NATIONAL MARINE FISHERIES SERVICE
ENDANGERED SPECIES ACT SECTION 7
BIOLOGICAL OPINION

Title: Biological Opinion on the National Science Foundation's Marine Geophysical Survey by the Research Vessel *Marcus G. Langseth* in the Northeast 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

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

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

Publisher: Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce

Approved:

for Donna S. Wieting
Director, Office of Protected Resources

Date: 7/10/19

Consultation Tracking number: OPR-2018-00008

Digital Object Identifier (DOI): 10.25923/027t-1p43

This page left blank intentionally

TABLE OF CONTENTS

Page

1 Introduction ... 1
1.1 Background ... 2
1.2 Consultation History ... 2
2 The Assessment Framework ... 4
3 Description of the Proposed Action ... 7
3.1 National Science Foundation's and Lamont-Doherty Earth Observatory of Columbia University's Proposed Activities ... 8
3.1.1 Seismic Survey Overview and Objectives ... 8
3.1.2 Source Vessel Specifications ... 10
3.1.3 Airgun Array and Acoustic Receivers Description ... 11
3.1.4 Multi-Beam Echosounder, Sub-Bottom Profiler, and Acoustic Doppler Current Profiler ... 14
3.1.5 Mitigation and Monitoring ... 15
3.2 National Marine Fisheries Service's Proposed Activities ... 28
3.2.1 National Marine Fisheries Service's Proposed Incidental Harassment Authorization ... 29
3.2.2 National Marine Fisheries Service's Revisions to Proposed Incidental Harassment Authorization ... 30
4 Action Area ... 30
5 Interrelated and Interdependent Actions ... 32
6 Potential Stressors ... 32
6.1 Pollution ... 32
6.2 Vessel Strikes ... 33
6.3 Acoustic Noise, Vessel Noise, and Visual Disturbance ... 35
6.4 Gear Entanglement ... 38
7 Species and Critical Habitat Not Likely to be Adversely Affected ... 39
7.1 Endangered Species Act-Listed Cetaceans ... 43
7.1.1 Gray Whale – Western North Pacific Population ... 43
7.1.2 Killer Whale – Southern Resident Distinct Population Segment ... 45
7.1.3 North Pacific Right Whale ... 45
7.2 Endangered Species Act-Listed Sea Turtles ... 46
7.3 Endangered Species Act-Listed Fish ... 47
7.3.1 Criteria and Thresholds to Predict Impacts to Fishes ... 47
7.3.2 Impulsive Sound Source Criteria (Airgun Arrays) for Fishes ... 48
7.3.3 Salmonids ... 50

7.3.4 Sturgeon ... 52
7.3.5 Rockfish ... 52
7.3.6 Eulachon ... 53
7.4 Designated Critical Habitat ... 53
7.4.1 Leatherback Turtle Critical Habitat ... 53
7.4.2 Green Sturgeon – Southern Distinct Population Segment Critical Habitat ... 54
7.4.3 Effects to Designated Critical Habitat ... 55

8 Species Likely to be Adversely Affected ... 56

9 Status of Species Likely to be Adversely Affected ... 57
9.1 Blue Whale ... 57
9.1.1 Life History ... 58
9.1.2 Population Dynamics ... 58
9.1.3 Vocalization and Hearing ... 60
9.1.4 Status ... 62
9.1.5 Critical Habitat ... 62
9.1.6 Recovery Goals ... 62
9.2 Fin Whale ... 62
9.2.1 Life History ... 63
9.2.2 Population Dynamics ... 63
9.2.3 Vocalization and Hearing ... 64
9.2.4 Status ... 66
9.2.5 Critical Habitat ... 66
9.2.6 Recovery Goals ... 66
9.3 Humpback Whale – Central America Distinct Population Segment ... 66
9.3.1 Life History ... 67
9.3.2 Population Dynamics ... 67
9.3.3 Vocalization and Hearing ... 68
9.3.4 Status ... 70
9.3.5 Critical Habitat ... 70
9.3.6 Recovery Goals ... 70
9.4 Humpback Whale – Mexico Distinct Population Segment ... 70
9.4.1 Life History ... 71
9.4.2 Population Dynamics ... 71
9.4.3 Vocalization and Hearing ... 71
9.4.4 Status ... 73
9.4.5 Critical Habitat ... 74
9.4.6 Recovery Goals ... 74
9.5 Sei Whale ... 74
9.5.1 Life History ... 75
9.5.2 Population Dynamics ... 75

9.5.3 Vocalization and Hearing ... 75
9.5.4 Status ... 76
9.5.5 Critical Habitat ... 76
9.5.6 Recovery Goals ... 76
9.6 Sperm Whale ... 76
9.6.1 Life History ... 77
9.6.2 Population Dynamics ... 77
9.6.3 Vocalization and Hearing ... 78
9.6.4 Status ... 80
9.6.5 Critical Habitat ... 80
9.6.6 Recovery Goals ... 80
9.7 Guadalupe Fur Seal ... 80
9.7.1 Life History ... 81
9.7.2 Population Dynamics ... 82
9.7.3 Vocalization and Hearing ... 83
9.7.4 Status ... 83
9.7.5 Critical Habitat ... 83
9.7.6 Recovery Goals ... 83
9.8 Leatherback Turtle ... 83
9.8.1 Life History ... 84
9.8.2 Population Dynamics ... 85
9.8.3 Vocalization and Hearing ... 85
9.8.4 Status ... 86
9.8.5 Critical Habitat ... 86
9.8.6 Recovery Goals ... 88

10 Environmental Baseline ... 89
10.1 Climate Change ... 89
10.2 Oceanic Temperature Regimes ... 93
10.3 Whaling and Subsistence Harvesting ... 96
10.4 Sea Turtle Harvesting ... 98
10.5 Vessel Strike ... 98
10.6 Whale Watching ... 100
10.7 Fisheries ... 101
10.7.1 Fisheries Interactions ... 102
10.7.2 Aquaculture ... 103
10.8 Pollution ... 104
10.8.1 Marine Debris ... 104
10.8.2 Pesticides and Contaminants ... 106
10.8.3 Hydrocarbons ... 107
10.9 Aquatic Nuisance Species ... 109

10.10 Anthropogenic Sound ... 109
10.10.1 Vessel Sound and Commercial Shipping ... 110
10.10.2 Aircraft ... 112
10.10.3 Seismic Surveys ... 112
10.10.4 Marine Construction ... 112
10.11 Military Activities ... 113
10.12 Scientific Research Activities ... 113
10.13 Impact of the Baseline on Endangered Species Act-Listed Species ... 114

11 Effects of the Action ... 115
11.1 Stressors Associated with the Proposed Action ... 116
11.2 Mitigation to Minimize or Avoid Exposure ... 116
11.3 Exposure and Response Analysis ... 117
11.3.1 Exposure Analysis ... 117
11.3.2 Response Analysis ... 145
11.4 Risk Analysis ... 168

12 Integration and Synthesis ... 169
12.1 Blue Whale ... 169
12.2 Fin Whale ... 170
12.3 Humpback Whale – Central America Distinct Population Segment ... 171
12.4 Humpback Whale – Mexico Distinct Population Segment ... 172
12.5 Sei Whale ... 173
12.6 Sperm Whale ... 174
12.7 Guadalupe Fur Seal ... 175
12.8 Leatherback Turtle ... 176

13 Cumulative Effects ... 176

14 Conclusion ... 177

15 Incidental Take Statement ... 177
15.1 Amount or Extent of Take ... 178
15.1.1 Marine Mammals ... 178
15.1.2 Sea Turtles ... 179
15.2 Effects of the Take ... 180
15.3 Reasonable and Prudent Measures ... 180
15.4 Terms and Conditions ... 181

16 Conservation Recommendations ... 181

17 Reinitiation Notice ... 183

18 References ... 185

19 Appendices ... 239

19.1 Appendix A – Proposed Incidental Harassment Authorization 239

LIST OF TABLES

Page

Table 1. Additional details of the R/V *Marcus G. Langseth*. 11

Table 2. Specifications of the source airgun array to be used by the R/V *Marcus G. Langseth* during the proposed seismic survey in the Northeast Pacific Ocean. 12

Table 3. Specifications of the R/V *Marcus G. Langseth*'s airgun arrays, trackline distances, and water depths associated with the two-dimensional and three-dimensional seismic survey in the Northeast Pacific Ocean. 12

Table 4. Specifications for the ocean bottom seismometers to be used during the proposed seismic survey in the Northeast Pacific Ocean. 14

Table 5. Predicted distances to permanent threshold shift thresholds for impulsive sources for various marine mammal hearing groups that could be received from the single airgun as well as the 18- and 36-airgun arrays during the proposed seismic survey in the Northeast Pacific Ocean. 18

Table 6. Predicted distances to which sound levels of 160 re: 1 µPa (rms) for Marine Mammal Protection Act Level B harassment for impulsive sources will be received from the single 40 cubic inch airgun as well as the 18- and 36-airgun arrays in water depths greater than 1,000 meters for marine mammals during the proposed seismic survey in the Northeast Pacific Ocean. 19

Table 7. Predicted distances to which sound levels of 175 and 195 dB re: 1 µPa (rms) will be received from the single 40 cubic inch airgun as well as the 18- and 36-airgun array in water depths greater than 1,000 meters for sea turtles during the proposed seismic survey in the Northeast Pacific Ocean. 19

Table 8. Endangered Species Act-listed threatened and endangered species or proposed for Endangered Species Act-listing potentially occurring in the action area that may be affected, but are not likely to be adversely affected. 40

Table 9. Threatened and endangered species that may be affected by the National Science Foundation and Lamont-Doherty Earth Observatory's proposed action of a marine seismic survey in the Northeast Pacific Ocean. 56

Table 10. Endangered Species Act-listed marine mammal mortalities as the result of whaling since 1985. 97

Table 11. Five-year annual average mortalities and serious injuries related to vessel strikes for Endangered Species Act-listed marine mammals within the action area. 100

Table 12. Five-year mortalities and serious injuries related to fisheries interactions for Endangered Species Act-listed marine mammals within the action area..... 102

Table 13. Functional hearing groups, generalized hearing ranges, and acoustic thresholds identifying the onset of permanent threshold shift and temporary threshold shift for marine mammals exposed to impulsive sounds (NOAA, 2018)..... 122

Table 14. Modeled sound source levels for the R/V *Marcus G. Langseth*'s single 40 cubic inch airgun, 3,300 cubic inch airgun array, and 6,600 cubic inch airgun array. 124

Table 15. Predicted radial distances in meters from the R/V *Marcus G. Langseth* seismic sound sources to isopleth corresponding to greater than or equal to 160 dB re: 1 µPa (rms) threshold..... 125

Table 16. Modeled radial distances in meters from the R/V *Marcus G. Langseth*'s single airgun, 18 airgun array, and 36 airgun array corresponding to harm (Marine Mammal Protection Act Level A harassment) thresholds. 125

Table 17. Densities of ESA-listed marine mammals in the action area during National Science Foundation's seismic survey in the Northeast Pacific Ocean..... 128

Table 18. Relevant isopleths, daily ensonified area, number of survey days, percent increase, and total ensonified areas during the National Science Foundation and Lamont-Doherty Earth Observatory's seismic survey in the Northeast Pacific Ocean..... 132

Table 19. Total ensonified areas for ESA-listed marine mammals in the action area during National Science Foundation and Lamont-Doherty Earth Observatory's seismic survey in the Northeast Pacific Ocean. 133

Table 20. Estimated exposure of Endangered Species Act-listed marine mammals calculated by the National Science Foundation, Lamont-Doherty Earth Observatory, and National Marine Fisheries Service Permits and Conservation Division during the seismic survey in the Northeast Pacific Ocean..... 133

Table 21. Probability of encountering humpback whales from each distinct population segment of humpback whales in the North Pacific Ocean in various feeding areas. Adapted from P. R. Wade et al. (2016). 136

Table 22. Generalized hearing range and acoustic thresholds identifying the onset of permanent threshold shift and temporary threshold shift for sea turtles exposed to impulsive sounds (U.S. Navy, 2017). 140

