μPa (rms) Isopleths, Trackline Distance, Ensonified Area, Number of Survey Days, Percent Increase, and Total Ensonified Areas During the National Science Foundation and Lamont-Doherty Earth Observatory's High- and Low-Energy Seismic Survey off Puerto Rico

Criteria (Water Depth)	Daily Trackline Distance (km)	Daily Ensonified Area (km^2)*	Survey Days	Ensonified Area (km^2)	Total Ensonified Area with 25% Increase (km^2)*
High-Energy Sound Source – 36-Airgun Array (MCS)					
175 dB re: 1 μPa (rms) (greater than 1,000 m)	182	604.8	13	7,862.4	9,828.2

Criteria (Water Depth)	Daily Trackline Distance (km)	Daily Ensonified Area (km²)*	Survey Days	Ensonified Area (km²)	Total Ensonified Area with 25% Increase (km²)*
175 dB re: 1 µPa (rms) (100-1,000 m)	182	38.7	13	503.1	629.0
Low-Energy Sound Source – 2-Airgun Array (MCS)					
175 dB re: 1 µPa (rms) (greater than 1,000 m)	182	17.7	3	53.1	66.4
175 dB re: 1 µPa (rms) (100-1,000 m)	182	20.0	3	60.0	75.0
High-Energy Sound Source – 36-Airgun Array (OBS)					
175 dB re: 1 µPa (rms) (greater than 1,000 m)	222	753.9	7	5,277.3	6,596.9
175 dB re: 1 µPa (rms) (100-1,000 m)	222	38.7	7	270.9	338.7

km=kilometers, km^2=square kilometers.
* Including endcaps and accounting for overlap

In addition to the ensonified area noted above, based on the small anticipated isopleths for ESA harm (in this case considered to be received sound levels exceeding the sea turtle threshold for PTS as shown in Table 5) and in consideration of the conservation measures (i.e., shutdown and buffer zones, shutdown procedures, pre-start clearance and ramp-up procedures, vessel-based visual monitoring by NMFS-approved PSOs, vessel strike avoidance measures, seasonal restrictions, and additional conservation measures), we do not expect take in the form of ESA harm for sea turtles.

10.3.2.3 Sea Turtle Exposures as a Percentage of the Population

Because we are relying on the extent of the ensonified area corresponding to behavioral thresholds as a surrogate to estimate sea turtle exposure, we are not able to quantify the number of sea turtles exposed as a percentage of the population. The high-energy survey can potentially expose sea turtles in offshore waters, where we expect sea turtles to be more dispersed. The high-energy survey will occur over a larger area, for a longer duration, because it has a larger ensonified area. In comparison, although it will be an overall smaller ensonified area occurring over a shorter amount of time, the low-energy survey may expose sea turtles by the fact that it would occur closer to shore, in the neritic environment, where they are more likely to be.

The exposures will consist of instantaneous moments in which an individual from each species will be exposed to sound fields from seismic survey activities at or above the behavioral disturbance threshold. The overall exposure is likely relatively low compared to the abundance of each sea turtle population that may occur within the action area. As for the duration of each instance of exposure, we were unable to produce estimates specific to the proposed action due to the temporal and spatial uncertainty of the research vessel and sea turtles within the action area. However, all the exposures are expected to be less than a single day due to the movement of the research vessel and animals.

The ESA-listed sea turtles exposed to the proposed seismic surveys could be comprised of a variety of life stages and exposed while engaging in different behaviors. Below, we provide a summary on the life stages of ESA-listed sea turtles that may be exposed to the action.

Green Turtles

There are 4 North Atlantic DPS green turtle nesting beaches throughout Puerto Rico, on the east and west sides of the island (Eckert and Eckert 2019), with none near the areas where the seismic airguns surveys will occur. In the area, green sea turtles nest from August to December (Crespo and Diez 2022). Adult male and female turtles from the North Atlantic DPS could be exposed to the sound from airgun surveys while traveling to or from the nesting beaches. Green turtle hatchlings would be emerging from their nests during the surveys and entering the offshore marine environment via ocean currents. Hatchlings from the North Atlantic DPS could be exposed to sound from airguns. Immature (including juvenile and sub-adult) green turtles use coastal foraging areas, and will make brief trips between nearby foraging areas (Griffin et al. 2019); these individuals are likely from the South Atlantic (transient) and North Atlantic (resident) DPSs.

Leatherback Sea Turtles

There are 21 nesting beaches throughout Puerto Rico, with 4 on the north side of the island in the vicinity of the 36-airgun survey area: Arecibo, Pinones, Dorardo, and San Juan (Eckert and Eckert 2019). There are no leatherback nesting beaches near the 2-airgun survey area. Leatherbacks nest primarily from February to July (Crespo and Diez 2022). By the time the action occurs in October, leatherback hatchlings would have emerged from their nests, have entered the water, and have dispersed on ocean currents. Therefore, we do not expect leatherback hatchlings to be exposed to the seismic airguns.

Adult leatherback sea turtle females that have left the nesting beaches will likely be migrating to foraging areas, along with adult males and juveniles/sub adults of either sex. These individuals could be exposed to the sound produced by airguns.

Hawksbill Sea Turtles

There are several known foraging areas for hawksbills around Puerto Rico, on the east and west sides of the island as well as on the south side (Hart et al. 2019). These foraging areas do not overlap with the seismic survey areas. Studies show that juvenile hawksbills near the action area have limited home ranges of 2 square kilometers or less, occupying coral reefs close to shore for foraging (Rincon-Diaz et al. 2011). Because of the offshore location of the high-energy survey, and that the extent of the ensonified area will not reach shore, foraging juvenile hawksbill sea turtles are not likely to be exposed to the sound produced by airguns. The low-energy survey is closer to shore and while the ensonified area is smaller compared to the high-energy survey, it may enter into locations where hawksbills occur.

After nesting, adult female hawksbills have been tracked moving away from their nesting beach to foraging grounds near Puerto Rico and throughout the wider Caribbean, including through the action area (Van Dam et al. 2008). In this study, females were tagged after nesting, between September and November. Adult male hawksbills have been observed around Mona Island in higher abundance between September and October, coinciding with peak breeding season (Van Dam et al. 2008). While individuals are present in the area, these activities occur closer to shore or on beaches. The ensonified area from the high-energy seismic survey will be further offshore, and thus we do not expect breeding or nesting individuals to be exposed; exposure may be possible during the low-energy survey since it is closer to shore and hawksbill habitat. Given the number of hawksbill sea turtle nesting beaches throughout Puerto Rico, the known feeding areas, and the timing of the action, we expect adult hawksbills to be exposed while transiting to foraging areas post-nesting and post-breeding. Hawksbill nesting occurs from June to November.

There are 2 known hawksbill nesting beaches near the proposed action areas; Pinones on the north side of Puerto Rico, and Caja de Muerto on the south side of the island (Eckert and Eckert 2019). It should be noted that there a lack of a comprehensive beach monitoring program, so it is possible that there are other nesting beaches in Puerto Rico. Due to the timing of nesting, length of incubation (~60 days), and the timing of the seismic activities, hatchlings could be leaving their nesting beaches during the proposed action. We do expect hatchlings to be exposed to the proposed action.

10.4 Response Analysis for Endangered Species Act-Listed Marine Mammals and Sea Turtles to the Acoustic Noise from the Airgun Array

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 and sea turtles considered in this opinion. Possible responses considered in this analysis consist of:

- Hearing threshold shifts.
- Auditory interference (masking).
- Behavioral responses.
- 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 and sea turtles in the action area.

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

During the proposed actions, sperm whales and sea turtles may be exposed to sound from the airgun array. We evaluated the estimates of the expected number of sperm whales exposed to received levels greater than or equal to 160 dB re: 1 μPa (rms) for the airgun array sound sources. For ESA-listed sea turtles, we examined the individuals exposed to received levels greater than or equal to 175 dB re: 1 μPa (rms). Based on information presented in the response analysis, sperm whales and sea turtles exposed to these sound levels could exhibit changes in behavior, suffer stress, or even strand.

We evaluated both the NSF and L-DEO's (and the NMFS Permit Division for cetacean species) exposure estimates of the number of sperm whales and sea turtles that will be "taken."

Generally, we estimate "take" by considering:

1. Acoustic thresholds above which NMFS believes the best available science indicates cetaceans will be behaviorally harassed, experience TTS, or incur some degree of PTS.
2. The area or volume of water that will be ensonified above these levels in a day.
3. The density or occurrence of ESA-listed species within these ensonified areas.
4. The number of days of seismic survey activities.

In consideration of the received sound levels, we believe the potential for ESA harm of mid-frequency cetaceans (sperm whales) and sea turtles (North Atlantic and South Atlantic DPS of green turtle, leatherback turtle, and hawksbill turtle) is unlikely. Harm is unlikely even before the moderating effects of aversion and/or other compensatory behaviors (e.g., (Nachtigall et al. 2018)) are considered. The constant movement of both the R/V *Langseth* and the ESA-listed sperm whales and sea turtles in the action area, and the short duration of exposure to loud sounds because the research vessel is not expected to remain in any area where individual animals may concentrate for an extended period of time, also make harm unlikely. In addition, as described in

Section 10.4.1 and Section 10.4.3, we expect that ESA-listed sperm whales and sea turtles are likely to move away from a sound source that represents an aversive stimulus, especially at levels that could result in PTS, because animals will likely be aware of the R/V *Langseth*'s approach given its slow speed when conducting seismic survey activities.

Based on the anticipated small isopleths for ESA harm, and in consideration of the conservation and monitoring measures, we conclude take by ESA harm will not occur.

Using the above acoustic thresholds, we evaluated the exposure and take estimates of ESA-listed whales associated with the sounds from the airgun array.