Table 23. Predicted radial distances from the R/V *Marcus G. Langseth*'s airgun array to isopleths corresponding to the behavioral harassment threshold and exclusion zone for sea turtles..... 141

Table 24. Density of ESA-listed sea turtles in the action area during the National Sciencd Foundation and Lamont-Doherty Earth Observatory's seismic survey in the Northeast Pacific Ocean 143

Table 25. Relevant isopleths, daily ensonified area, number of survey days, percent increase, and total ensonified areas during the National Science Foundation and Lamont-Doherty Earth Observatory's seismic survey in the Northeast Pacific Ocean. 143

Table 26. Estimated exposure of Endangered Species Act-listed sea turtles during the National Science Foundation and Lamont-Doherty Earth Observatory's seismic survey in the Northeast Pacific Ocean. 143

Table 27. Estimated amount of incidental take of Endangered Species Act-listed marine mammals authorized in the Northeast Pacific Ocean by the incidental take statement. 179

Table 28. Estimated amount of incidental take of Endangered Species Act-listed sea turtles authorized in the Northeast Pacific Ocean by the incidental take statement. 180

LIST OF FIGURES

Page

Figure 1. Map of the National Science Foundation and Lamont-Doherty Earth Observatory's high-energy marine seismic survey in the Northeast Pacific Ocean for this consultation. EEZ=Exclusive Economic Zone OBS=Ocean Bottom Seismometer EBSA=Ecologically or Biologically Significant Marine Areas HT=Hydrothermal 31

Figure 2. Map depicting leatherback turtle designated critical habitat along the United States Pacific Coast. 54

Figure 3. Map of geographic range (within the contiguous United States) and designated critical habitat for Southern distinct population segment of green sturgeon. 55

Figure 4. Map identifying the range of the endangered blue whale. 58

Figure 5. Map identifying the range of the endangered fin whale. 63

Figure 6. Map identifying 14 distinct population segments with one threatened and four endangered, based on primarily breeding location of the humpback whale, their range, and feeding areas (Bettridge et al., 2015). 67

Figure 7. Map identifying the range of the endangered sei whale. 74

Figure 8: Map identifying the range of the endangered sperm whale. 77

Figure 9. Map identifying the range of the threatened Guadalupe fur seal. 81

Figure 10. Map identifying the range of the endangered leatherback turtle. Adapted from (Wallace et al., 2013)..... 84

Figure 11. Map depicting leatherback turtle designated critical habitat in the United States Virgin Islands. 87

Figure 12. Map depicting leatherback turtle designated critical habitat along the United States Pacific Coast..... 88

1 INTRODUCTION

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

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

The action agencies for this consultation are the National Science Foundation and the NMFS, Office of Protected Resources, Permits and Conservation Division. Two federal action were considered during consultation. The first was the National Science Foundation's proposal to sponsor and conduct a seismic survey in the Northeast Pacific Ocean in summer (July and August) 2019. The second was the NMFS Permits and Conservation Division's proposal to issue an incidental harassment authorization authorizing non-lethal "takes" by Level B harassment (as defined by the Marine Mammal Protection Act [MMPA]) of marine mammals incidental to the planned seismic survey, pursuant to section 101(a)(5)(D) of the MMPA 16 U.S.C. 1371(a)(5)(D). The consulting agency is the NMFS Endangered Species Act Interagency Cooperation Division.

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

were prepared by NMFS, Office of Protected Resources, ESA Interagency Cooperation Division in accordance with section 7(b) of the ESA and implementing regulations at 50 C.F.R. Part 402.

This document represents the NMFS ESA Interagency Cooperation Division's opinion on the effects of these actions on threatened and endangered species and critical habitat that have been designated for those species (see Table 8 and Table 9). A complete record of this consultation is on file at the NMFS Office of Protected Resources in Silver Spring, Maryland.

1.1 Background

The National Science Foundation is proposing to sponsor and conduct a marine seismic survey for scientific research purposes and data collection in the Northeast Pacific Ocean in summer (July and August) 2019. In conjunction with this action, the NMFS Permits and Conservation Division will issue an incidental harassment authorization under the MMPA for incidental takes of marine mammals that could occur during the National Science Foundation seismic survey. Both the National Science Foundation and the NMFS Permits and Conservation Division have conducted similar actions in the past and have been the subject of ESA section 7 consultations. The previous opinions for National Science Foundation's seismic surveys in the Gulf of Mexico (2003), Eastern Tropical Pacific Ocean (2003), Norwegian Sea (2003), Mid-Atlantic Ocean (2003), Gulf of Alaska (2004), Northeast Pacific Ocean (2004), Southeast Caribbean Sea (2004), Aleutian Islands (2005), Southern Gulf of Mexico (2005), Central America (2005), Northern Gulf of Mexico (2007 through 2008), Central America (2008), Gulf of Alaska (2008), Canada (2009), Southeast Asia (2009), Tonga (2009), Vancouver and Oregon (2009), North Pacific Ocean (2010), Costa Rica (2011), Line Islands (2012), Northeast Pacific Ocean (2012), Northeast Atlantic Ocean (2013), New Jersey (2014), North Carolina (2014), Mediterranean Sea (2015), Southeast Pacific Ocean (2016), South Atlantic Ocean (2016), New Zealand (2017), Hawaii (2018), and Western Gulf of Alaska (2019) and the issuance of an incidental harassment authorization determined that the authorized activities are not likely to jeopardize the continued existence of ESA-listed species, or the destruction or adverse modification of designated critical habitat.

1.2 Consultation History

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

- On September 6, 2018, the National Science Foundation requested a list of ESA-listed species and designated critical habitat that may occur in the proposed action area in the Northeast Pacific Ocean as well as recommended data sources for marine mammal and sea turtle abundances and densities in the action area.
- On September 14, 2018, we responded to the National Science Foundation request and provided a list of ESA-listed species and designated critical habitat that may occur in the action area in the Northeast Pacific Ocean as well as recommended data sources for marine mammal and sea turtle abundances and densities in the action area.
- On December 21, 2018, we received a request from the National Science Foundation for ESA section 7 consultation for a proposed seismic survey to be undertaken in the Northeast Pacific Ocean in 2019 through 2020. The National Science Foundation provided a letter and draft environmental analysis pursuant to the National Environmental Protection Act, which includes information necessary for a biological assessment, in support of the request.
- On December 21, 2018, the National Science Foundation submitted an incidental harassment authorization application to us and NMFS Permits and Conservation Division. NMFS Permits and Conservation Division deemed the incidental harassment authorization application adequate and complete on May 3, 2019.
- On December 21, 2018, we determined there was sufficient information to initiate formal consultation. We provided the National Science Foundation with an initiation letter on May 22, 2019.
- On December 22, 2018, consultation was held in abeyance for 38 days due to a lapse in appropriations and resulting partial government shutdown. Consultation resumed on January 28, 2019.
- On June 4, 2019, we received a request for formal consultation pursuant to section 7 of the ESA from the NMFS Permits and Conservation Division to authorize the incidental harassment of marine mammal species during the National Science Foundation's seismic survey on the research vessel (R/V) *Marcus G. Langseth* in the Northeast Pacific Ocean. The consultation request package included an initiation memorandum, incidental harassment authorization application, draft *Federal Register* notice of a proposed incidental harassment authorization, draft incidental harassment authorization, and draft environmental analysis.
- On June 4, 2019, we determined there was sufficient information to initiate formal consultation. We provided NMFS Permits and Conservation Division with an initiation letter on June 17, 2019.
- On June 10, 2019, NMFS Permits and Conservation Division published a notice of a proposed incidental harassment authorization in the *Federal Register* soliciting public comment on their intent to issue an incidental harassment authorization for National Science Foundation's high-energy marine seismic survey on the R/V *Marcus G. Langseth* in the Northeast Pacific Ocean.

- On June 10, 2019, we provided the National Science Foundation with additional questions on the draft environmental analysis. National Science Foundation responded to the questions on June 13, 2019.
- On June 14, 2019, we received a revised final environmental analysis from National Science Foundation.
- On July 7, 2019, NMFS Permits and Conservation notified us that they will be revising the number of authorized takes by MMPA Level B harassment of sei whales and Guadalupe fur seals as well as adding shut-down procedures for North Pacific right whales observed at any distance in the final incidental harassment authorization based on comments received from the Marine Mammal Commission during the 30-day public comment period. We received a revised draft final incidental harassment authorization from the NMFS Permits and Conservation Division.
- On July 10, 2019, the public comment period closed for the *Federal Register* notice of the proposed incidental harassment authorization. During the 30-day public comment period, NMFS Permits and Conservation Division received comment letters from the Marine Mammal Commission and one private citizen.

2 THE ASSESSMENT FRAMEWORK

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

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

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

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

An ESA section 7 assessment involves the following steps:

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

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

Interrelated and Interdependent Actions (Section 5): We identify any interrelated and interdependent actions. *Interrelated* actions are those that are part of a larger action and depend on that action for their justification. *Interdependent* actions are those that do not have independent use, apart from the action under consideration.

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

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

Species Likely to be Adversely Affected (Section 8): During the ESA section 7 consultation process, we identify the ESA-listed species and designated critical habitat that are likely to co-occur with the stressors produced by the proposed action in space and time and evaluate the status of those species and habitat.

Status of Species Likely to be Adversely Affected (Section 9): We examine the status of ESA-listed species that may be adversely affected by the proposed action throughout the action area..

*Environmental Baseline (*Section 10): We describe the environmental baseline in the action area including: past and present impacts of federal, state, or private actions and other human activities in the action area; anticipated impacts of proposed federal projects that have already undergone formal or early section 7 consultation, and impacts of state or private actions that are contemporaneous with the consultation in process.

Effects of the Action (Section 11): We identify the number, age (or life stage), and gender of ESA-listed individuals that are likely to be exposed to the stressors and the populations or sub-populations to which those individuals belong. We also consider whether the action “may affect” designated critical habitat. This is our exposure analysis. We evaluate the available evidence to determine how individuals of those ESA-listed species are likely to respond given their probable exposure. We also consider how the action may affect designated critical habitat. This is our response analysis. We assess the consequences of these responses of individuals that are likely to be exposed to the populations those individuals represent, and the species those populations comprise. This is our risk analysis. The adverse modification analysis considers the impacts of the proposed action on the essential features and conservation value of designated critical habitat.

Integration and Synthesis (Section 12): In this section we integrate the analyses in the opinion to summarize the consequences to ESA-listed species and designated critical habitat under NMFS' jurisdiction.

Cumulative Effects (Section 13): Cumulative effects are the effects to ESA-listed species and designated critical habitat of future state or private activities that are reasonably certain to occur within the action area (50 C.F.R. §402.02). Effects from future Federal actions that are unrelated to the proposed action are not considered because they require separate ESA section 7 compliance.

Conclusion (Section 14): With full consideration of the status of the species and the designated critical habitat, we consider the effects of the action within the action area on populations or subpopulations and on essential features of designated critical habitat when added to the environmental baseline and the cumulative effects to determine whether the action could reasonably be expected to:

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

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

In addition, we include an incidental take statement (Section 15) that specifies the impact of the take, reasonable and prudent measures to minimize the impact of the take, and terms and conditions to implement the reasonable and prudent measures. ESA section 7 (b)(4); 50 C.F.R. §402.14(i). We also provide discretionary conservation recommendations that may be implemented by action agency (Section 16) (50 C.F.R. §402.14(j)). Finally, we identify the circumstances in which reinitiation of consultation is required (Section 17) (50 C.F.R. §402.16).

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

- Information submitted by the National Science Foundation, Lamont-Doherty Earth Observatory of Columbia University, and NMFS Permits and Conservation Division;

- Government reports (including NMFS biological opinions and stock assessment reports);
- National Oceanic and Atmospheric Administration (NOAA) technical memorandums;
- Monitoring reports; and
- Peer-reviewed scientific literature.

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

3 DESCRIPTION OF THE PROPOSED ACTION

"Action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by federal agencies (50 C.F.R. 402. §02).