10.4.1 Potential Response of Cetaceans to Acoustic Sources

Exposure of cetaceans to very strong impulsive sound sources from airgun arrays can result in auditory damage, such as changes to sensory hairs in the inner ear, which may temporarily or permanently impair hearing by decreasing the range of sound an animal can detect within its normal hearing ranges. Hearing threshold shifts depend upon the duration, frequency, sound pressure, and rise time of the sound. 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 the cochlear nerves leading to delayed but permanent hearing damage (Kujawa and Liberman 2009). At higher received levels, particularly in frequency ranges where animals are more sensitive, PTS (which is a form of ESA harm) 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 (Schlundt 2000; Kastak 2005; Ketten 2012)).

Few data are available to precisely define each ESA-listed cetacean species' hearing range, let alone its sensitivity and levels necessary to induce TTS or PTS. Sperm whales have an estimated generalized functional hearing frequency range of 150 Hz to 160 kHz (Southall 2007).

Thresholds for TTS and PTS are based on the best available information, which are derived from captive studies of marine mammals, our understanding of terrestrial mammal hearing, and extensive modeling.

PTS is expected at received levels of 185 dB re: 1 μPa^2-second (SEL weighted) or 230 dB re: 1 µPa (Peak SPL) from impulsive sound for mid-frequency cetaceans (Southall et al. 2007c). The best available information supports the position that received levels at a given frequency will need to be approximately 170 dB re: 1 μPa^2-second (SEL weighted) or 224 dB re: 1 µPa (Peak SPL) for TTS onset from impulsive sound for mid-frequency cetaceans (Southall et al. 2007c).

In terms of exposure to the R/V *Langseth*'s airgun array, an individual needs to be within a few meters of the largest airgun to experience a single pulse greater than 230 dB re: 1 μPa (Peak SPL; Caldwell and Dragoset 2000). If an individual experienced exposure to several airgun pulses of approximately 230 dB re: 1 μPa (Peak SPL) for mid-frequency cetaceans, PTS could occur. Cetaceans have to be within certain modeled radial distances specified in Table 4, Table 6, and Table 7 from the R/V *Langseth*'s 36-airgun array to be within the ESA harm threshold isopleth, or risk a TTS or other measurable behavioral responses.

As stated earlier, only ESA harassment of sperm whales is expected during the high-energy seismic survey. Ranges to some behavioral impacts include 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.

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 could result in behavioral harassment in the form of TTS. As the seismic survey proceeds along each transect trackline and the vessel approaches ESA-listed individuals, the sound intensity increases, and individuals will experience conditions (e.g., stress, loss of prey, discomfort, etc.) that will likely prompt them to move away from the research vessel and sound source and thus avoid exposures that will induce TTS. Ramp-ups reduce the probability of TTS-inducing exposure at the start of seismic survey activities for the same reasons because, as acoustic intensity increases, animals will likely move away, making it unlikely they will be exposed to more injurious sound levels. Furthermore, conservation measures will be in place to initiate a shutdown if individuals enter or are about to enter the 500 meter (1,640.4 feet) shutdown zone during the 36-airgun array operations, which is beyond the distances believed to have the potential for PTS for sperm whales, as described above. As stated in the exposure analysis, each individual could be exposed to 160 dB re: 1 μPa (rms) levels. We do not expect this to produce a cumulative TTS auditory injury. We expect that individuals will recover from TTS between each of these short-duration 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 at least a short distance away as received sound levels increase, reducing the likelihood of exposure at levels that could affect an individual's fitness. In summary, if there are animals exposed to TTS, we expect that any TTS will be temporary, and animals are expected to quickly make a full recovery.

10.4.1.1 Cetaceans and Auditory Interference (Masking)

Interference, or masking, occurs when a sound is a similar frequency and similar to or louder than the sound an animal is trying to hear (Clark et al. 2009; Erbe et al. 2016). Masking can interfere with an individual's ability to gather acoustic information about its environment, such as predators, prey, conspecifics, and other environmental cues (Richardson 1995). This can result in loss of cues of predatory risk, mating opportunity, or foraging options (Francis and Barber

2013). Low frequency sounds are broad and tend to have relatively constant bandwidth, whereas higher frequency bandwidths are narrower (NMFS 2006h).

The frequency range of the airgun array overlaps with the frequency range of ESA-listed cetacean vocalizations, particularly those of baleen whales and to some extent sperm whales. The high-energy seismic survey could mask sperm whale calls at some of the lower frequencies for this species. This could affect communication between individuals, affect their ability to receive information from their environment, or affect sperm whale echolocation (Evans 1998; NMFS 2006h). Most of the energy of sperm whale clicks is concentrated at 2-4 kHz and 10-16 kHz and, though the findings by Madsen et al. (2006) suggest frequencies of pulses from airgun arrays can overlap this range, the dominant frequency component of the R/V *Langseth*'s airgun array is below 200 Hz (2-188 Hz). Any masking that might occur will 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 seismic survey activities on the R/V *Langseth* will occur over the course of approximately 45 days. Given the disparity between sperm whale echolocation and communication-related sounds with the dominant frequencies for seismic surveys, masking is not likely to be significant for sperm whales (NMFS 2006h). Nieukirk et al. (2012) analyzed 10 years of recordings from the Mid-Atlantic Ridge. When several surveys were recorded simultaneously, whale sounds were masked (drowned out), and the airgun noise became the dominant component of background noise levels. The R/V *Langseth*'s airgun array will emit an approximately 0.01 second pulse when fired approximately every 10 seconds for the high-energy seismic survey, while sperm whale calls last 0.5-1 second. Therefore, pulses will not "cover up" the vocalizations of sperm whales to a significant extent (Madsen et al. 2002b). We address the response of sperm whales stopping vocalizations because of sound from the airgun array in Section 10.4.1.2.

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 impulsive sound can add significantly to the acoustic background (Guerra et al. 2011), potentially interfering with the ability of animals to hear otherwise detectible sounds in their environment.

The sound localization abilities of cetaceans suggest that, if signal and sound come from different directions, masking will not be as severe as the usual types of masking studies might suggest (Richardson 1995). The dominant background noise may be 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 et al. 1993; Bain 1993; Bain and Dahlheim 1994; Bain 1994; Dubrovskiy 2004). Toothed whales, and probably other cetaceans, have additional capabilities besides directional hearing that can facilitate detection of sounds in the presence of background sound. There is evidence that some toothed whales can shift the dominant frequencies of their echolocation signals from a frequency range with a lot of ambient sound toward frequencies with less noise (Au et al. 1974; Au 1974; Au 1975; Moore 1990; Thomas 1990; Romanenko and Kitain 1992; Romanenko 1992; Lesage 1999). A few marine mammal species increase the source levels or alter the frequency of their calls in the presence of elevated sound levels (Dahlheim 1987; Au 1993; Lesage 1993; Lesage 1999; Terhune 1999; Foote 2004; Parks et al. 2007; Holt et al. 2009; Parks 2009).

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 cetaceans. For example, Zaitseva et al. (1980) found that, for 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 kHz, in contrast to the pronounced effect at higher frequencies. Studies have noted directional hearing at frequencies as low as 0.5-2 kHz in several cetaceans, including killer whales (Richardson et al. 1995b). This ability may be useful in reducing masking at these frequencies.

Some studies indicate that mid-frequency cetaceans may also alter components of their vocalizations in response to anthropogenic noise. However, there may be energetic costs to producing louder and more frequent calls. Other studies reported decreased likelihood of calling during periods of high noise, or even complete cessation of calling (e.g., (Melcón et al. 2012; Tsujii et al. 2018). In the Beaufort Sea, bowhead whales recorded at sites near seismic survey airgun activity decreased their call localization rate (the number of localized calls per hours within a specified study area) during and after the seismic survey. In other words, calling was highest before seismic activity. In contrast, call localization rates or bowhead whales recorded at sites further away from the seismic survey activity were either unchanged before, during, and after seismic activity, or were lowest before seismic activity (Blackwell et al. 2013).

In summary, high levels of sound generated by the seismic survey activities may act to mask the detection of weaker biologically important sounds for some cetaceans considered in this consultation. For toothed whales (sperm whales), which hear best at frequencies above the predominant ones produced by airguns, there may be modifications to aspects of their vocalizations that allow them to reduce the effects of masking on higher frequency sounds such as echolocation clicks like other toothed whales mentioned above (e.g., belugas, Au et al. 1985). As such, toothed whales are not expected to experience significant masking during the period of time the airgun arrays are producing sound for the proposed actions.

10.4.1.2 Cetaceans and Behavioral Responses

We expect the greatest response of cetaceans to airgun array sounds, in terms of number of responses and overall impact, to be in the form of changes in behavior. Sperm whales 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 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 because of increased seismic survey activity (Parente et al. 2007). Cetacean responses to anthropogenic sound vary by species, state of maturity, prior exposure, current activity, reproductive state, time of day, and other factors (Ellison et al. 2012; Harris et al. 2018). These differences are reflected in a variety of aquatic, aerial, and terrestrial animal responses to anthropogenic noise that may ultimately have fitness consequences (NRC 2005a; Francis and Barber 2013; New et al. 2014; Costa et al. 2016; Fleishman et al. 2016). Although some studies are available that address responses of sperm whales considered in this consultation directly, additional studies to other related whales (such as bowhead whales, gray whales, and North Atlantic right whales) are relevant in determining the responses expected by sperm whales. Therefore, we consider studies from non-ESA-listed or species outside the action area.