Two federal actions were evaluated in during consultation. The first proposed action for this consultation is the National Science Foundation's (along with researchers from the University of Texas at Austin's Institute for Geophysics, the Nevada Seismological Laboratory at the University of Nevada Reno, and the Scripps Institution of Oceanography at the University of California San Diego) proposal to sponsor and conduct a high-energy marine seismic survey on the R/V *Marcus G. Langseth* in the Northeast Pacific Ocean in summer (July and August) 2019. The R/V *Marcus G. Langseth* is operated by the Lamont-Doherty Earth Observatory of Columbia University under an existing cooperative agreement. The second proposed action for this consultation is NMFS Permits and Conservation Division's issuance of a proposed incidental harassment authorization authorizing non-lethal "takes" by MMPA Level A and B harassment (ESA harassment and harm) pursuant to section 101(a)(5)(D) of the MMPA for the National Science Foundation's high-energy marine seismic survey in the Northeast Pacific Ocean.

The proposed action includes a two-dimensional and three-dimensional high-energy seismic surveys in International Waters outside of the U.S. Exclusive Economic Zone. The National Science Foundation, as the research funding and action agency, has a mission to "promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense…". The proposed seismic survey will collect data in support of a research proposal that has been reviewed under the National Science Foundation merit review process and identified as a National Science Foundation program priority. It will provide data necessary to explore the linkages between complex magma chamber structure, caldera dynamics, fluid pathways, and hydrothermal venting and contribute to a more comprehensive assessment of geohazards for the region that can be used to evaluate earthquake, tsunami, and submarine landslide hazards.

The information presented here is based primarily on the draft environmental analysis, incidental harassment authorization application, and *Federal Register* notice of the proposed incidental

harassment authorization provided by the National Science Foundation and NMFS Permits and Conservation Division as part of their initiation packages.

3.1 National Science Foundation's and Lamont-Doherty Earth Observatory of Columbia University's Proposed Activities

The National Science Foundation proposes to fund and conduct a seismic survey in the Northeast Pacific Ocean on the R/V *Marcus G. Langseth*. An airgun array, multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler will be deployed as an energy source.

3.1.1 Seismic Survey Overview and Objectives

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

The purpose of the proposed two-dimensional and three-dimensional seismic survey is to study the Axial volcano/seamount and associated rift axes off the coast of the Pacific Northwest to understand the three-dimensional nature of the magmatic reservoirs that set Axial volcano's framework. The objectives are to create a detailed three-dimensional image of the main and satellite magma reservoirs that set the Axial volcano's framework, image the three-dimensional fracture network and how they influence the magma bodies, and to connect the subsurface observations to the surface features. The main goal of the seismic survey is to explore linkages between complex magma chamber structure, caldera dynamics, fluid pathways, and hydrothermal venting. To achieve the main goal, the researchers will conduct a two-dimensional and three-dimensional multi-channel seismic survey of the Axial volcano and associated rift axes using a source receiver offset with two-dimensional reflection profiles to look at the deep-seated structure of magma delivery. The proposed seismic survey activities will collect data in support of a research proposal that has been reviewed through the National Science Foundation merit review process and have been identified as a National Science Foundation program priorities to meet the agency's critical need to foster an understanding of Earth processes.

Researchers from the University of Texas at Austin's Institute for Geophysics, the Nevada Seismological Laboratory at the University of Nevada Reno, and the Scripps Institution of Oceanography at the University of California San Diego propose to conduct a high-energy marine seismic survey for scientific research purposes, with funding from the National Science Foundation, using an airgun array in the waters of the Northeast Pacific Ocean in summer 2019. The principal investigators are Drs. A. Arnulf (University of Texas at Austin's Institute for Geophysics), G. Kent and A. Kell (Nevada Seismological Laboratory at the University of Nevada Reno), and A. Harding (Scripps Institution of Oceanography at the University of California San Diego). The two-dimensional seismic survey will use a towed 36 airgun array

with a total discharge volume of approximately 108,154.6 cubic centimeters (6,600 cubic inches) and the third-dimensional seismic survey will use a towed 18 airgun array with a total discharge volume of approximately 54,077.3 cubic centimeters (3,300 cubic inches). The seismic survey will take place in International Waters outside of the U.S. Exclusive Economic Zone (370.4 kilometers [200 nautical miles]) in waters depths of approximately 1,400 to 2,800 meters (4,593.2 to 9,186.4 feet). The seismic survey is tentatively planned to depart port on July 11, 2019 and return to port on August 13, 2019. The seismic survey activities will consist of a total of approximately 33 days, including approximately 19 days of airgun array operations (approximately three days for the two-dimensional seismic survey and approximately 16 days for the three-dimensional seismic survey), approximately seven days of equipment deployment and retrieval, approximately five days of contingency time, two days of turns (with no airgun array firing), and approximately two days of transit. Some minor deviation from the dates is possible, depending on logistics and weather.

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

The R/V *Marcus G. Langseth* will first deploy four 6 kilometer (3.2 nautical miles) towed hydrophone streamers and an airgun array to conduct the three-dimensional multi-channel seismic survey to examine the Axial volcano and associate rift axes within an approximate 17 by 40 kilometer (9.2 by 21.6 nautical miles) area. The three-dimensional seismic survey will consist of racetrack formation with 57 40-kilometer (21.6 nautical mile) long tracklines and a turning diameter of 8.5 kilometers (4.6 nautical miles). The airgun array will not be fired during turns. After the three-dimensional seismic survey is completed, the airgun array and four towed hydrophone streamers are recovered, and one 15 kilometers (8.1 nautical miles) towed hydrophone streamer will be deployed with the airgun array to a acquire eight approximately 26 kilometer (14 nautical miles) tracklines for the two-dimensional seismic survey. These tracklines are source-receiver offset two-dimensional reflection profiles that will look at deep-seated structure of magma delivery. During the two-dimensional seismic survey, the airgun array will fire during turns to the next trackline. The location of the tracklines may shift from what is depicted in Figure 1 depending on factors such as science drivers, poor data quality, weather, etc.

A maximum of approximately 3,760 kilometers (2,030.2 nautical miles) of tracklines will be surveyed in the Northeast Pacific Ocean, with approximately 3,196 kilometers (1,725.7 nautical miles) of tracklines during the three-dimensional seismic survey (including run-ins and run-outs) and approximately 564 kilometers (304.5 nautical miles) of tracklines during the two-dimensional seismic survey. The proposed activities will occur 24 hours per day during the proposed seismic survey. There will be additional airgun array operations in the seismic survey area associated with turns, airgun array testing, and repeat coverage of any areas where initial

data quality is considered sub-standard by the project scientists. A section of a trackline may need to be repeated when data quality is poor or missing due to equipment failure (e.g., airgun array or towed hydrophone streamer problems; data acquisition system issues, research vessel issues); shut-downs or ramp-ups for protected species, which will tie into good data on the other side of the trackline. To account for these additional airgun array operations in the estimate of incidental takes of marine mammals that will occur as a result of the seismic survey, the National Science Foundation added 25 percent to the total proposed line kilometers to the seismic survey for their calculations of marine mammal exposures to sounds exceeding the ESA harassment and harm (MMPA Level A and Level B harassment) thresholds. All planned seismic data acquisition activities will be conducted by the National Science Foundation and researchers, with onboard assistance by technical staff and the marine operations group. The research vessel will be self-contained, and the scientific party and crew will live aboard the vessel for the entire seismic survey. The National Science Foundation's environmental analysis and Lamont-Doherty Earth Observatory's incidental harassment authorization application present more detailed information on the project.

3.1.2 Source Vessel Specifications

The seismic survey will involve one source vessel, the U.S.-flagged R/V *Marcus G. Langseth*. The R/V *Marcus G. Langseth* is owned by the National Science Foundation and operated by Columbia University's Lamont-Doherty Earth Observatory under an existing Cooperative Agreement. The R/V *Marcus G. Langseth* will tow a source airgun array as a sound source along predetermined lines. The R/V *Marcus G. 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). Its propulsion system consists of two diesel Bergen BRG-6 engines, each producing 3,550 horsepower, and an 800 horsepower bowthruster. The R/V *Marcus G. Langseth*'s design is that of a seismic research vessel, with a particularly quiet propulsion system to avoid interference with the seismic signals. The operating speed during seismic data acquisition is typically approximately 8 kilometers per hour (4.3 to 4.5 knots). During the two-dimensional seismic survey, the vessel speed will be approximately 7.8 kilometers per hour (4.2 knots) and approximately 8.3 kilometers per hour (4.5 knots) during the three-dimensional seismic survey. When not towing seismic survey gear, the R/V *Marcus G. Langseth* typically cruises at 18.5 kilometers per hour (10 knots) and has a range of approximately 13,500 kilometers (7,289.4 nautical miles). No chase vessel will be used during seismic survey activities. The R/V *Marcus G. Langseth* will also serve as the platform from which vessel-based protected species observers (acoustic and visual) will listen and watch for animals (e.g., marine mammals and sea turtles). See Table 1 for additional details regarding the R/V *Marcus G. Langseth*.

Table 1. Additional details of the R/V *Marcus G. Langseth*.

Research Vessel Specifications	
Owner	National Science Foundation
Vessel Operator	Lamont-Doherty Earth Observatory of Columbia University
Flag	United States of America
Gross Tonnage	2,842
Accommodation Capacity	55 including approximately 35 Scientists/Researchers

3.1.3 Airgun Array and Acoustic Receivers Description

The energy source for the seismic survey was chosen by the National Science Foundation to be the lowest practical to meet the scientific objectives.

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

The airgun array for the two-dimensional seismic survey will consist of 36 Bolt airguns (plus four spares) with a total discharge volume of 108,154.6 cubic centimeters (6,600 cubic inches) (Table 2). The airguns will be configured as four identical linear arrays or “strings”. The airgun array for the three-dimensional seismic survey will consist of two separate 18 airgun arrays with a total discharge volume of 54,077.3 cubic centimeters (3,300 cubic inches) that will fire alternately. Each string will have nine airguns plus one spare airgun (ten total) in case of failure of another airgun. All nine airguns in each string will be fired simultaneously. The four airgun strings will be towed behind the R/V *Marcus G. Langseth* and will be distributed across an area approximately 24 meters (78.7 feet) by 16 meters (52.5 feet). The shot interval will be approximately 16 to 17 seconds (approximately 37.5 meter [123 feet]) for the two-dimensional and three-dimensional seismic survey. The firing pressure of the airgun array will be approximately 1,900 pounds per square inch (psi) (plus or minus 100 psi). The four airgun strings will be towed approximately 30 meters (98 feet) behind the vessel at a tow depth of 10 to

12 meters (32.8 to 39.4 feet) for the two-dimensional seismic survey and 10 meters (32.8 feet) for the three-dimensional seismic survey. It is expected that the airgun array will be active 24 hours per day during the seismic survey. Airguns will operate continually during the seismic survey period except for unscheduled shut-downs. See Table 3 for the specifications of the R/V *Marcus G. Langseth*'s airgun array, trackline distances, and water depths associated with the seismic survey in the Northeast Pacific Ocean.

Table 2. Specifications of the source airgun array to be used by the R/V *Marcus G. Langseth* during the proposed seismic survey in the Northeast Pacific Ocean.

Source Airgun Array Specifications	
Energy Source – Number of Airguns	18 Bolt Airguns of 210 in^3 or less (1,900 psi) Two Strings of Nine Operating Airguns per String (Two Pairs of Two Strings Flip-Flop) 36 Bolt Airguns of 210 in^3 or less (1,900 psi) Four Strings of Nine Operating Airguns per String
Source Output (Downward) of 18 and 36 Airgun Array	Peak-to-Peak = 259 dB re: 1 µPa-m 0-to-Peak = 252 dB re; 1 µPa-m Peak-to-Peak = 265 dB re: 1 µPa-m 0-to-Peak = 250 dB re; 1 µPa-m
Tow Depth	10 to 12 m (32.8 to 39.4 ft)
Air Discharge Volume of 18 and 36 Airgun Array	Approximately 3,300 in^3 Approximately 6,600 in^3
Dominant Frequency Components	2 to 188 Hz
Pulse Duration	Approximately 0.1 Seconds
Shot Interval	Approximately 16 to 17 Seconds

in^3=cubic inches
psi=pounds per square inch
m=meters
ft=feet
Hz=Hertz

Table 3. Specifications of the R/V *Marcus G. Langseth*'s airgun arrays, trackline distances, and water depths associated with the two-dimensional and three-dimensional seismic survey in the Northeast Pacific Ocean.