Animals generally respond to anthropogenic perturbations as they would to predators, increasing vigilance, and altering habitat selection (Reep et al. 2011). There is increasing evidence 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 mammals and cetaceans, we expect it possible for ESA-listed cetaceans to behave in a similar manner to terrestrial mammals when they detect a sound stimulus. For additional information on the behavioral responses cetaceans exhibit in response to anthropogenic noise, including non-ESA-listed cetaceans species, see the *Federal Register* notice of the proposed IHA and request for comments and possible renewal (88 FR 56964-56993) as well as scientific reviews (e.g., Southall et al. 2007b; Gomez et al. 2016).

Several studies have aided in assessing the various levels at which whales may modify or stop their calls in response to sounds from airguns. Whales may continue calling while seismic surveys are operating locally (Richardson et al. 1986; McDonald et al. 1993; McDonald et al. 1995; Greene Jr et al. 1999; Madsen et al. 2002a; Tyack et al. 2003; Nieukirk et al. 2004; Smultea et al. 2004; Jochens et al. 2006). Some blue whales, fin whales, and sperm whales stopped calling for short and long periods apparently in response to airguns (Bowles et al. 1994; McDonald et al. 1995; Clark and Gagnon 2006).

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; McCall Howard 1999; Madsen et al. 2002a). Some exposed sperm whales may cease calling or otherwise alter their vocal behavior in response to the R/V *Langseth*'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 later or in a location away from the R/V *Langseth*'s airgun array once the acoustic stressor has diminished.

Sperm whale response to airguns has thus far included mild behavioral disturbance (temporarily disrupted foraging, avoidance, cessation of vocal behavior) or no reaction. Several studies have found sperm whales in the Atlantic Ocean to show little or no response (Davis et al. 2000; Stone 2003; Moulton and Miller 2005; Madsen et al. 2006; Stone and Tasker 2006; Weir 2008; Miller et al. 2009; Stone et al. 2017). Detailed study of sperm whales in the Gulf of Mexico suggests some alteration in foraging from less than 130-162 dB re: 1 μPa peak-to-peak, although other behavioral reactions were not noted by several authors (Gordon et al. 2004; Gordon et al. 2006; Jochens et al. 2006; Madsen et al. 2006; Winsor and Mate 2006). This has been contradicted by other studies, which found avoidance reactions by sperm whales in the Gulf of Mexico in response to seismic ensonification (Mate et al. 1994; Jochens 2003; Jochens and Biggs 2004). The intensity and the frequency of the disturbance created by the airguns seems to have bearing on the effects to exposed sperm whales. The persistent, high-level disturbance caused exposure to underwater noise associated with oil and gas activities in the Gulf of Mexico was predicted to cause significant reductions in fitness, especially for reproductive female sperm whales due to lost foraging opportunities, to the point of starvation(Farmer et al. 2018a). An individual sperm whale's resilience to foraging disturbance on its size and daily energetic demands; pregnant and nursing sperm whales are thus most vulnerable (Farmer et al. 2018b). The amount of time between disturbances to foraging behavior matters because sperm whales would need time to replenish lost reserves. Thus, intermittent disturbances to foraging behavior are less impactful than continuous disruption.

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 (Watkins and Schevill 1975a; Watkins et al. 1985b; Goold 1999b). 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 and did not move away from the airgun array at and beyond these distances in the Gulf of Mexico. 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 Hz) pulses produced by seismic airguns (Richardson et al. 1995b). Sperm whales are exposed to considerable energy above 500 Hz 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 kHz and 60 dB re: 1 μPa lower at 80 kHz compared to dominant frequencies during a seismic source calibration. Another odontocete, bottlenose dolphins, progressively reduced their vocalizations as an airgun array came closer and got louder (Woude 2013). Reactions of sperm whales to impulse noise likely vary depending on the activity at the time of exposure. For example, in the presence of abundant food or during breeding encounters, toothed whales sometimes are extremely tolerant of noise pulses (NMFS 2010a).

In summary, sperm whales are expected to exhibit a wide range of behavioral responses when exposed to sound fields from the airgun array. Toothed whales (sperm whales) are expected to exhibit less overt behavioral changes, but may alter foraging behavior, including echolocation vocalizations. While exposure to the airgun array may be temporary, normal behavioral patterns of sperm whales can be disrupted over the period of the survey.

10.4.1.3 Cetaceans 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; Zimmer and Tyack 2007; Tal et al. 2015), 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 sperm whales to experience any of these more severe physical and physiological responses because of the 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 stimulation by a stressor, causing a cascade of physiological responses, such as the release of the stress hormones cortisol, adrenaline (epinephrine), glucocorticosteroids, and others (Thomson and Geraci 1986; St. Aubin and Geraci 1988; St. Aubin et al. 1996; Gulland et al. 1999; Gregory and Schmid 2001; Busch and Hayward 2009). These hormones 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 (Thomson and Geraci 1986; Kaufman and Kaufman 1994; Dierauf and Gulland 2001; Cattet et al. 2003; Elftman et al. 2007; Fonfara et al. 2007; Noda et al. 2007; Mancia et al. 2008; Busch and Hayward 2009; Dickens et al. 2010; Costantini et al. 2011). In some species, stress can also increase an individual's susceptibility to gastrointestinal parasitism (Greer et al. 2005). In highly stressful circumstances, or in species prone to strong "fight-or-flight" responses, more extreme consequences can result, including muscle damage and death (Cowan and Curry 1998; Cowan and Curry 2002; Herraez et al. 2007; Cowan 2008). The most widely recognized indicator of vertebrate stress, cortisol, normally takes hours to days to return to baseline levels following a significantly stressful event, but other hormones of the hypothalamic-pituitary-adrenal axis may persist for weeks (Dierauf and Gulland 2001). Stress levels can vary by age, sex, season, and health status (St. Aubin et al. 1996; Gardiner and Hall 1997; Hunt et al. 2006; Keay et al. 2006; Romero et al. 2008). For example, stress is lower in immature North Atlantic right whales than adults, and mammals with poor diets or undergoing dietary change tend to have higher fecal cortisol levels (Hunt et al. 2006; Keay et al. 2006).

Loud sounds 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. 2012). These levels returned to baseline after 24 hours of vessel traffic resuming.

Because 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 some individuals exposed at sound levels 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, because, in all cases, exposure to sounds from the airgun array are expected to be temporary, we expect 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. 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. 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 sperm whales exposed to these sounds.

It is possible that an animal's prior exposure to sounds from seismic surveys influences its future response. We have little information 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 subsequent response to exposure of an individual will likely be similar to or less than prior responses to novel stimuli and behavioral responses will occur as a consequence (such as moving away and reduced time budget for activities otherwise undertaken; Andre 1997; André 1997; Gordon et al. 2006). 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). However, 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 expected to produce a more intense, frequent, and/or earlier response to subsequent exposures (see Exposure Analysis, section 10.3). Additionally, the proposed actions will take place over approximately 61 days (spread between 2 operational legs); 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 sperm whales to be transiting through.

10.4.1.4 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 2007). In September 2002, 2 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 inches]) 22 kilometers (11.9 nautical miles) offshore at the time the stranding occurred. The link between the stranding and the seismic surveys was inconclusive and not based on any physical evidence because 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 1 exposure without the other does not produce the same result (Fair and Becker 2000; Moberg 2000; Kerby et al. 2004; Romano et al. 2004; Creel 2005). At present, the factors of airgun arrays from seismic surveys that may contribute to 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 sperm whales to strand because of the high-energy seismic survey. If exposed to seismic survey activities, we expect sperm whales will have sufficient space in the open ocean to move away from the sound source and would not be likely to strand given that similar seismic surveys have been conducted by NSF in the past in the Northwest Atlantic Ocean with no documented strandings.

10.4.2 Potential Responses of Sea Turtles to Acoustic Sources

Like cetaceans, if exposed to loud sounds sea turtles may experience ESA harm and/or harassment. Although all sea turtle species exhibit the ability to detect low frequency sound, the potential effects of exposure to loud sounds on sea turtle biology remain largely unknown (Samuel et al. 2005; Nelms et al. 2016). Few data are available to assess sea turtle hearing, let alone the effects of sound sources from seismic surveys on their hearing potential. The only study addressing sea turtle TTS was conducted by Moein et al. (1994) in which a loggerhead turtle experienced TTS upon multiple exposures to an airgun in a shallow water enclosure, but recovered full hearing sensitivity within 1 day.

As with marine mammals, we assume that sea turtles will not move towards a sound source that causes them stress or discomfort. Some experimental data suggest sea turtles may avoid seismic sound sources (Moein et al. 1994; McCauley et al. 2000a; McCauley et al. 2000c), but monitoring reports from seismic surveys in other regions suggest that some sea turtles do not avoid airguns and were likely exposed to higher levels of pulses from a seismic airgun array (Smultea and Holst 2003). For this reason, conservation measures will be implemented to limit sea turtle exposures from the sound source by implementing shutdowns within 150 meters (492.1 feet) from the sound source. In most cases, we expect sea turtles will move away from sounds produced by the airgun array. Although data on the precise sound levels that can result in TTS or PTS are lacking for sea turtles and the effectiveness of conservation measures is not fully understood, we do not expect the vast majority of sea turtles present in the action area to be exposed to sound levels that will result in TTS. Although it could occur for a few individuals the probability of occurrence will be extremely low. For those individuals that will experience TTS, the available data suggest hearing will return to normal within days of the exposure (Moein et al. 1994).

We have determined that PTS for sea turtles is highly unlikely to occur. For sea turtles, the thresholds for PTS are 204 dB re 1 µPa²·s $SEL_{cum;}$ and 232 dB re: 1 µPa SPL (0-pk). With a source level at the frequency of greatest energy, which is within the sensitive hearing range of sea turtles, the animal will almost have to be directly under the sound source exactly when it fires. Further, PTS may not ever be realized at close distances due to near-field interactions. The airgun array will be shut down if a sea turtle is about to enter the 150 meter exclusion zone; the calculated isopleth distance to the PTS threshold for sea turtles is 15.4 meters.

10.4.2.1 Sea Turtles and Behavioral Responses

As with ESA-listed marine mammals, it is likely that sea turtles will experience behavioral responses in the form of avoidance. We do not have specific information on how sea turtles will respond, but we present the available information on the range of possible responses. Behavioral responses to human activity have been investigated for green and loggerhead (O'hara and Wilcox 1990; McCauley et al. 2000b), and leatherback, loggerhead, olive ridley, and 160 unidentified sea turtles (hardshell species; Weir 2007). The work by O'Hara and Wilcox (1990) and McCauley et al. (2000b) reported behavioral changes of sea turtles in response to seismic airgun arrays. These studies formed the basis for our 175 dB re: 1 µPa (rms) threshold for determining when sea turtles will be harassed due to sound exposure because, at and above this level, loggerhead turtles were observed exhibiting avoidance behavior, increased swimming speed, and erratic behavior. Loggerhead turtles have also been observed moving towards the surface upon exposure to an airgun (Lenhardt et al. 1983; Lenhardt 1994). In contrast, loggerhead turtles resting at the ocean surface were observed to startle and dive as an active seismic source approached them, with the responses decreasing with increasing distance (Deruiter and Larbi Doukara 2012). However, some of these animals may have reacted to the vessel's presence rather than the sound source (Deruiter and Larbi Doukara 2012). Monitoring reports from seismic surveys show that some sea turtles move away from approaching airgun arrays, although sea turtles may approach active airgun arrays within 10 meters (32.8 feet) with minor behavioral responses (Holst et al. 2005c; Smultea et al. 2005; Holst et al. 2006; NMFS 2006; NMFS 2006h; Holst and Smultea 2008a).

Observational evidence suggests that sea turtles are not as sensitive to sound as are marine mammals, and that behavioral changes are only expected when sound levels rise above received sound levels of 175 dB re: 1 µPa (rms). If exposed at such sound levels, based on the available data, we anticipate some change in swimming patterns. Some sea turtles may approach the active airgun array, but we expect them to eventually turn away in order to avoid the active airgun array. As such, we expect temporary displacement of exposed individuals from some portions of the action area during the seismic survey.

10.4.2.2 Sea Turtles and Physical and Physiological Effects

Direct evidence of seismic sound causing stress is lacking for sea turtles. However, animals often respond to anthropogenic stressors in a manner that resembles a prey response (Harrington and Veitch 1992; Lima 1998; Gill et al. 2001; Frid and Dill 2002; Frid 2003; Beale and Monaghan 2004; Romero 2004; Harris et al. 2018). As predators generally induce a stress response in their prey (Lopez 2001; Dwyer 2004; Mateo 2007), we assume that sea turtles experience a stress response if exposed to loud sounds from airgun arrays. We expect that breeding adult females may experience a lower stress response. Female green, hawksbill, and loggerhead turtles appear to have a physiological mechanism to reduce or eliminate hormonal responses to stress (predator attack, high temperature, and capture) in order to maintain reproductive capacity at least during their breeding season; a mechanism apparently not shared with males (Jessop et al. 2000; Jessop 2001; Jessop et al. 2004). Individuals may experience a stress response at levels lower than approximately 175 dB re: 1 μPa (rms), but data are lacking to evaluate this possibility. Therefore, we follow the best available evidence identifying a behavioral response as the point at which we also expect a significant stress response.

10.4.3 Potential Responses of Marine Mammal and Sea Turtle Prey to Acoustic Sources

Seismic surveys may have indirect, adverse effects on ESA-listed marine mammals and sea turtles by affecting their prey availability (including larval stages) through lethal or sublethal damage, stress responses, or alterations in their behavior or distribution. Prey includes fishes, zooplankton, cephalopods, and other invertebrates such as crustaceans, mollusks, and jellyfish. Studies described herein provide extensive support for this, which is the basis for later discussion on implications for ESA-listed marine mammals and sea turtles. In a comprehensive 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 and sea turtles is not available. Until more information specific to prey of the ESA-listed species considered in this opinion is available, we expect that prey (e.g., teleosts, zooplankton, and cephalopods) of ESA-listed marine mammals and sea turtles considered in this consultation will react in manners similar to those fish and invertebrates described herein.

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 may be 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. 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, we assume that some fishes and invertebrates that serve as prey 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 sperm whales and sea turtles 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 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 oysters appear to close their valves in response to low frequency sinusoidal sounds. 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.

Fish or invertebrate mortality may occur from exposure to airguns, but will be limited to close-range exposure to high amplitudes (Falk and Lawrence 1973; Kostyuchenko 1973; Holliday et al. 1987; La Bella et al. 1996; D'Amelio 1999; Santulli et al. 1999; McCauley et al. 2000a; McCauley et al. 2000c; Bjarti 2002; Hassel et al. 2003; McCauley et al. 2003; Popper et al. 2005). Lethal effects, if any, are expected within a few meters of the airgun array (Dalen and Knutsen 1986; Buchanan et al. 2004). If fishes that are not within close range to the airgun array detect the sound and leave the area, it is because the sound is perceived as a threat or it causes some discomfort. We expect these fishes will return to the area once the disturbance abates. For example, a common response by fishes to airgun sound is a startle or distributional response, where fish react by changing orientation or swimming speed, or change their vertical distribution in the water column (Fewtrell 2013a; Davidsen et al. 2019). During airgun studies in which the received sound levels were not reported, Fewtrell (2013a) observed caged *Pelates* spp., pink snapper (*Pagrus auratus*), and trevally (*Caranx ignobilis*) to generally exhibit startle, displacement, and/or grouping responses upon exposure to airguns. This effect generally persisted for several minutes, although subsequent exposures of 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 that 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 change swimming depth and horizontal position more frequently during airgun sound production (Davidsen et al. 2019). We expect that, if fish detect a 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 be available as prey for marine mammals.

There are reports showing sublethal effects to some fish species from airgun arrays. Several species at various life stages have been exposed to high-intensity sound sources (220-242 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 10-15 dB of hearing loss with recovery within 1 day (Popper et al. 2005). Caged pink snapper (*Pelates* spp.) have experienced PTS when exposed over 600 times to received sound levels of 165-209 dB re: 1 μPa peak-to-peak. Exposure to airguns at close range was 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).

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 20-60 minutes after firing of the airgun ceased. A downward shift was also noted by Skalski et al. (1992) at received seismic sounds of 186-191 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 3 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 2 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 1 hour and returned to normal depth (sound environments of 185-192 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 156-161 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 195-218 dB re: 1 µPa 0-to-peak, but did exhibit continual startle responses and fled from the acoustic source when visible (Wardle et al. 2001b). Blue whiting (*Micromesistius poutassou*) and mesopelagic fishes were found to re-distribute 20-50 meters (65.6-164 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 in salmonids receiving 142-186 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 160-180 dB re: 1 µPa 0-to-peak (Dalen and Knutsen 1986; Løkkeborg 1991; Engås et al. 1993; Løkkeborg and Soldal 1993; Turnpenny et al. 1994; Engås et al. 1996b).

Increased swimming activity in response to airgun exposure in 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 163-191 dB re: 1 µPa 0-to-peak (Turnpenny and Nedwell 1994). Similarly, European sea bass apparently did not leave their inshore habitat during a 4-5 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 important prey for sperm whales and some sea turtle species. 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 (McCauley et al. 2000a; McCauley et al. 2000c; Fewtrell 2013b). The authors also noted some movement upward. During ramp-up, squid did not discharge ink but alarm responses occurred when received sound levels reached 156-161 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 246-252 dB after 3-11 minutes. Andre et al. (2011) exposed 4 cephalopod species (*Loligo vulgaris*, *Sepia officinalis*, *Octopus vulgaris*, and *Ilex coindetii*) to 2 hours of continuous sound from 50-400 Hz 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.

The overall response of fishes and squids is to exhibit startle responses and undergo vertical and horizontal movements away from the sound field. Sperm whales regularly feed on squid and some fishes and we expect individuals to feed while in the action area during the 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) or 175 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 and sea turtles to reach a measurable level. Effects are likely to be temporary and, if displaced, marine mammals, sea turtles 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 during and 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 impact on sperm whales or sea turtles. As described above, we believe that, in most cases, sperm whales and sea turtles will avoid closely approaching the airgun array when it is active, and will not be in areas where prey could be temporarily displaced or otherwise affected and the quantity of available prey compared to prey that may suffer mortality is high.

10.5 Summary of Effects

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

We expect up to 482 sperm whales, to be exposed to the airgun array within the 160 dB re: 1 μPa (rms) ensonified areas during the seismic survey activities and exhibit responses in the form of ESA behavioral harassment or TTS. As described earlier, we are not able to quantify the amount of sea turtle exposure, and are relying on the extent of the ensonified area as a surrogate. We expect North Atlantic DPS and South Atlantic DPS of green turtles, leatherback turtles, and hawksbill turtles, to be exposed to the airgun array within 175 dB re: 1 μPa (rms) ensonified areas during the seismic survey activities and exhibit responses in the form of ESA behavioral harassment or TTS.