	Two-Dimensional Seismic Survey	Three-Dimensional Seismic Survey
Energy Source – Number of	36 Airguns	18 Airguns

Airguns	Four Strings	Two Alternating Two-String Sub-Arrays
Source Output (Downward) of Airgun Array	Peak-to-Peak = 265 dB re: 1 µPa-m 0-to-Peak = 250 dB re: 1 µPa-m	Peak-to-Peak = 259 dB re: 1 µPa-m 0-to-Peak = 252 dB re: 1 µPa-m
Tow Depth	10 to 12 m	10 m
Air Discharge Volume	Approximately 6,600 in^3	Approximately 3,300 in^3
Dominant Frequency Components	2 to 188 Hz	2 to 188 Hz
Pulse Duration	0.1 seconds	0.1 seconds
Shot Interval	37.5 m	37.5 m
Sound Source Velocity (Tow Speed)	4.2 knots	4.5 knots
Water Depth	>1,000 m	>1,000 m
Trackline Distance	564 km	3,196 km

m=meters
in^3=cubic inches
Hz=Hertz
km=kilometer

The receiving system will consist of either four six-kilometer (3.2 nautical miles) long towed hydrophone streamers (for the three-dimensional seismic survey) and a single 15 kilometer (8.1 nautical miles) long towed hydrophone streamer (for the two-dimensional seismic survey), and ocean bottom seismometers. A longer hydrophone streamer provides opportunities to suppress unwanted energy that interferes with imaging targets, allows for accurate measurements of seismic velocities, and provides a large amount of data redundancy for enhancing seismic images during data processing. As the airgun array is towed along the tracklines, the hydrophone streamer will receive the returning acoustic signals and transfer the data to the onboard processing system. The ocean bottom seismometers will receive and store the returning acoustic signals internally for later analysis.

During the seismic survey, the R/V *Marcus G. Langseth* will deploy up to eight ocean bottom seismometers. The ocean bottom seismometers will be deployed upon arrival in the seismic survey area. The ocean bottom seismometers are long-term broadband instruments that will remain on the ocean floor for approximately one year and recovered by another research vessel (yet to be determined). See Table 4 for specification of the ocean bottom seismometers to be used during the proposed seismic survey in the Northeast Pacific Ocean.

Table 4. Specifications for the ocean bottom seismometers to be used during the proposed seismic survey in the Northeast Pacific Ocean.

Dimensions	Ocean Bottom Seismometers
Height	1 m
Diameter	1 m
Anchor Description	NA
Anchor Dimensions	NA
Anchor Weight	80 kg (176.4 lb)

NA=not available
m=meter
kg=kilogram
lb=pounds

To retrieve an ocean bottom seismometer placed on the sea floor, an acoustic release transponder (pinger) transmits a signal to the instrument at a frequency of 8 to 11 kiloHertz and a response is received at a frequency of 11.5 to 13 kiloHertz (operator selectable), to activate and release the instrument. The transmitting beam pattern is 55 degrees. The sound source level is approximately 93 dB. The pulse duration is 2 milliseconds (±10 percent) and the pulse repetition rate is one per second (±50 microseconds). The transponder will trigger the burn-wire assembly that releases the instrument from the anchor on the sea floor and the device floats to the surface. The anchor for the ocean bottom seismometer is scuttled and left on the sea floor.

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

Along with operations of the airgun array, three additional acoustical data acquisition systems will operate during the seismic survey from the R/V *Marcus G. Langseth*. The Kongsberg EM 122 multi-beam echosounder and Knudsen Chirp 3260 sub-bottom profiler will map the ocean floor during the seismic survey. The Teledyne RDI 75 kiloHertz Ocean Surveyor acoustic Doppler current profiler will measure water current velocities. The multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler sound sources will operate continuously from the R/V *Marcus G. Langseth*, including simultaneously with the airgun array, but not during transit to and from the seismic survey area.

3.1.4.1 Multi-Beam Echosounder

The ocean floor will be mapped with the Kongsberg EM122 multi-beam echosounder. The multi-beam echosounder is a hull-mounted system operating at 10.5 to 13 (usually 12) kiloHertz. The transmitting beamwidth is one or two degrees fore-aft and 150 degrees (maximum) athwartship (i.e., perpendicular to the ship's line of travel). The maximum sound source level is 242 dB re: 1 µPa at 1 meter (root mean square [rms]). Each ping consists of eight (in water greater than 1,000 meters [3,281 feet]) or four (in water less than 1,000 meters [3,281 feet]) successive fan-shaped transmissions, each ensonifying a sector that extends one degree fore-aft.

Continuous-wave signals increase from 2 to 15 milliseconds long in water depths up to 2,600 meters (8,530 feet), and frequency modulated chirp signals up to 100 milliseconds long are used in water greater than 2,600 meters (8,530 feet). The successive transmissions span an overall cross-track angular extent of about 150 degrees, with two millisecond gaps between the pings for successive sectors.

3.1.4.2 Sub-Bottom Profiler

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

3.1.4.3 Acoustic Doppler Current Profiler

The Teledyne RDI 75 kiloHertz Ocean Surveyor acoustic Doppler current profiler will be mounted on the hull of the R/V *Marcus G. Langseth* to measure the speed of the water currents. The acoustic Doppler current profiler will operate at a frequency of 75 kiloHertz and a maximum sound source level of 224 dB re: 1 µPa at 1 meter (rms) over a conically-shaped 30 degree beam.

3.1.5 Mitigation and Monitoring

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

NMFS Permits and Conservation Division will require and the National Science Foundation and Lamont-Doherty Earth Observatory will implement the mitigation and monitoring measures listed below. These mitigation and monitoring measures are required during the seismic survey to reduce potential for injury or harassment to marine mammals and sea turtles. Additional detail for each mitigation and monitoring measure is described in subsequent sections of this opinion:

- Proposed exclusion and buffer zones;
- Power-down procedures;
- Shut-down procedures;
- Ramp-up procedures;

- Visual monitoring by NMFS-approved protected species observers;
- Passive acoustic monitoring;
- Vessel strike avoidance measures; and
- Additional mitigation measures considered.

We discuss the proposed exclusion and buffer zones in more detail in the next section (see below). Additional details for the other mitigation and monitoring measures (e.g., power-down, shut-down, and ramp-up procedures can be found in NMFS Permits and Conservation Division *Federal Register* notice of proposed incidental harassment authorization and request for comments on proposed incidental authorization and possible renewal (84 FR 26940 to 26978) and Appendix A (Section 19.1).

3.1.5.1 Proposed Exclusion and Buffer Zones – Ensonified Area

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

Ensonified Area

Lamont-Doherty Earth Observatory model results are used to determined the 160 dB re: 1 µPa (rms) radius for single 40 cubic inch airgun array, 18 airgun array, and 36 airgun array in deep water (greater than 1,000 meters [3,280.8 feet]) down to a maximum water depth of 2,000 meters (6,561.7 feet). Received sound levels were predicted by Lamont-Dohert Earth Observatory's model (Diebold et al. 2010), which uses ray tracing for the direct wave traveling from the airgun array to the receiver and its associated source ghost (i.e., reflection at the air-water interface in the vicinity of the airgun array), in a constant-velocity half-space (infinite homogeneous ocean layer, unbounded by a seafloor). In 2003, empirical data concerning 190, 180, and 160 dB re: 1 µPa (rms) distances were acquired during the acoustic calibration study of the R/V *Maurice Ewing*'s airgun array in a variety of configurations in the northern Gulf of Mexico (Tolstoy 2004). In addition, propagation measurements of pulses from the R/V *Marcus G. Langseth*'s 36 airgun array at a tow depth of 6 meters (19.7 feet) have been reported in deep water (approximately 1,600 meters [5,249.3 feet]), intermediate water depth on the slope (approximately 600 to 1,100 meters [1,968.5 to 3,608.9 feet]), and shallow water (approximately 50 meters [164 feet]) in the Gulf of Mexico in 2007 through 2008 (Diebold et al. 2010; Tolstoy et al. 2009). Results of the propagation measurements (Tolstoy et al. 2009) showed that radii around the airguns for various received levels varied with water depth. However, the depth of the

airgun array was different in the Gulf of Mexico calibration study 6 meters [19.7 feet]) from in the proposed seismic survey activities (10 to 12 meters [32.8 to 39.4 feet]). Because propagation varies with airgun array depth, correction factors have been applied to the distances reported by Tolstoy et al. (2009).

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

In deep and intermediate water depths, comparisons at short ranges between sound levels for direct arrivals recorded by the calibration hydrophone and model results from the same airgun array tow depth are in good agreement. Consequently, isopleths falling within this domain can be predicted reliably by the Lamont-Doherty Earth Observatory model, although they may be imperfectly sampled by measurements recorded at a single depth. At greater distances, the calibration data show that seafloor-reflected and sub-seafloor-refracted arrivals dominate, whereas the direct arrivals become weak and/or incoherent. Aside from local topography effects, the region around the critical distance is where the observed levels rise closest to the model curve. However, the observed sound levels are found to fall almost entirely below the model curve. Thus, analysis of the Gulf of Mexico calibration measurements demonstrates that although simple, the Lamont-Doherty Earth Observatory model is a robust tool for conservatively estimating isopleths. For deep water depths (greater than 1,000 meters [3,280.8 feet]), Lamont-Doherty Earth Observatory used the deep water radii obtained from model results down to a maximum water depth of 2,000 meters (6,561.7 feet).

Measurements have not been reported for the single 40 cubic inch airgun array. Lamont-Doherty Earth Observatory model results are used to determine the 160 dB re: 1 µPa (rms) radius for the single 40 cubic inch airgun array at a tow depth of 12 meters (39.4 feet) in deep water. The estimated distances to the 160, 175, and 195 dB re: 1 µPa (rms) isopleths for the single 40 cubic inch airgun array, 18 airgun array, and 36 airgun array are in Table 6 and Table 7.

Establishment of Proposed Exclusion and Buffer Zones

An exclusion zone is a defined area within which occurrence of a marine mammal triggers mitigation action intended to reduce the potential for certain outcomes (e.g., auditory injury, disruption of critical behaviors). Protected species observers will establish a default (minimum) exclusion zone with a 500 meter (1,640.4 feet) radius for visual monitoring for the 18 and 36

airgun arrays. The 500 meter (1,640.4 feet) exclusion zone will be based on the radial distance from any element of the airgun array (rather than being based on the center of the airgun array or around the vessel itself). With certain exceptions (described below), if a marine mammal appears within, enters, or appears on course to enter this zone, the airgun array will be powered-down or shut-down, depending on the circumstance.

The 500 meter (1,640.4 feet) exclusion zone is intended to be precautionary in the sense that it will be expected to contain sound exceeding the injury criteria for all cetacean hearing groups (based on the dual criteria of SEL_{cum} and peak SPL), while also providing a consistent, reasonably observable zone within which protected species observers will typically be able to conduct effective observational effort. Additionally, a 500 meter (1,640.4 feet) is 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 NMFS Permits and Conservation Division believes that 500 meter (1,640.4 feet) is likely regularly attainable for protected species observers using the naked eye during typical conditions.

Table 5. Predicted distances to permanent threshold shift thresholds for impulsive sources for various marine mammal hearing groups that could be received from the single airgun as well as the 18- and 36-airgun arrays during the proposed seismic survey in the Northeast Pacific Ocean.