Because of the requirements in the Permits Division’s proposed IHA, and the nature of the seismic survey activities (high- and low-energy airgun array), as described above, we do not expect 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 ESA behavioral harassment or TTS, to sperm whales. Additionally, as described above, the proposed actions will result in temporary effects, largely behavioral responses (e.g., avoidance, discomfort, loss of foraging opportunities, and stress) but with some potential for TTS, to the exposed sea turtles (North Atlantic DPS and South Atlantic DPS of green turtle, leatherback turtle, and hawksbill turtle). Harassment is not expected to have more than short-term effects on individual ESA-listed marine mammal and sea turtle species (sperm whale; North Atlantic DPS and South Atlantic DPS of green turtle, hawksbill turtle, and leatherback turtle). Because of the large ranges of the affected ESA-listed marine mammals and sea turtles compared to the relatively small size of the portion of the action area where seismic surveys will occur, combined with the relatively short duration of the seismic survey activities, there may be multiple exposures of a small number of individuals in the action area.

The estimates of the number of individuals exhibiting measureable responses are considered conservative (i.e., they are likely higher than what the actual exposures would be and a lower number are likely to be harassed given the conservative assumptions in our effects analysis and the conservation measures that will be implemented). We do not expect the effects of ESA harassment of these individuals, which will be temporary, will have population-level effects.

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 actions are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

We expect that those aspects described in the Environmental Baseline (Section 9) will continue to impact ESA-listed resources into the foreseeable future. We expect climate change, vessel strikes, fisheries (fisheries interactions), pollutants, marine debris, aquatic nuisance species, anthropogenic sound (vessel sound and commercial shipping, sonar, seismic surveys), military activities, and scientific research activities to continue into the future with continuing impacts to marine mammals and sea turtles. Because of recent trends and based on available information, we expect the amount and frequency of vessel activity to persist in the action area, and ESA-listed species will continue to be impacted. Different aspects of vessel activity can impact ESA-listed species, such as vessel noise, disturbance, and the risk of vessel strike causing injury or mortality to marine mammals, especially large whales and, to a lesser extent, sea turtles. However, movement towards bycatch reduction of sea turtles is generally occurring throughout the Northwest Atlantic Ocean waters and near Puerto Rico, which may aid in abating the downward trajectory of sea turtle populations due to activities such as incidental bycatch in fisheries in the action area.

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.

Future tribal, state, and local government actions will likely be in the form of legislation, administrative rules, or policy initiatives and fishing permits. Some activities occurring in the action area are those conducted under state management. These actions may include changes in ocean policy and increases and decreases in the types of activities currently seen in the action area, including changes in the types of fishing activities, resource extraction, and designation of marine protected areas, any of which could influence the status of listed species in the action area in the future. Government actions are subject to political, legislative and fiscal uncertainties. As a result, any analysis of cumulative effects is difficult, particularly when taking into account the geographic scope of the action area, the various authorities involved in the action, and the changing economies of the region.

12 Integration and Synthesis

The Integration and Synthesis is the final step in our assessment of the risk posed to species and their designated critical habitat because of implementing the proposed actions. In this section, we add the Effects of the Action (Section 10) to the Environmental Baseline (Section 9) and the Cumulative Effects (Section 11) to formulate the agency's biological opinion as to whether the proposed actions are likely to reduce appreciably the likelihood of both the survival and recovery of an ESA-listed species in the wild by reducing its numbers, reproduction, or distribution. This assessment is made in full consideration of the Status of the Species Likely to be Adversely Affected (Section 8).

The following discussions separately summarize the probable risks the proposed actions pose to threatened and endangered species that are likely to be adversely affected as a consequence of exposure to the stressors associated with the seismic survey activities, specifically the sound from the use of the airgun array.

12.1 Jeopardy Analysis

Based on our effects analysis, adverse effects to ESA-listed species are likely to result from the proposed actions. The following discussions summarize the probable risks that seismic survey activities and the associated MMPA authorization of harassment of marine mammals because of these activities pose to ESA-listed species over the 45 days of the low- and high-energy seismic surveys. These summaries integrate our exposure and response analyses from the Effects of the Action (Section 10).

12.1.1 Sperm Whale

Adult, juvenile, and calf sperm whales are present in the action area and may be exposed and respond to noise from the seismic survey activities.

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

The sperm whale is the most abundant of the large whale species, with total abundance estimates between 200,000 and 1,500,000. The most recent estimate indicated a global population of between 300,000 and 450,000 individuals (Whitehead 2009a). The higher estimates may be approaching population sizes prior to commercial whaling, the reason for ESA-listing. It is estimated that 761,523 sperm whales were killed between 1900 and 1999 (NMFS 2015b). There are 6 recognized sperm whale stocks in U.S. waters: Puerto Rico and U.S. Virgin Islands, Northern Gulf of Mexico, North Atlantic, North Pacific, California/Oregon/Washington, and Hawaii.

Sperm whales are listed as endangered throughout their range, though the stock most likely to be present in the action area is the North Atlantic stock. There are no reliable estimates for sperm whale abundance across the entire North Atlantic Ocean. The population estimate for Puerto Rico and U.S. Virgin Islands stock is unknown. The best population estimate for the Northern Gulf of Mexico stock is 1,180 individuals (CV = 0.22) from 2017 and 2018 summer/fall surveys (N_{min} = 983 individuals; (Garrison et al. 2020). For the North Atlantic stock, the best recent abundance estimate is 4,349 individuals (CV = 0.28), which is the sum of abundance estimates from Central Florida to the lower Bay of Fundy in 2016 (N_{min} = 3,451 individuals; (Garrison 2020; Palka 2020). No trend analysis has been conducted for the North Atlantic stock. In the North Pacific Ocean, the abundance of sperm whales was estimated to be 1,260,000 individuals prior to commercial whaling. In 1997, population estimates in the northeastern temperate North Pacific Ocean were 26,300 individuals (CV = 0.81) and 32,100 individuals (CV = 0.36) based on visual and acoustic surveys, respectively (NMFS 2015b). In the eastern tropical Pacific Ocean, the abundance of sperm whales was estimated to be 22,700 individuals (95% CI = 14,800-34,600 individuals) in 1993 (NMFS 2015b). There are insufficient data to reliably estimate the population abundance of the North Pacific stock; however, N_{min} is estimated at 244 sperm whales in the Gulf of Alaska (Rone et al. 2017). The best population estimate for the California/Oregon/Washington stock is 1,997 individuals (CV = 0.57) in 2014 (N_{min} = 1,270 individuals; (Moore and Barlow 2014). The population estimate for the Hawaii stock is 5,707 individuals (CV = 0.23) in 2017 (N_{min} = 4,486 individuals(Becker et al. 2021). There are currently no reliable population estimates for sperm whales in the South Pacific Ocean. There is insufficient data to evaluate trends in abundance and growth rates of sperm whale populations at this time. An attempt to determine trends for the Northern Gulf of Mexico stock showed no significant differences in abundance estimates between 2003 and 2018; however, there is little statistical power to detect a trend because of the relatively imprecise estimates and limited survey area (Garrison et al. 2020). Additionally, it has been reported that the California/Oregon/Washington stock abundance appeared stable, but the estimated growth rate include high uncertainty levels.

No reduction in the distribution of sperm whales from the Northwest Atlantic Ocean in the waters around Puerto Rico or changes to the geographic range of the species are expected because of the NSF and L-DEO's seismic survey activities and the Permits Division's issuance of an IHA.

No reduction in numbers is anticipated as part of the proposed actions. Therefore, no reduction in reproduction is expected because of the proposed actions. Non-lethal take of 482 individuals, which could be adults, juveniles, and/or calves, is expected because of the seismic survey activities. We anticipate ESA behavioral harassment, which will include 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 to be the form of ESA take, with individuals returning to normal shortly after the exposure has ended. Because we expect the responses to be temporary, we do not anticipate any delay in reproduction. Because we do not anticipate a reduction in numbers or reproduction of sperm whales due to the seismic survey activities and the Permits Division's issuance of an IHA, a reduction in the species' likelihood of survival in the wild is not expected.

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

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

Because no mortalities or effects on the abundance, distribution, and reproduction of sperm whale populations are expected because of the proposed actions, we do not anticipate the seismic survey activities and the Permits Division's issuance of an IHA will impede the recovery objectives for sperm whales. In conclusion, we believe the nonlethal effects associated with the proposed actions will not appreciably reduce the likelihood of survival and recovery of sperm whales in the wild by reducing the reproduction, numbers, or distribution of the species.

12.1.2 Green Turtle—North Atlantic and South Atlantic Distinct Population Segments

Adult, juvenile, and hatchling green sea turtles from the North Atlantic and South Atlantic DPS are present in the action area and are expected to be exposed to noise from the seismic survey activities.

The North Atlantic DPS is the largest of the 11 green sea turtle DPSs with an estimated abundance of over 167,000 adult females from 73 nesting sites. All major nesting populations demonstrate long-term increases in abundance (Seminoff et al. 2015a). The South Atlantic DPS is large, estimated at over 63,000 nesting females, but data availability is poor with 37 of the 51 identified nesting sites not having sufficient data to estimate the number of nesters or trends (Seminoff et al. 2015a). While the lack of data is a concern due to increased uncertainty, the overall trend of the South Atlantic DPS was not considered to be a major concern because some of the largest nesting beaches such as Ascension Island and Aves Island in Venezuela and Galibi in Suriname appear to be increasing, while others (Trinidad, Brazil; Atol das Rocas, Brazil; Poilão and the rest of Guinea-Bissau) appearing to be stable. In the U.S., nesting of green sea turtles occurs in the South Atlantic DPS on beaches of the U.S. Virgin Islands, primarily on Buck Island and Sandy Beach, St. Croix, although there are not enough data to establish a trend.

No reduction in the distribution of green sea turtles from the North Atlantic or South Atlantic DPS is expected because of the NSF and L-DEO's seismic survey activities and the Permits Division's issuance of an IHA.