Threshold	Low Frequency Cetaceans (m)	Mid Frequency Cetaceans (m)	High Frequency Cetaceans (m)	Phocid Pinnipeds (m)	Otariid Pinnipeds (m)
Source – 1 Airgun					
SEL_{cum}	0.5	0	0	0	0
Peak SPL_{flat}	1.76	0.51	12.5	1.98	0.4
Source – 18 Airgun Array					
SEL_{cum}	75.6	0	0.3	2.9	0
Peak SPL_{flat}	23.2	11.2	118.7	25.1	9.9
Source – 36 Airgun Array					
SEL_{cum}	426.9	0	1.3	13.9	0
Peak SPL_{flat}	38.9	13.6	268.3	43.7	10.6

m=meters
NA=Not available or not assessed

The National Science Foundation's draft environmental analysis and Lamont-Doherty Earth Observatory's incidental harassment authorization application have a detailed description of the modeling for the R/V *Marcus G. Langseth*'s airgun arrays as well as the resulting isopleths to

thresholds for the various marine mammal hearing groups and sea turtles (Table 6). Predicted distances to harm (MMPA Level A harassment) isopleths, which vary based on marine mammal hearing groups, were calculated based on modeling performed by Lamont-Doherty Earth Observatory using the NUCLEUS software program and the NMFS User Spreadsheet (https://www.fisheries.noaa.gov/action/user-manual-optional-spreadsheet-tool-2018-acoustic-technical-guidance). The 160 dB re: 1 µPa (rms) isopleth is the distance at which ESA harassment (take by MMPA Level B harassment) is expected to occur (see Table 6). The 175 dB re: 1 µPa (rms) isopleth represents our best understanding of the threshold at which sea turtles exhibit behavioral responses to seismic airgun arrays (see Table 7). The 195 dB re: 1 µPa (rms) isopleth will be the exclusion zone distance for sea turtles (see Table 7).

Table 6. Predicted distances to which sound levels of 160 re: 1 µPa (rms) for Marine Mammal Protection Act Level B harassment for impulsive sources will be received from the single 40 cubic inch airgun as well as the 18- and 36-airgun arrays in water depths greater than 1,000 meters for marine mammals during the proposed seismic survey in the Northeast Pacific Ocean.

Source	Volume (in^3)	Water Depth (m)	Predicted Distance to Threshold (160 dB re: 1 µPa [rms]) (m)
1 Airgun	40	>1,000	431
18 Airguns	3,300	>1,000	3,758
36 Airguns	6,600	>1,000	6,733

in^3=cubic inches
m=meters

Table 7. Predicted distances to which sound levels of 175 and 195 dB re: 1 µPa (rms) will be received from the single 40 cubic inch airgun as well as the 18- and 36-airgun array in water depths greater than 1,000 meters for sea turtles during the proposed seismic survey in the Northeast Pacific Ocean.

Source	Volume (in^3)	Water Depth (m)	Predicted Distance to Threshold (175 dB re: 1 µPa [rms]) (m)	Predicted Distance to Threshold (195 dB re: 1 µPa [rms]) (m)*
1 Airgun	40	>1,000	77	8
18 Airguns	3,300	>1,000	814	76
36 Airguns	6,600	>1,000	1,864	181

in^3=cubic inches
m=meters
*The 195 dB re: 1 µPa (rms) threshold will be used as the exclusion zone for sea turtles based upon estimated criteria for PTS.
Note: The National Science Foundation and Lamont-Doherty Earth Observatory will use a 100 meter exclusion zone for the 18 airgun array and 181 meter exclusion zone for the 36 airgun array as the shut-down distance for sea turtles.

3.1.5.2 Shut-Down and Power-Down Procedures

The shut-down of the airgun array requires the immediate de-activiation of all individual elements of the airgun array while a power-down of the airgun array requires the immediate de-activiation of all individual elements of the airgun aray excep the single 40 cubic inch airgun. Any protected species observer on duty will have the authority to delay the start of seismic survey activities or to call for shut-down or power-down of the airgun array if a marine mammal is detected within the applicable exclusion zone. The operator must also establish and maintain clear lines of communication directly between protected species observers on duty and crew controlling the airgun array to ensure that shut-down and power-down commands are conveyed swiftly while allowing protected species observers to maintain watch. When both visual and acoustic protected species observers are on duty, all detections will be immediately communicated to the remainder of the on-duty protected species observer team for potential verification of visual observations by the acoustic protected species observer or of acoustic detections by visual protected species observers. When the airgun array is active (i.e., anytime one or more airgun is active, including during ramp-up and power-down) and (1) a marine mammal appears within or enters the applicable exclusion zone and/or (2) a marine mammal (other than delphinds) is detected acoustically and localized witinthe applicable exclusion zone, the airgun array will be shut-down. When shut-down is called for by a protected species observer, the airgun array will be immediately deactivated and any dispute resolved only following deactivation. Additionally, shut-down will occur whenever passive acoustic monitoring alone (without visual sighting), confirms presence of marine mammal(s) in the exclusion zone. If the acoustic protected species observer cannot confirm presence within the exclusion zone, visual protected species observers will be notified but shut-down is not required.

Following a shut-down, airgun aray activity will not resume until the marine mammal has cleared the 500 meter (1,640.4 feet). The animal will be considered to have cleared the 500 meter (1,640.4 feet) exclusion zone if it is visually observed to have departed the 500 meter (1,640.4 feet) exclusion zone, or it has not been seen within the 500 meter (1,640.4 feet) exclusion zone, or if has not been seen within the 500 meter (1,640.4 feet) exclusion zone for 15 minutes in the case of small odontocetes and pinnipeds, or 30 minutes in the case of mysticetes and large odontocetes, including sperm whales.

The shut-down requirement can be waived for small dolphins in which case the airgun array will be powered-down to the single 40 cubic inch airgun array if an individual is visually detected within the exclusion zone. As defined here, the small delphinoid group is intended to encompass those members of the Family Delphinidae most likely to voluntarily approach the sound source vessel for purposes of interacting with the vessel and/or airgun array (e.g., bow riding). This exception to the shut-down requirement will apply solely to specific genera of small dolphins (*Tursiops*, *Delphinus*, *Stenella*, *Lagenorhynchus*, and *Lissodelphis*). The airgun array will be powered-down to a single 40 cubic inch airgun array if an individual belonging to these genera is visually detected within the 500 meter (1,640.4 feet) exclusion zone.

Power-down conditions will be maintained until delphinids for which shut-down is waived are no longer observed within the 500 meter (1,640.4 feet) exclusion zone, following which full-power operations may be resumed without ramp-up. Visual protected species observers may elect to waive the power-down requirement if delphinids for which shut-down is waived to be voluntarily approaching the vessel for the purpose of interacting with the vessel or towed gear, and may use best professional judgement in making this decision.

The NMFS Permits and Conservation Division include this small delphinoid exception because power-down and/or shut-down rquirements for small delphinoids under all circumstances represent practiability concerns without likely commensurate benefits for the animals in question. Small delphinoids are generally the most commonly observed marine mammals in the specific geographic region and will typically be the only marine mammals likely to intentionally approach the vessel. As describe above, auditory injury is extremely unlikely to occur for mid-frequency cetaceans (e.g., 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).

A large body of anecdotal evidence indicates that small delphinoids commonly approach vessels and/or towed airgun arrays during active sound production for purposes of bow riding, with no apparent effect observed in those delphinoids (Barkaszi et al. 2012a). The potential for increased shut-downs resulting from such a measure will require the R/V *Marcus G. Langseth* to revisit the missed trakcline to reacquire data, resulting in an overall increase in the total sound energy input to the marine environment and an increase in the total duration over which the seismic survey activities is active in a given area. Although other mid-frequency hearing specialists (e.g., large delphinoids) are no more likely to incur auditory injury than are small delphinoids, they are much less likely to approach vessels. Therefore, retaining a power-down and/or shut-down requirement for large delphinoids will not have similar impacts in terms of either practicability for the applicant or corollary increase in sound energy output and time on the water. The NMFS Permits and Conservation Division anticipates some benefit for a power-down and/or shut-down requirement for large delphinoids in that it simplifies somewhat the total range of decision-making for protected species observers and may preclude any potential for physiological effects other than to the auditory system as well as some more severe behavioral reactions for any such animals in close proximity to the sound source vessel.

Power-down conditions will be maintained until the marine mammal(s) of the above listed genera are no longer observed within the exclusion zone, following which full-power airgun array operations may be resumed without ramp-up. Additionally, visual protected species observers may elect to waive the power-down requirement if the small dolphin(s) appear to be voluntarily approaching the vessel for the purpose of interacting with the vessel or towed gear, and may use best professional judgement in making this decision. Visual protected species observers will use best professional judgement in making the decision to call for a shut-down if there is uncertainty regarding identification (i.e., whether the observed marine mammal[s]

belongs to one of the delphinid genera for which shut-down is waived or one of the species with a larger exclusion zone). If protected species observers observe any behaviors in a small delphinid for which shut-down is waived that indicate an adverse reaction, then power-down will be initiated immediately.

Upon implementation of shut-down, the airgun array may be reactivated after the marine mammal(s) has been observed exiting the applicable exclusion zone (i.e., animal is not required to fully exit the buffer zone where applicable) or following 15 minutes for small odontocetes and 30 minutes for all other species with no further observation of marine mammal(s).

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

- The airgun array will be shut-down if a North Pacific right whale is observed at any distance.
- The airgun array will be shut-down if any large whale (defined as a sperm whale or any mysticete [baleen whale] species with a calf (defined as an animal less than two-thirds the body size of an adult observed to be in close association with an adult) or an aggregation of six or more large whales is observed at any distance.

3.1.5.3 Pre-Clearance and Ramp-Up Procedures

Ramp-up (sometimes referred to as "soft-start") means the gradual and systematic increase of emitted sound levels from an airgun array. Ramp-up begins by first activating a single airgun of the smallest volume, followed by doubling the number of active elements in stages until the full complement of an airgun array are active. Each stage will be approximately the same duration, and the total duration will not be less than approximately 20 minutes. The intent of pre-clearance observation (30 minutes) is to ensure no protected species are observed within the buffer zone prior to the beginning of ramp-up. During pre-clearance is the only time observatios of protected species in the buffer zone will prevent operations (i.e., the beginning of ramp-up). The intent of ramp-up is to warn protected sepcies of pending seismic survey activities and to allow sufficient time for those animals to leave the immediate vicinity. A ramp-up procedure, involving a step-wise increase in the number of airguns firing and total airgun array volume until all operational airguns are activated and the full volume is achieved, is required at all times as part of the activation of the airgn array. All operators must adhere to the following pre-clearance and ramp-up requirements:

- The operator must notify a designated protected species observer of the planned start of ramp-up as agreed upon with the lead protected species observer; the notification time will not be less than 60 minutes prior to the planned ramp-up in order to allow the protected species observer time to monitor the exclusion and buffer zones for 30 minutes prior to the initiation of ramp-up (pre-clearance);
- Ramp-ups will be scheduled so as to minimize the time spent with the airgun array activated prior to reaching the designated run-in;

- One of the protected species observers conducting pre-clearance observations must be notified again immediately prior to initiating ramp-up procedures and the operator must receive confirmation from the protected species observer to proceed;
- Ramp-up may not be initiated if any marine mammals is within the applicable exclusion or buffer zone. If a marine mammal is observed withinthe applicable exclusion zone or the buffer zone during the 30 minute pre-clearance period, ramp-up may not begin until the animal(s) has been observed exiting the zones or until an additional time period has elapsed with no further sightings (15 minutes for small odontocetes and 30 minutes for all other species).
- Ramp-up will begin by activating a single airgun array of the smallest volume in the airgun array and will continue in stages by doubling the number of active elements at the commencement of each stage, with each stage of approximately the same duration. Duration will not be less than 20 minutes. The operator must provide information to the protected species observer documenting that appropriate documenting that appropriate procedures were followed;
- Protected species observers must monitor the exclusion and buffer zones during ramp-up, and ramp-up must cease and the airgun array must be shut-down upon observation of a marine mammals within the applicable exclusion zone. Once ramp-up has begun, observations of marine mammals within the buffer zone do not require shut-down or power-down, but such observation will be communicated to the operator to prepare for the potential shut-down or power-down;
- 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. Airgun array activation may only occur at times of poor visibility where operational planning cannot reasonably avoid such circumstances;
- If the airgun array is shut-down for brief periods (i.e., less than 30 minutes) for reasons other than that described for shut-down and power-down (e.g., mechanical difficulty), it may be activated again without ramp-up if protected species observers have maintained constant visual and/or passive acoustic monitoring and no visual or acoustic detections of marine mammals have occurred within the applicable exclusion zone. For any longer shut-down, pre-clearance observation and ramp-upr are required. For any shut-down at night or in periods of poor visibility (e.g., Beaufort sea state4 or greater), ramp-up is required, but if the shut-down period was brief and constant observation was maintained, pre-clearance watch of 30 minutes is not required; and
- Testing of the airgun array involving all elements requires ramp-up. Testing limited to individual elements or strings of the airgun array does not require ramp-up but does require pre-clearance of 30 minutes.

3.1.5.4 Vessel-Based Visual Mitigation Monitoring

Visual monitoring requires the use of trained protected species observers to scan the ocean surface visually for the presence of marine mammals. The area to be scanned visually includes primarily the exclusion zone, but also the buffer zone. The buffer zone means an area beyond the exclusion zone to be monitored for the presence of marine mammals and sea turtles that may enter the exclusion zone. During pre-clearance monitoring (i.e., before ramp-up begins), the buffer zone also acts as an extension of the exclusion zone in that observations of marine mammals within the buffer zone will also prevent airgun array operations from beginning (i.e., ramp-up). The buffer zone encompasses the area at and below the sea surface from the edge of the 0 to 500 meter (0 to 1,640.4 feet) exclusion zone, out to a radius of 1,000 meters (3,280.8 feet) from the edges of the airgun array (500 to 1,000 meters [1,640.4 to 3,280.8 feet]). Visual monitoring of the exclusion znoe and adjacent waters is intended to establish and, when visual conditions allow, maintain zones around the sound source that are clear of marine mammals and sea turtles, thereby reducing or eliminating the potential for injury and minimizing the potential for more severe behavioral reactions for animals occurring close to the vessel. Visual monitoring of the buffer zone is intended to (1) provide additional protection to naïve marine mammals that may be in the area during pre-clearance; and (2) during use of the airgun array, aid in establishing and maintaining the exclusion zone by alerting the visual protected species observer and crew of marine mammals and sea turtles that are outside of, but may approach and enter, the exclusion zone.

The National Science Foundation and Lamont-Doherty Earth Observatory must use at least five dedicated, trained, NMFS-approved protected species observers. The protected species observers must have no tasks other than to conduct observational effort, record observational data, and communicate with and instruct relevant vessel crew with regard to the presence of marine mammals and mitigation requirements. Protected species observer resumes shall be provided to NMFS for approval.

At least one of the visual and two of the acoustic protected species observers 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 protected species observer with such experience shall be designated as the lead for the entire protected species observer team. The lead protected species observer shall serve as the primary point of contact for the vessel operator and ensure all protected species observer requirements per the MMPA incidental harassment authorization are met. To the maximum extent practicable, the experienced protected species observers will be scheduled to be on duty with those protected species observers with appropriate training but who have not yet gained relevant experience.

During seismic survey activities (e.g., any day on which use of the airgun array is planned to occur, and whenever the airgun array is in the water, whether activated or not), a minimum of two visual protected species observers must be on duty and conducting visual observations at all

times during daylight hours (i.e., from 30 minutes prior to sunrise through 30 minutes following sunset) and 30 minutes prior to and during nighttime ramp-ups of the airgun array. Visual monitoring of the exclusion and buffer zones must begin no less than 30 minutes prior to ramp-up and must continue until one hour after use of the airgun array ceases or until 30 minutes pas sunset. Visual protected sepcies observers shall coordinate to ensure 360 degree visual coverage around the vessel from the most appropriate eobservation posts, and shall conduct visual observations using binoculars and the naked eye while free from distractions and in a consistent, systematic, and diligent manner.

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

During use of the airgun array (i.e., anytime the airgun array is active, including ramp-up), occurrences of marine mammals within the buffer zone (but outside the exclusion zone) will be communicated to the operator to prepare for the potential shut-down or power-down of the airgun array. Visual protected species observers will immediately communicate all observations to the on-duty acoustic protected species observer(s), including any determination by the protected species observer regarding species identification, distance, and bearing and the degree of confidence in the determination. Any observations of marine mammals and sea turtles by crew members will be relayed to the protected species observer team. During good conditions (e.g., daylight hours, Beaufort sea state three or less), visual protected species observers will conduct 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 protected species observers may be on watch for a maximum of four consecutive hours followed by a break of at least one hour between watches and may conduct a maximum of 12 hours of observation per 24-hour period. Combined observational duties (visual and acoustic, but not at the same time) may not exceed 12 hours per 24-hour period for any individual protected species observer.

3.1.5.5 Passive Acoustic Monitoring

Passive acoustic monitoring means the use of trained personnel operators, herein referred to as acoustic protected species observers to operate passive acoustic monitoring equipment to acoustically detect the presence of marine mammals. Passive acoustic monitoring involves acoustically detecting marine mammals, regardless of distance from the airgun array, as localization of animals may not always be possible. Passive acoustic monitoring is intended to further support visual monitoring (during daylight hours) in maintaining an exclusion 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), passive acoustic monitoring may be used to allow certain activities to occur, as further detailed below.

Passive acoustic monitoring will take place in addition to the visual monitoring program. Visual monitoring typically is not effective during periods of poor visibility or at night, and even with good visibility, is unable to detect marine mammals when they are below the surface or beyond visual range. Passive acoustic monitoring can be used in addition to visual observations to improve detection, identification, and localization of cetaceans. The passive acoustic monitoring will serve to alert visual protected species observers (if on duty) when vocalizing cetaceans are detected. It is only useful when marine mammals call, but it can be effective either by day or night, and does not depend on good visibility. It will be monitored in real time so that the visual protected species observers can be advised when cetaceans are detected.

The R/V *Marcus G. Langseth* will use a towed passive acoustic monitoring system, which must be monitored by a minimum one on duty acoustic protected species observer beginning at least 30 minutes prior to ramp-up and at all times during use of the airgun array. Acoustic protected species observers may be on watch for a maximum of four consecutive hours followed by a break of at least one hour between watches and may conduct a maximum of 12 hours of observation per 24-hour period for any individual protected species observer.

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

- Beaufort sea state is less than or equal to four;
- No marine mammals (excluding delphinids) detected solely by passive acoustic monitoring in the applicable exclusion zone in the previous two hours;
- NMFS is notified via email as soon as practicable with the time and location in which operations began occurring without an active passive acoustic monitoring system; and
- Operations with an active airgun array, but without an operating passive acoustic monitoring system, do not exceed a cumulative total of four hours in any 24-hour period.

3.1.5.6 Vessel Strike Avoidance

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

- The vessel operator (R/V *Marcus G. Langseth*) and crew will maintain a vigilant watch for all marine mammals and sea turtles and slow down or stop or alter course of the

vessel, as appropriate and regardless of vessel size, to avoid striking any marine mammal and sea turtle during seismic survey activities as well as transits. A single marine mammal at the surface may indicate the presence of submerged animals in the vicinity of the vessel; therefore, precautionary measures should be exercised when an animal is observed. A visual observer aboard the vessel will monitor a vessel strike avoidance zone around the vessel (specific distances detailed below), to ensure the potential for vessel strike is minimized, according to the parameters stated below. Visual observers monitoring the vessel strike avoidance zone can be either third-party protected species observers or crew members, but crew members responsible for these duties will be provided sufficient training to distinguish marine mammals and sea turtles from other phenomena and broadly to identify a marine mammal and sea turtles to broad taxonomic group (i.e., as a large whale or other marine mammal).

- Vessel speeds must be reduced to 18.5 kilometers per hour (10 knots) or less when mother/calf pairs, pods, or large assemblages of marine mammals are observed near the vessel.
- The vessel (R/V *Marcus G. Langseth*) will maintain a minimum separation distance of 100 meter (328.1 feet) from large whales (i.e., all baleen whales and sperm whales).
- The vessel will maintain a minimum separation distance of 50 meter (164 feet) from all other marine mammals, with an exception made for animals that approach the vessel.
- When marine mammals are sighted while a vessel is underway, the vessel must take action as necessary to avoid violating the relevant separation distance. If marine mammals are sighed 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 recommendation does not apply to any vessel towing gear.

The following avoidance measures will be taken if a sea turtle is close to the vessel (R/V *Marcus G. Langseth*):

- When sea turtles are sighted, attempts to maintain a distance of 45 meters (147.6 feet) or greater whenever possible will be undertaken.

3.1.5.7 Additional Mitigation Measures Considered

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

Sound Source

The National Science Foundation considered and evaluated whether the research objectives could be met with a smaller sound source for the proposed seismic survey. The National Science Foundation determined that the scientific objectives for the proposed seismic surveys could not be met using smaller sound sources. During the two-dimensional seismic survey, a strong

reflection sound source is important in order to fully image the bottom of the magma chamber. For the three-dimensional seismic survey, the sound source is reduced from the 36 airgun array to 18 airgun array, which is needed to create a detailed three-dimensional geologic image at depth.

Location and Timing

The principal investigators worked with the National Science Foundation and Lamont-Doherty Earth Observatory to considering potential times to carry out the proposed seismic surveys, key factors taken into consideration included environmental conditions (i.e., the seasonal presence of marine mammals, sea turtles, and sea birds), weather conditions, equipment, and optimal timing for other proposed seismic surveys using the R/V *Marcus G. Langseth*.

Few marine mammal species are expected to occur in the seismic survey area, which is offshore. Some migratory baleen whales are likely more common in the region during the summer, but most animals are expected to occur closer to shore.

3.2 National Marine Fisheries Service's Proposed Activities

On December 21, 2018, NMFS Permits and Conservation Division received a request from the National Science Foundation and Lamont-Doherty Earth Observatory for an incidental harassment authorization to take marine mammals incidental to conducting a high-energy marine seismic survey in the Northeast Pacific Ocean. On May 3, 2019, NMFS Permits and Conservation Division deemed the National Science Foundation and Lamont-Doherty Earth Observatory's application for an incidental harassment authorization to be adequate and complete. The National Science Foundation and Lamont-Doherty Earth Observatory's request is for take of a small number of 26 species of marine mammals by MMPA Level A and Level B harassment. Neither the National Science Foundation, Lamont-Doherty Earth Observatory, nor NMFS Permits and Conservation Division expects serious injury or mortality to result from the proposed activities, therefore, an incidental harassment authorization is appropriate. The planned seismic survey is not expected to exceed one year; hence, the NMFS Permits and Conservation Division does not expect subsequent MMPA incidental harassment authorizations will be issued for this proposed action. The incidental harassment authorization will be valid for a period of one year from the date of issuance. The NMFS Permits and Conservation Division proposes to issue the incidental harassment authorization after July 10, 2019, so that the National Science Foundation and Lamont-Doherty Earth Observatory's will have the incidental harassment authorization prior to the start of the proposed seismic survey activities. Because the National Science Foundation and Lamont-Doherty Earth Observatory has tentatively scheduled the proposed seismic survey to begin on July 11, 2019 and has requested that the incidental harassment authorization be issued by July 11, 2019, the NMFS Permits and Conservation Division has requested the consultation be completed by July 10, 2019.

3.2.1 National Marine Fisheries Service's Proposed Incidental Harassment Authorization

The NMFS Permits and Conservation Division is proposing to issue an incidental harassment authorization authorizing non-lethal "takes" by MMPA Level A and Level B harassment of marine mammals incidental to the planned seismic survey. The incidental harassment authorization be valid for a period of one year from the date of issuance. The incidental harassment authorization will authorize the incidental harassment of the following threatened and endangered species: blue whale (*Balaenoptera musculus*), fin whale (*Balaenoptera physalus*), Central America distinct population segment (DPS) of humpback whale (*Megaptera novaeangliae*), Mexico DPS of humpback whale, sei whale (*Balaenoptera borealis*), sperm whale (*Physeter macrocephalus*), and Guadalupe fur seal (*Arctocephalus townsendi*). The proposed incidental harassment authorization identifies requirements that the National Science Foundation must comply with as part of its authorization. The NMFS Permits and Conservation Division does not expect the National Science Foundation's planned seismic survey to exceed one year and do not expect subsequent MMPA incidental harassment authorizations will be issued for this particular specified activity.