No reduction in numbers is anticipated due to the proposed actions. Individual adult or juvenile green sea turtles within the extent of the ensonified area (19,215 square kilometers) will be harassed or experience TTS because of the proposed seismic survey activities. Nesting or mating is not expected to be delayed or prevented as a result of the proposed actions because of the relatively short duration of the surveys, and that the location of the surveys will largely occur away from where we expect green turtles to be. Because we do not anticipate a reduction in numbers or reproduction of North Atlantic or South Atlantic DPS of green turtles as a result of the proposed seismic survey activities and the Permits Division's issuance of an IHA, a reduction in the species' likelihood of survival in the wild is not expected.

The Atlantic Recovery Plan for the population of Atlantic green sea turtles (NMFS and USFWS 1991b) lists the following recovery objective for a period of 25 continuous years that is relevant to the impacts of the proposed action:

- A reduction in stage class mortality is reflected in higher counts of individuals on foraging grounds.

Because we do not expect mortalities or effects on the distribution of North Atlantic or South Atlantic DPS green sea turtle populations as a result of the proposed actions, we do not anticipate the proposed seismic survey activities, or the Permits, and Conservation Division's issuance of an incidental harassment authorization, will impede the recovery objectives for North Atlantic or South Atlantic of green sea turtles. In conclusion, we believe the effects associated with the proposed actions are not expected to cause a reduction in the likelihood of survival and recovery of the North Atlantic DPS or South Atlantic DPS of green sea turtles in the wild.

12.1.3 Hawksbill Sea Turtle

Adult and juvenile hawksbill sea turtles are present in the action area and are expected to be exposed to noise from the seismic survey activities.

Mortimer and Donnelly (2008) found that for nesting populations in the Atlantic (especially in the Insular Caribbean and Western Caribbean Mainland), 9 of the 10 sites with recent data (within the past 20 years from approximately 1988-2008) show nesting increases in the Caribbean. There are no current population estimates for hawksbill sea turtles in Puerto Rico, although we have some information available. There are 20 known nesting beaches throughout Puerto Rico. NMFS estimates that there are between 500 and 1,000 hawksbill nests laid annually on Mona Island, Puerto Rico

No reduction in the distribution of hawksbill sea turtles is expected because of the NSF and L-DEO's seismic survey activities and the Permits Division's issuance of an incidental harassment authorization.

No reduction in numbers is anticipated due to the proposed actions. Individual adult or juvenile hawksbill sea turtles within the extent of the ensonified area (19,215 square kilometers) will be harassed because of the proposed seismic survey activities. Nesting or mating is not expected to be delayed or prevented as a result of the proposed actions because of the relatively short duration of the surveys, and that the location of the surveys will largely occur away from where we expect hawksbill sea turtles to be. Because we do not anticipate a reduction in numbers or reproduction of hawksbill sea turtles as a result of the proposed seismic survey activities and the Permits Division's issuance of an incidental harassment authorization, a reduction in the species' likelihood of survival in the wild is not expected.

In the 1998 Recovery Plan for U.S. Pacific populations of hawksbill sea turtles (NMFS and USFWS 1998), NMFS identified the following items as top recovery actions to support species' recovery:

- Identify important nesting beaches.
- Ensure long-term protection and management of important nesting beaches.
- Protect and manage nesting habitat; prevent the degradation of nesting habitat caused by seawalls, revetments, sand bags, other erosion-control measures, jetties and breakwaters.
- Identify important marine habitats; protect and manage populations in marine habitat.
- Protect and manage marine habitat; prevent the degradation or destruction of important [marine] habitats caused by upland and coastal erosion.
- Prevent the degradation of reef habitat caused by sewage and other pollutants.
- Monitor nesting activity on important nesting beaches with standardized index surveys.
- Evaluate nest success and implement appropriate nest-protection on important nesting beaches.
- Ensure that law-enforcement activities prevent the illegal exploitation and harassment of sea turtles and increase law-enforcement efforts to reduce illegal exploitation.
- Determine nesting beach origins for juvenile and sub adult populations.

However, because we do not expect mortalities or effects on the distribution of hawksbill sea turtle populations as a result of the proposed actions, we do not anticipate the proposed seismic survey activities, or the Permits, and Conservation Division's issuance of an incidental harassment authorization, will impede the recovery objectives for hawksbill sea turtles. In conclusion, we believe the effects associated with the proposed actions are not expected to cause a reduction in the likelihood of survival and recovery of hawksbill sea turtles in the wild.

12.1.4 Leatherback Sea Turtle

Adult, juvenile, and hatchling leatherback sea turtles are present in the action area and are expected to be exposed to noise from the seismic survey activities.

Between 1978-2005, leatherback nesting increased in Puerto Rico from a minimum of 9 nests recorded in 1978-469-882 nests recorded each year from 2000-2005. The annual rate of increase in nesting was estimated to be 1.1 with a growth rate interval between 1.04-1.12, using nesting numbers from 1978-2005 (USFWS and NMFS 2007). More recent information from surveys conducted from 2011 to 2018 provides nest counts in Puerto Rico. Over this period, the highest number of nests in Puerto Rico was in 2016, with 2,167 nests, and a low of 1,187 nests in 2017. There are an estimated 788 nesting females in Puerto Rico(NMFS 2020b). Due to past harvesting, and bycatch in pelagic fisheries, leatherback abundance in the action area has suffered (Martínez et al. 2007; NMFS 2020b); although the population remains at risk due to these ongoing threats, bycatch reduction efforts and observed increases in nesting in the Northwest Atlantic indicate signs of improvement.

No reduction in the distribution of leatherback turtles from the Atlantic Ocean is expected because of the NSF and L-DEO's seismic survey activities and the Permits Division's issuance of an incidental harassment authorization.

No reduction in numbers is anticipated due to the proposed actions. Individual adult and juvenile leatherback sea turtles of both sexes within the extent of the ensonified area (19,215 square kilometers) will be harassed because of the proposed seismic survey activities. Nesting or mating is not expected to be delayed or prevented as a result of the proposed actions because of the relatively short duration of the surveys, and that the location of the surveys will largely occur away from where we expect leatherback sea turtles to be. Therefore, no reduction in reproduction is expected because of the proposed actions. Because we do not anticipate a reduction in the numbers or reproduction of leatherback turtles as a result of the proposed seismic survey activities and the Permits Division's issuance of an incidental harassment authorization, a reduction in the species' likelihood of survival in the wild is not expected.

The Atlantic Recovery Plan for the U.S. population of the leatherback sea turtle (NMFS and USFWS 1992) listed the following relevant recovery objective:

- The adult female population increases over the next 25 years, as evidenced by a statistically significant trend in the number of nests at Culebra, Puerto Rico; St. Croix, U.S. Virgin Islands; and along the east coast of Florida.

Because no mortalities or effects on the distribution of leatherback turtle populations are expected as a result of the proposed actions, we do not anticipate the proposed seismic survey activities and the Permits Division's issuance of an incidental harassment authorization will impede the recovery objectives for leatherback turtles. In conclusion, we believe the effects associated with the proposed actions are not expected to cause a reduction in the likelihood of survival and recovery of leatherback turtles 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's biological opinion that the proposed actions are not likely to jeopardize the continued existence of: sperm whale, leatherback sea turtle, green sea turtle (North Atlantic and South Atlantic DPS), and hawksbill sea turtle.

It is also NMFS's biological opinion that the actions are not likely to adversely affect the following ESA-listed species: blue whale, fin whale, sei whale; olive ridley sea turtles, loggerhead sea turtles (Northwest Atlantic Ocean DPS), elkhorn, staghorn, boulder star, lobed star, mountainous star, rough cactus, and pillar (listed threatened, proposed endangered) corals, queen conch (proposed), Nassau grouper, giant manta ray, oceanic whitetip shark, and scalloped hammerhead shark (Central and Southwest Atlantic DPS). The actions are not likely to adversely affect the following proposed or designated critical habitats: designated critical habitat for elkhorn and staghorn coral and Atlantic-Caribbean corals (pillar coral, lobed star coral, mountainous star coral, boulder star coral, and rough cactus coral) or proposed critical habitat for Nassau grouper, and North Atlantic DPS green turtle.

14 Incidental Take Statement

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. 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, feeding, or sheltering.

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. When an action will result in incidental take of ESA-listed marine mammals, ESA section 7(b)(4) requires that such taking be authorized under the MMPA section 101(a)(5) before the Secretary can issue an ITS for ESA-listed marine mammals and that an ITS specify those measures that are necessary to comply with Section 101(a)(5) of the MMPA.

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. “Take” is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. 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, feeding, or sheltering.

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.

14.1 Amount or Extent of Take

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

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

14.1.1 Marine Mammals

We anticipate noise from seismic survey activities is reasonably likely to result in the incidental take of ESA-listed marine mammals by injury or harassment. Specifically, we anticipate the take of marine mammals in the action area as detailed in Table 13 below.

Table 13. Estimated amount of incidental take of ESA-listed marine mammals authorized in the Northwest Atlantic Ocean by the incidental take statement.

Species	Authorized Incidental Take by Harassment (Potential Temporary Threshold Shift and Behavioral)	Authorized Incidental Take by Harm (Permanent Threshold Shift)
Sperm Whale	482	0

14.1.2 Sea Turtles

We anticipate noise from seismic survey activities is reasonably likely to result in the incidental take of ESA-listed leatherback, hawksbill, and green sea turtles by harassment.

Where it is not practical to quantify the number of individuals that are expected to be taken by the action, a surrogate (e.g., similarly affected species, habitat, ecological conditions, and sound pressure thresholds) may be used to express the amount or extent of anticipated take if we: 1) describe the causal link between the surrogate and take of the listed species, 2) explain why it is not practical to express the amount or extent of anticipated take or to monitor take-related impacts in terms of individuals of the listed species, and 3) set a clear standard for determining when the level of anticipated take has been exceeded (50 CFR 402. §14(i)(1)(i)). Because there are no reliable estimates of leatherback, hawksbill, or green (North Atlantic and South Atlantic DPS) sea turtle population densities in the action area, it is not practical to develop numerical estimates of leatherback, hawksbill, or green sea turtle exposure.

NMFS is not able to estimate the number of endangered or threatened sea turtles that might be "taken" by the proposed seismic airgun activities because such estimates are impossible to produce with current levels of knowledge. In other words, numerical values cannot be practically obtained for these species and DPSs. Although we cannot estimate the amount of take of individual sea turtles, we can estimate the extent of habitat affected by the seismic airgun transmissions, which is used as a proxy for the take of endangered or threatened sea turtles herein. Any anticipated take of endangered or threatened sea turtles that occurs will be in the form of harassment. Mortality and/or PTS is not reasonably expected to occur in sea turtles.

We are relying on the extent of the 175 dB re: 1 µPa (rms) ensonified area in the non-territorial seas of the action area (19,215 square kilometers). A leatherback, hawksbill, or green sea turtle within the 175 dB re: 1 µPa (rms) during airgun array operations will be affected by the stressor, and expected to respond in a manner that constitutes take. The take will last for the duration of the exposure—that is, the amount of time the sea turtle spends in the 175 dB re: 1 µPa (rms) ensonified area. Depending on the water depth (deep water), and the vessel speed during acquisition, a sea turtle could be exposed for up to 13 minutes (in deep water).

If the amount or location of trackline surveyed changes, or the number of seismic survey days is increased, then incidental take for leatherback, hawksbill, or green sea turtles (North Atlantic and South Atlantic DPS) may be exceeded. As such, if more tracklines are surveyed, there is an increase in the number of survey days beyond 27 days (21 days of seismic activity, plus the 25% contingency, or 6 days, rounded up from 5.25), there are greater estimates of sound propagation, and/or increases in source levels from the airgun array occur, reinitiation of consultation will be necessary.

14.2 Reasonable and Prudent Measures

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

Reasonable and prudent measures are nondiscretionary measures to minimize the amount or extent of incidental take (50 C.F.R. §402.02). NMFS believes the reasonable and prudent measures described below are necessary and appropriate to minimize the impacts of incidental take on the ESA-listed marine mammals and sea turtles discussed in detail in this opinion:

1. The Permits Division must ensure that the NSF and L-DEO implement a program to mitigate and report the potential effects of seismic survey activities as well as the effectiveness of mitigation measures incorporated as part of the proposed incidental harassment authorization for the incidental taking of sperm whales pursuant to section 101(a)(5)(D) of the MMPA and as specified below for sea turtles (i.e., the monitoring requirements). In addition, the Permits Division must ensure that the provisions of the incidental harassment authorization are carried out, and inform the NMFS ESA Interagency Cooperation Division if take is exceeded.
2. The NSF and the L-DEO must implement a program to mitigate and report the potential effects of seismic survey activities as well as the effectiveness of mitigation measures for endangered and threatened sea turtles.

14.3 Terms and Conditions

To be exempt from the prohibitions of section 9 of the ESA and regulations issued pursuant to section 4(d), the NSF, L-DEO and Permits Division must comply with the following terms and conditions, which implement the RPMs described above. These include the take minimization, monitoring and reporting measures required by the section 7 regulations (50 C.F.R. §402.14(i)). If the NSF, L-DEO and Permits Division fail to ensure compliance with these terms and conditions to implement the RPMs applicable to the authorities of the agencies, the protective coverage of section 7(o)(2) may lapse.

The terms and conditions detailed below for each of the RPMs include monitoring and minimization measures where needed:

1. A copy of the draft comprehensive report on all seismic survey activities and monitoring results must be provided to the ESA Interagency Cooperation Division within 90 days of

the completion of the seismic survey, or expiration of the incidental harassment authorization, whichever comes sooner. Send report to nmfs.hq.esa.consultations@noaa.gov, with the subject line, "NSF Puerto Rico Seismic Survey Draft Report".

2. Any reports of injured or dead ESA-listed species must be provided by the L-DEO and NSF to the ESA Interagency Cooperation Division within 24 hours to Tanya Dobrzynski, Chief, ESA Interagency Cooperation Division by email at tanya.dobrzynski@noaa.gov, and nmfs.hq.esa.consultations@noaa.gov, with the subject line, "NSF Puerto Rico Seismic Survey: Dead/Injured ESA-listed Species Report".

15 Conservation Recommendation

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

We recommend the following discretionary conservation recommendations that we believe are consistent with this obligation and therefore may be considered by NSF and the Permits Division in relation to their 7(a)(1) responsibilities. These recommendations will provide information for future consultations involving seismic surveys and the issuance of IHAs that may affect ESA-listed species:

1. We recommend that the NSF promote and fund research examining the potential effects of seismic surveys on ESA-listed sea turtle and fish species.
2. We recommend that the NSF 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 NSF 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.
4. We recommend that the Permits Division develop a flow chart with decision points for mitigation and monitoring measures to be included in future MMPA incidental take authorizations for seismic surveys.
5. We recommend the NSF use (and Permits 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.
6. We recommend the NSF 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.

7. We recommend the NSF and Permits 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 PSO 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.
8. We recommend the NSF and Permits Division consider using the potential standards for towed array PAM in the *Towed Array Passive Acoustic Operations for Bioacoustic Applications: ASA/JNCC Workshop summary March 14-18, 2016 Scripps Institution of Oceanography, La Jolla, California, USA* (Thode 2017).
9. We recommend the NSF use real-time cetacean sighting services such as the WhaleAlert application (http://www.whalealert.org/). We recognize that the research vessel may not have reliable internet access during operations far offshore, but nearshore, where many of the cetaceans considered in this opinion are likely found in greater numbers, we anticipate internet access may be better. Monitoring such systems will help plan seismic survey activities and transits to avoid locations with recent ESA-listed cetacean sightings, and may also be valuable during other activities to alert others of ESA-listed cetaceans within the area, which they can then avoid.
10. We recommend the NSF submit their monitoring data (i.e., visual sightings) by PSOs to the Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations online database so that it can be added to the aggregate marine mammal, seabird, sea turtle, and fish observation data from around the world.
11. We recommend the vessel operator and other relevant vessel personnel (e.g., crewmembers) on the R/V *Langseth* take the U.S. Navy's marine species awareness training available online at: https://www.youtube.com/watch?v=KKo3r1yVBBA in order to detect ESA-listed species and relay information to PSOs.

In order for NMFS's 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 NSF and/or Permits Division should notify the ESA Interagency Cooperation Division of any conservation recommendations they implement in their final action.

16 Reinitiation Notice

This concludes formal consultation for the NSF and L-DEO's proposed low- and high-energy marine seismic surveys by the R/V *Marcus G. Langseth* of the Puerto Rico Trench and Southern Slope and the Permits Division's issuance of an incidental harassment authorization for the proposed high-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 or by the Service, 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 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.

17 APPENDIX A

INCIDENTAL HARASSMENT AUTHORIZATION

The Lamont-Doherty Earth Observatory of Columbia University (L-DEO) 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 waters surrounding Puerto Rico, as specified in L-DEO's IHA application.

3. General Conditions

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

   (b) The species authorized for taking are listed in Table 1. The taking, by Level A and Level B harassment only, is limited to the species and numbers listed in Table 1.

   (c) The taking by 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, or a species for which authorization has been granted but the takes have been met, appears within or enters the Level B harassment zone (Table 2) the acoustic source must be shut down.

   (e) L-DEO must ensure that relevant vessel personnel and 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) L-DEO must use independent, dedicated, trained visual and acoustic 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 appropriate for their designated task (visual or acoustic). Individual PSOs may perform acoustic and visual PSO duties (though not at the same time).

(b) At least one visual and two acoustic PSOs must have a minimum of 90 days at-sea experience working in those roles, respectively, 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 Table 2 for reference.

(iii) Visual PSOs must immediately communicate all observations to the acoustic PSO(s) on duty, including any determination by the PSO regarding species identification, distance, and bearing and the degree of confidence in the determination.

(iv) 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.

(v) 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. Combined observational duties (visual and acoustic but not at same time) may not exceed 12 hours per 24-hour period for any individual PSO.

(d) Acoustic Monitoring

(i) The source vessel must use a towed passive acoustic monitoring system (PAM) which must be monitored by, at a minimum, one on-duty acoustic PSO beginning at least 30 minutes prior to ramp-up and at all times during use of the acoustic source.

(ii) When both visual and acoustic PSOs are on duty, all detections must be immediately communicated to the remainder of the on-duty PSO team for potential verification of visual observations by the acoustic PSO or of acoustic detections by visual PSOs.

(iii) Acoustic 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. Combined observational duties may not exceed 12 hours per 24-hour period for any individual PSO.

(iv) Survey activity may continue for 30 minutes when the PAM system malfunctions or is damaged, while the PAM operator diagnoses the issue. If the diagnosis indicates that the PAM system must be repaired to solve the problem, operations may continue for an additional five hours without acoustic monitoring during daylight hours only under the following conditions:

a. Sea state is less than or equal to BSS 4;

b. With the exception of delphinids, no marine mammals detected solely by PAM in the applicable exclusion zone in the previous two hours;

c. NMFS is notified via email as soon as practicable with the time and location in which operations began occurring without an active PAM system; and

d. Operations with an active acoustic source, but without an operating PAM system, do not exceed a cumulative total of five hours in any 24-hour period.