On June 10, 2019, NMFS Permits and Conservation published a notice of proposed incidental harassment authorization and request for comments on proposed incidental harassment authorization and possible renewal in the *Federal Register* (84 FR 26940 to 26978). The public comment period closed on July 10, 2019. Appendix A (see Section 19.1) contains the proposed incidental harassment authorization. The text in Appendix A (see Section 19.1) was taken directly from the proposed incidental harassment authorization provided to us in the consultation initiation package.

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

- A request for renewal is received no later than 60 days prior to expiration of the current incidental harassment authorization;
- The request for renewal must include the following: (1) an explanation that the activities to be conducted under the proposed renewal are identical to the activities analyzed under the initial incidental harassment authorization, are a subset of the activities, or include changes so minor (e.g., reduction in pile size) that changes do not affect the previous analyses, mitigation and monitoring requirements, or take estimates (with the exception of reducing the type or amount of take because only a subset of the initially analyzed activities remain to be completed under the renewal); and (2) a preliminary monitoring report showing the results of the required monitoring to date and an explanation showing

that the monitoring results do not indicate impacts of a scale or nature not previously analyzed or authorized.

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

3.2.2 National Marine Fisheries Service's Revisions to Proposed Incidental Harassment Authorization

The NMFS Permits and Conservation Division's has made revisions to the proposed incidental harassment authorization since the notice was published in the *Federal Register* on June 10, 2019 (84 FR 26940 to 26978). The revisions are based on public comments received from the Marine Mammal Commission. The revisions to the proposed incidental harassment authorization include modifications to the incidental take estimates of marine mammals (sei whales and Guadalupe fur seals) as well as additional mitigation measures (shut-down procedures for North Pacific right whales observed at any distance, and shut-down procedures if any large whale [any mysticete species or sperm whale] with a calf or an aggregation of six or more large whales observed at any distance).

4 ACTION AREA

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

The proposed action will take place in the Northeast Pacific Ocean, between approximately 45.5 to 46.5 degrees North, and 129.5 to 130.5 degrees West. The seismic survey will take place in International Waters outside of the U.S. Exclusive Economic Zone (approximately 370.1 kilometers [230 miles] from shore at its closest point off the coast of Washington and Oregon), in water depths from 1,400 to 2,800 meters (4,593.2 to 9,186..4 feet). Representative tracklines are shown in Figure 1. The representative tracklines shown in Figure 1 have a total length of approximately 3,760 kilometers (2,030.2 nautical miles). Some minor deviation of the tracklines, including the order of operations, may occur for reasons such as science drivers, poor data quality, inclement weather, or mechanical issues with the equipment and/or research vessel. The tracklines can occur anywhere within the coordinates noted in Figure 1. The action area will also include the area covered by the R/V *Marcus G. Langseth* while transiting from its port to the seismic survey area, and its return at the conclusion of the seismic survey. The R/V *Marcus G. Langseth* is expected to leave and return to the port of Astoria, Oregon. The port locations may be subject to change. We do not anticipate any effects outside the area shown on the map in Figure 1.

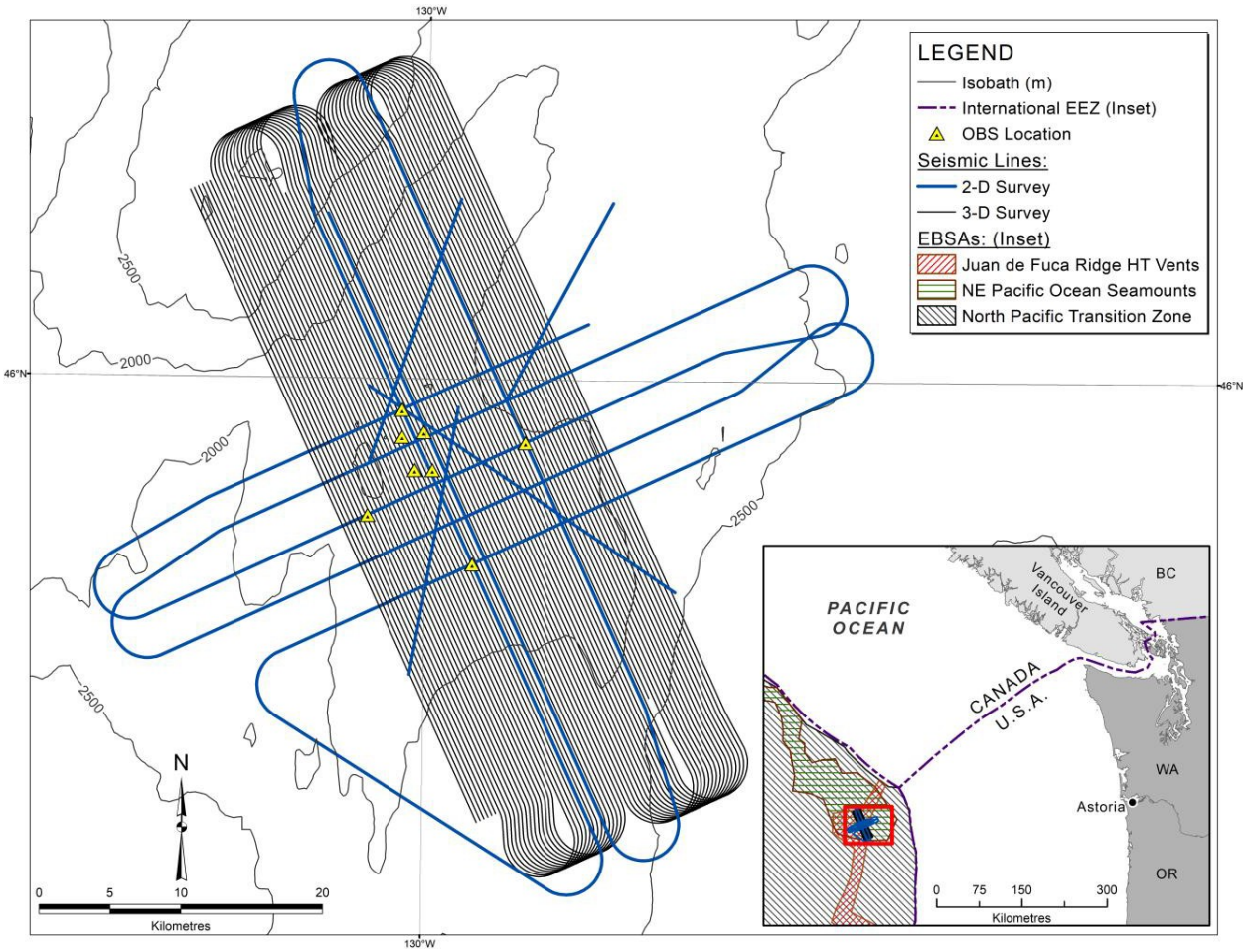

Figure 1. Map of the National Science Foundation and Lamont-Doherty Earth Observatory's high-energy marine seismic survey in the Northeast Pacific Ocean for this consultation.

EEZ=Exclusive Economic Zone
OBS=Ocean Bottom Seismometer
EBSA=Ecologically or Biologically Significant Marine Areas
HT=Hydrothermal

5 INTERRELATED AND INTERDEPENDENT ACTIONS

Interrelated actions are those that are part of a larger action and depend on that action for their justification. *Interdependent* actions are those that do not have independent utility apart from the action under consideration.

The two proposed actions considered during consultation are interdependent. The National Science Foundation's sponsoring and conducting the proposed marine seismic survey is interdependent on NMFS Permits and Conservation Division's proposal to issue an incidental harassment authorization under the MMPA, as it will not have an interdependent use if not for the actual activity the National Science Foundation proposed. Likewise, the National Science Foundation's proposed action will not carry forward without the incidental harassment authorization to exempt marine mammal take from the NMFS Permits and Conservation Division. For this consultation, we consider all vessel transit associated with seismic survey activities that will be conducted under the incidental harassment authorization as interdependent. Thus, we evaluate the effects of these activities on ESA-listed species and include all waters traversed during such transits as part of the action area. No actions were considered interrelated.

6 POTENTIAL STRESSORS

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

6.1 Pollution

The operation of the R/V *Marcus G. Langseth* as a result of the proposed action may result in pollution from exhaust, fuel, oil, trash, and other debris. Air and water quality are the basis of a healthy environment for all species. Emissions pollute the air, which could be harmful to air-breathing organisms and lead to ocean pollution (Chance et al. 2015; Duce et al. 1991). Emissions also cause increased greenhouse gases (carbon dioxide, methane, nitrous oxide, and other fluorinated gases) that can deplete the ozone, affect natural earth cycles, and ultimately

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

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

The research vessel used during the National Science Foundation-funded seismic survey has spill-prevention plans, which will allow a rapid response to a spill in the event one occurred. The potential of pollution from fuel or oil leakages is extremely unlikely. An oil or fuel leak will likely pose a significant risk to the research vessel and its crew and actions to correct a leak should occur immediately to the fullest extent possible. In the event that a leak should occur, the amount of fuel or oil onboard the R/V *Marcus G. Langseth* is unlikely to cause widespread, high-dose contamination (excluding the remote possibility of severe damage to the research vessel) that will impact ESA-listed species directly or pose hazards to their food sources. Because the potential for oil or fuel leakage is extremely unlikely to occur, we find that the risk from this potential stressor is discountable. Therefore, we conclude that pollution by oil or fuel leakage is not likely to adversely affect ESA-listed species, and will not be analyzed further in this opinion.

6.2 Vessel Strikes

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

Vessel traffic associated with the proposed action carries the risk of vessel strikes of marine mammals, sea turtles, and fishes. In general, the probability of a vessel collision and the associated response depends, in part, on size and speed of the vessel. The R/V *Marcus G. Langseth* has a length of 72 meters (235 feet) and the operating speed during seismic data acquisition is typically approximately 9.3 kilometers per hour (5 knots). When not towing seismic survey gear, the R/V *Marcus G. Langseth* typically transits at 18.5 kilometers per hour (10 knots). The majority of vessel strikes of large whales occur when vessels are traveling at speeds greater than approximately 18.5 kilometers per hour (10 knots), with faster travel, especially of large vessels (80 meters [262.5 feet] or greater), being more likely to cause serious

injury or death (Conn and Silber 2013b; Jensen and Silber 2004; Laist et al. 2001; Vanderlaan and Taggart 2007).

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). Based on behavioral observations of sea turtle avoidance of small vessels, green turtles may be susceptible to vessel strikes at speeds as low as 3.7 kilometers per hour (2 knots) (Hazel et al. 2007). If an animal is struck by a vessel, responses can include death, serious injury, and/or minor, non-lethal injuries, with the associated response depending on the size and speed of the vessel, among other factors (Conn and Silber 2013a; Jensen and Silber 2004; Laist et al. 2001; Vanderlaan and Taggart 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' utilization of the upper portion of the water column for at least some of their life history, in most cases, we would anticipate the ESA-listed fishes considered in this opinion would be able to detect vessels or other in-water devices and avoid them. Fish are able to use a combination of sensory cues to detect approaching vessels, such as sight, hearing, and their lateral line (for nearby changes in water motion). A study on fish behavioral responses to vessels showed that most adults exhibit avoidance responses to engine noise, sonar, depth finders, and fish finders (Jørgensen et al. 2004), reducing the potential for vessel strikes. Misund (1997) found that fish ahead of a ship showed avoidance reactions at ranges of 50 to 350 meters (160 to 490 feet). When the vessel passed over them, some fish responded with sudden escape responses that movement away from the vessel laterally or through downward compression of the school. In an early study conducted by Chapman and Hawkins (1973), the authors observed avoidance responses of herring from the low-frequency sounds of large vessels or accelerating small vessels. Avoidance responses quickly ended within ten seconds after the vessel departed. Conversely, Rostad (2006) observed that some fish are attracted to different types of vessels (e.g., research vessels, commercial vessels) of varying sizes, noise levels, and habitat locations.

Several conservation measures proposed by the NMFS Permits and Conservation Division and/or National Science Foundation and Lamont-Doherty Earth Observatory will minimize the risk of vessel strike. In addition, the overall level of vessel activity associated with the proposed action is low relative to the large size of the action area, further reducing the likelihood of a vessel strike of an ESA-listed species. Nevertheless, vessel strikes remain a potential stressor associated with the proposed action.