(e) Exclusion zone and buffer zone

(i) Except as provided below in 4(e)(ii), the PSOs must establish and monitor a 500-m exclusion zone and additional 500-m buffer zone (total 1,000 m). The 1,000-m zone shall serve to focus observational effort but not limit such effort; observations of marine mammals beyond this distance 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 a radius of 500 meter from the edges of the airgun array (rather than being based on the center of the array or around the vessel itself) (0–500 m). The buffer zone encompasses the area at and below the sea surface from the edge of the exclusion zone, out to a radius of 1,000 meters from the edges of the airgun array (500–1,000 m). 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 exclusion zone must be established for all beaked whales and *Kogia* species. No buffer zone is required.

(f) 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(f)(vi).

(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 sperm whales, beaked whales, *Kogia* species, killer whales, and Risso's dolphins).

(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. Duration must not be less than 20 minutes.

(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 or acoustic detection 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) Ramp-up may occur at times of poor visibility, including nighttime, if appropriate acoustic monitoring has occurred with no detections in the 30 minutes prior to beginning ramp-up.

(vi) 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 visual and/or acoustic observation and no visual or acoustic 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.

(vii) 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.

(g) 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 (1) a marine mammal (excluding delphinids of the species described in 4(g)(v)) appears within or enters the exclusion zone and/or (2) a marine mammal is detected acoustically and localized within 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. Large whale (defined as a sperm whale or 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).

2. Aggregation of six or more large whales.

(v) The shutdown requirement shall be waived for dolphins of the following genera: *Delphinus, Lagenodelphis, Lissodelphis, Stenella, Steno, and Tursiops.*

a. If a dolphin of these genera is visually and/or acoustically detected and localized within the exclusion zone, no shutdown is required unless the acoustic PSO or a visual PSO confirms the individual to be of a species other than those listed above, in which case a shutdown is required.

b. If there is uncertainty regarding identification, visual PSOs may use best professional judgment in making the decision to call for a shutdown.

(vi) 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 sperm whales, beaked whales, *Kogia* species, killer whales, and Risso's dolphins) with no further observation of the marine mammal(s).

(h) Vessel strike avoidance:

(i) Vessel operator and crew must maintain a vigilant watch for all marine mammals and slow down, stop their vessel, or alter course, as appropriate and regardless of vessel size, to avoid striking any marine mammals. 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 marine mammals from other phenomena and 2) broadly to identify a marine mammal as a right whale, other whale (defined in this context as sperm whales or baleen whales other than right whales), or other marine mammal.

(ii) Vessel speeds must 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 100 meter from sperm whales and all other baleen whales.

(iv) The vessel must, to the maximum extent practicable, attempt to maintain a minimum separation distance of 50 meter from all other marine mammals, with an understanding that at times this may not be possible (e.g., for animals that approach the vessel).

(v) When marine mammals 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 marine mammals are sighted within the relevant separation distance, the vessel must reduce speed and shift the engine to neutral, not engaging the engines until animals are clear of the area. This does not apply to any vessel towing gear or any vessel that is navigationally constrained.

(vi) 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 observation, 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) PAM must include a system that has been verified and tested by an experienced acoustic PSO that will be using it during the trip for which monitoring is required.

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

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

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

(v) Compass (plus backup).

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

(vii) Any other tools necessary to adequately perform necessary PSO tasks.

(c) Protected Species Observers (PSOs, Visual and Acoustic) Qualifications

(i) PSOs must have successfully completed an acceptable PSO training course appropriate for their designated task (visual or acoustic). Acoustic PSOs are required to complete specialized training for operating PAM systems and are encouraged to have familiarity with the vessel with which they will be working.

(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 visual PSO with experience as shown in 4(b) shall be designated as the lead for the entire protected species observation 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 duty schedule must be devised 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% 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) secondary education and/or experience comparable to PSO duties; (2) previous work experience conducting academic, commercial, or government-sponsored protected species surveys; or (3) previous work experience as a PSO; the PSO should demonstrate good standing and consistently good performance of PSO duties.

(d) Data Collection

(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:

a. Vessel name and call sign;

b. PSO names and affiliations;

c. Date and participants of PSO briefings (as discussed in General Requirement);

d. Dates of departures and returns to port with port name;

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

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

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

h. 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;

i. 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

j. 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 marine mammal, the following information must be recorded:

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

b. PSO who sighted the animal;

c. Time of sighting;

d. Vessel location at time of sighting;

e. Water depth;

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

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

h. Pace of the animal;

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

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

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

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

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

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

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

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

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

(iv) If a marine mammal is detected while using the PAM system, the following information must be recorded:

a. An acoustic encounter identification number, and whether the detection was linked with a visual sighting;

b. Date and time when first and last heard;

c. Types and nature of sounds heard (e.g., clicks, whistles, creaks, burst pulses, continuous, sporadic, strength of signal);

d. Any additional information recorded such as water depth of the hydrophone array, bearing of the animal to the vessel (if determinable), species or taxonomic group (if determinable), spectrogram screenshot, and any other notable information.

6. Reporting

(a) L-DEO 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 marine mammals 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;

(iii) Summary of dates and locations of survey operations (including (1) the number of days on which the airgun array was active 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);

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

(v) 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; and

(vi) 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, L-DEO must report the incident to the NMFS Office of Protected Resources (OPR) and the NMFS West Coast Regional Stranding Coordinator as soon as feasible. The report must include the following information:

a. Time, date, and location (latitude/longitude) of the first discovery (and updated location information if known and applicable);

b. Species identification (if known) or description of the animal(s) involved;

c. Condition of the animal(s) (including carcass condition if the animal is dead);

d. Observed behaviors of the animal(s), if alive;

e. If available, photographs or video footage of the animal(s); and

f. 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, L-DEO must report the incident to NMFS OPR and to the West Coast Regional

Stranding Coordinator as soon as feasible. The report must include the following information:

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

b. Species identification (if known) or description of the animal(s) involved;

c. Vessel's speed during and leading up to the incident;

d. Vessel's course/heading and what operations were being conducted (if applicable);

e. Status of all sound sources in use;

f. 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;

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

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

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

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

k. 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

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

7. Actions to minimize additional harm to live-stranded (or milling) marine mammals – In the event of a live stranding (or near-shore atypical milling) event within 50 kilometers of the survey operations, where the NMFS stranding network is engaged in herding or other interventions to return animals to the water, the NMFS Director of OPR (or designee) will advise L-DEO of the need to implement shutdown procedures for all active acoustic sources operating within 50 kilometers of the stranding. Shutdown procedures for live stranding or milling marine mammals include the following:

(a) If at any time, the marine mammal(s) die or are euthanized, or if herding/intervention efforts are stopped, the Director of OPR, NMFS (or designee) will advise L-DEO that the shutdown around the animals' location is no longer needed.

(b) Otherwise, shutdown procedures will remain in effect until the Director of OPR, NMFS (or designee) determines and advises L-DEO that all live animals involved have left the area (either of their own volition or following an intervention).

(c) If further observations of the marine mammals indicate the potential for re-stranding, additional coordination with L-DEO will be required to determine what measures are necessary to minimize that likelihood (*e.g.*, extending the shutdown or moving operations farther away) and to implement those measures as appropriate.

(d) Additional information requests – If NMFS determines that the circumstances of any marine mammal stranding found in the vicinity of the activity suggest investigation of the association with survey activities is warranted, and an investigation into the stranding is being pursued, NMFS will submit a written request to L-DEO indicating that the following initial available information must be provided as soon as possible, but no later than 7 business days after the request for information.

(i) Status of all sound source use in the 48 hours preceding the estimated time of stranding and within 50 kilometers of the discovery/notification of the stranding by NMFS; and

(ii) If available, description of the behavior of any marine mammal(s) observed preceding (*i.e.*, within 48 hours and 50 kilometers) and immediately after the discovery of the stranding.

In the event that the investigation is still inconclusive, the investigation of the association of the survey activities is still warranted, and the investigation is still being pursued, NMFS may provide additional information requests, in writing, regarding the nature and location of survey operations prior to the time period above.

8. 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, or (2) the prescribed measures are likely not or are not effecting the least practicable adverse impact on the affected species or stocks and their habitat.

9. Renewals – 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 as described in the Specified Activities section of this notice is planned or (2) the activities as described in the Specified Activities section of this notice would not be completed by the time the IHA expires and a Renewal would allow for completion of the activities beyond that described in the Dates and Duration section of this notice, provided all of the following conditions are met:

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

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

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

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

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

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Kimberly Damon-Randall,
Director, Office of Protected Resources,
National Marine Fisheries Service.

Table 1. Numbers of Incidental Take of Marine Mammals Authorized

Species	Proposed Take	
	Level B	Level A
Humpback whale	262	12
Minke whale	58	3
Fin whale	2	0
Sei whale	22	1
Blue whale	1	0
Sperm whale	482	0
Beaked whales	540	0
Risso's dolphin	164	0
Rough-toothed dolphin	477	0
Bottlenose dolphin	2,132	0
Pantropical spotted dolphin	779	0
Atlantic spotted dolphin	1,540	0
Spinner dolphin	1,932	0
Striped dolphin	318	0
Clymene dolphin	1,589	0
Fraser's dolphin	213	0
Common dolphin	88	0
Short-finned pilot whale	1,833	0
Killer whale	2	0
False killer whale	218	0
Pgymy killer whale	130	0
Melon-headed whale	987	0
Kogia spp	354	14

Table 2. Level A and Level B Harassment Zones (m)

Water Depth (m)	Level B harassment zone (m)	Level A			
		Low-frequency cetaceans	Mid-frequency cetaceans	High-frequency cetaceans	Otariid Pinnipeds
>1,000	6,733	320	14	268	11
100-1,000	10,100				

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