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 seismic surveys. The R/V *Marcus G. Langseth* will be traveling at generally low speeds, reducing the amount of noise produced by the propulsion system and the probability of a vessel strike (Kite-Powell et al. 2007; Vanderlaan and Taggart 2007). Our expectation of vessel strike is discountably small due to the hundreds of thousands of

kilometers the R/V *Marcus G. Langseth* has traveled without a vessel strike, general expected movement of marine mammals away from or parallel to the R/V *Marcus G. Langseth*, as well as the generally slow movement of the R/V *Marcus G. Langseth* during most of its travels (Hauser and Holst 2009; Holst 2010; Holst and Smultea 2008b). In addition, adherence to observation and avoidance procedures is also expected to avoid vessel strikes. All factors considered, we have concluded the potential for vessel strike from the research vessel is highly improbable. Because the potential for vessel strike is extremely unlikely to occur, we find that the risk from this potential stressor is discountable. Therefore, we conclude that vessel strike is not likely to adversely affect ESA-listed species and will not be analyzed further in this opinion.

6.3 Acoustic Noise, Vessel Noise, and Visual Disturbance

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

The research vessel associated with the proposed action may cause visual or auditory disturbances to ESA-listed species that spend time near the surface, such as marine mammals, sea turtles, and fishes which may generally disrupt their behavior. Studies have shown that vessel operations can result in changes in the behavior of marine mammals, sea turtles, and fishes (Hazel et al. 2007; Holt et al. 2009; Luksenburg and Parsons 2009; Noren et al. 2009; Patenaude et al. 2002; Richter et al. 2003; Smultea et al. 2008). In many cases, particularly when responses are observed at great distances, it is thought that animals are likely responding to sound more than the visual presence of vessels (Blane and Jaakson 1994a; Evans et al. 1992; Evans et al. 1994). Nonetheless, it is generally not possible to distinguish responses to the visual presences of vessels from those to the sounds associated with those vessels. Moreover, at close distances animals may not even differentiate between visual and acoustic disturbances created by vessels and simply respond to the combined disturbance.

Unlike vessels, which produce sound as a byproduct of their operations, 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. Assessing whether these sounds may adversely affect ESA-listed species involves understanding the characteristics of the acoustic sources, the species that may be present in the vicinity of the sound, and the effects that sound may have on the physiology and behavior of those species. Although it is known that sound is important for marine mammal communication, navigation, and foraging (NRC 2003b; NRC 2005), there are many unknowns in assessing impacts of sound, such as the potential interaction of different effects and the significance of responses by marine mammals to sound exposures (Nowacek et al. 2007; Southall et al. 2007a). 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 and how they use sound, the impacts of anthropogenic sound are difficult to assess (Nelms et al. 2016; Popper et al. 2014). Nonetheless, depending on the circumstances, exposure to anthropogenic sounds may result in auditory injury, changes in hearing ability, masking of important sounds, behavioral responses, as well as other physical and physiological responses (see Section 11.3.2).

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

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

Sounds emitted by large vessels can be characterized as low-frequency, continuous, or tonal, and sound pressure levels at a source will vary according to speed, burden, capacity, and length (Kipple and Gabriele 2007; McKenna et al. 2012; Richardson et al. 1995c). Source levels for 593 container ships transits were estimated from long-term acoustic recording received levels in the Santa Barbara shipping channel, and a simple transmission loss model using Automatic Indentification System data for source-receiver range (McKenna et al. 2013). Vessel noise levels could vary 5 to 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 463 kilometers (75.1 to 250 nautical miles) away (Polefka 2004). Hatch et al. (2008) measured commercial ship underwater noise levels and reported average source level estimates (71 to 141 Hertz, re: 1 µPa [rms] ± standard error) for individual vessels ranged from 158 ± 2 dB (research vessel to 186 ± 2 dB (oil tanker). McKenna et al (2012) in a study off Southern California documented different acoustic levels and spectral shapes observed from different modern vessel-types.

Numerous studies of interactions between surface vessels and marine mammals have demonstrated that free-ranging marine mammals engage in avoidance behavior when surface vessels move toward them. It is not clear whether these responses are caused by the physical presence of a surface vessel, the underwater noise generated by the vessel or an interaction between the two (Amaral and Carlson 2005; Au and Green 2000; Bain et al. 2006; Bauer 1986; Bejder et al. 1999; Bejder and Lusseau. 2008; Bejder et al. 2009; Bryant et al. 1984; Corkeron 1995; Erbe 2002b; Félix 2001; Goodwin and Cotton 2004; Lemon et al. 2006; Lusseau 2003; Lusseau 2006; Magalhaes et al. 2002; Nowacek et al. 2001; Richter et al. 2003; Scheidat et al. 2004; Simmonds 2005a; Watkins 1986b; Williams et al. 2002; Wursig et al. 1998). However,

several authors suggest that the noise generated during motion is probably an important factor (Blane and Jaakson 1994b; Evans et al. 1992; Evans et al. 1994). These studies suggest that the behavioral responses of marine mammals to surface vessels are similar to their behavioral responses to predators.

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. These responses appear limited to non-injurious, minor changes in behavior based on the limited information available on sea turtle response to vessel noise.

All fish species can detect vessel noise due to its low-frequency content and their hearing capabilities. Therefore, ESA-listed fishes could be exposed to a range of vessel noises, depending on the source and context of the exposure. Because of the characteristics of vessel noise, sound produced from seismic research vessels are unlikely to result in direct injury, hearing impairment, or other trauma to fishes. Plus, 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 either visually, via sound and motion in the water would be capable of avoiding the vessel or move away from the area affected by vessel sound. Thus, fish are more likely to react to vessel noise at close range than to vessel noise emanating from a greater distance away. These reactions may include physiological stress responses, or avoidance behaviors.

The contribution of vessel noise by the R/V *Marcus G. Langseth* is likely small in the overall regional sound field. The R/V *Marcus G. Langseth*'s passage past a marine mammal, sea turtle, or fish will be brief and not likely to be significant in impacting any individual's ability to feed, reproduce, or avoid predators. Brief interruptions in communication via masking are possible, but unlikely given the habits of marine mammals and fish to move away from vessels, either as a result of engine noise, the physical presence of the vessel, or both (Lusseau 2006; Mitson and Knudsen 2003). Also, as stated sea turtles are most likely to habituate and are shown to be less effected by vesselnoise at distances greater than 10 meters (32.8 feet) (Hazel et al. 2007). In addition, the R/V *Marcus G. 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, 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 is not likely to adversely affect ESA-listed marine mammals, sea turtles, or fishes, and will not be analyzed further.

6.4 Gear Entanglement

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

Towed gear from the seismic survey activities pose a risk of entanglement to ESA-listed marine mammals. The towed hydrophone streamer could come in direct contact with ESA-listed species and sea turtle entanglements have occurred in towed gear from seismic survey vessels. For example, a National Science Foundation-funded seismic survey off the coast of Costa Rica during 2011 recovered a dead olive ridley turtle (*Lepidochelys olivacea*) in the foil of towed seismic equipment; 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 or operating in regions of high sea turtle density and entanglements not occurring (Hauser 2008; Holst and Smultea 2008a; Holst et al. 2005b; Holst et al. 2005c). To the best of our knowledge, sea turtles do not occur in high densities in the action area. The towed hydrophone streamer is rigid and as such will not encircle, wrap around, or in any other way entangle any of the large whales considered during this consultation. We expect the taut cables will prevent entanglement. Furthermore, mysticetes (baleen whales) and possible sperm whales are expected to avoid areas where the airgun array is actively being used, meaning they will also avoid towed gear. Instances of such entanglement events with ESA-listed marine mammals are unknown to us.

In addition to marine mammals and sea turtles, some of the ESA-listed fish species in the action area are more susceptible to entanglement in derelict fishing gear and other marine debris, compared to other fish groups. For example, the shape of the body of some elasmobranchs such

as manta rays, increase their risk of entanglement compared to fishes with smoother, more streamlined bodies such as steelhead. Nevertheless, for most of the pelagic species of ESA-listed fish species including steelhead and oceanic whitetip sharks the risk of entanglement is unlikely given their body shape and ability to avoid materials that could entangle them in the water column.

Although the towed hydrophone streamer or passive acoustic monitoring array could come in direct contact with an ESA-listed species, entanglements are highly unlikely and considered discountable. Based upon extensive deployment of this type of equipment with no reported entanglement and the nature of the gear that is likely to prevent it from occurring, we find the probability of adverse impacts to ESA-listed species and designated critical habitat to be discountable, not likely to adversely affect any ESA-listed species, and will not be analyzed further in this opinion.

The only potential stressor that is likely to affect ESA-listed species within the action area are sound fields produced by the seismic airgun array, multi-beam echosounder, sub-bottom profiler, acoustic Doppler current profiler, and acoustic release transponder. This stressor and these sound sources associated with seismic survey activities may adversely affect the ESA-listed marine mammals and sea turtles and are further analyzed and evaluated in detail in Section 11.3.

7 SPECIES AND CRITICAL HABITAT NOT LIKELY TO BE ADVERSELY AFFECTED

This section identifies the ESA-listed species and designated critical habitat under NMFS jurisdiction that may occur within the action area (as described in Table 8) that are not likely to be adversely affected by the proposed action. NMFS uses two criteria to identify the ESA-listed species or designated critical habitat that are not likely to be adversely affected by the proposed action, as well as the effects of activities that are interrelated to or interdependent with the Federal agency’s proposed action. The first criterion is exposure, or some reasonable expectation of a co-occurrence, between one or more potential stressors associated with the proposed activities and ESA-listed species or designated critical habitat. If we conclude that an ESA-listed species or designated critical habitat is not likely to be exposed to the proposed activities, we must also conclude that the species or critical habitat is not likely to be adversely affected by those activities.

The second criterion is the probability of a response given exposure. ESA-listed species or designated critical habitat that is exposed to a potential stressor but is likely to be unaffected by the exposure is also not likely to be adversely affected by the proposed action. We applied these criteria to the ESA-listed species in Table 8 and we summarize our results below.

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

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

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

In this section, we evaluate effects to several ESA-listed species and designated critical habitat that may be affected, but are not likely to be adversely affected, by the proposed action. For these ESA-listed species and critical habitat, we focus specifically on stressors associated with the National Science Foundation and Lamont-Dohert Earth Observatory's seismic survey activities and their effects on these species. The effects of other stressors associated with the proposed action, which are not likely to adversely affect ESA-listed species, are evaluated in Section 6. The species potentially occurring within the action arear that may be affected, but are not likely to be adversely affected, are listed in Table 8, along with their regulatory status, designated critical habitat, and recovery plan. The designated critical habitat that occurs within the action area and may be affected by the proposed action is listed in Table 8.

Table 8. Endangered Species Act-listed threatened and endangered species or proposed for Endangered Species Act-listing potentially occurring in the action area that may be affected, but are not likely to be adversely affected.

Species	ESA Status	Critical Habitat	Recovery Plan
Marine Mammals – Cetaceans			
Gray Whale (*Eschrichtius robustus*) – Western North Pacific Population	E – 35 FR 18319	-- --	-- --
Killer Whale (*Orcinus orca*) – Southern Resident DPS	E – 70 FR 69903 Amendment 80 FR 7380	71 FR 69054*	73 FR 4176 01/2008
North Pacific Right Whale (*Eubalaena japonica*)	E – 73 FR 12024	73 FR 19000*	78 FR 34347 06/2013
Marine Reptiles			
Green Turtle (*Chelonia mydas*) – East Pacific DPS	T – 81 FR 20057	-- --	63 FR 28359 01/1998

Species	ESA Status	Critical Habitat	Recovery Plan
Hawksbill Turtle (*Eretmochelys imbricata*)	E – 35 FR 8491	63 FR 46693	57 FR 38818 08/1992 – U.S. Caribbean, Atlantic, and Gulf of Mexico 63 FR 28359 05/1998 – U.S. Pacific
Loggerhead Turtle (*Caretta caretta*) – North Pacific Ocean DPS	E – 76 FR 58868	-- --	63 FR 28359
Olive Ridley Turtle (*Lepidochelys olivacea*) – Mexico's Pacific Coast Breeding Colonies	E – 43 FR 32800	-- --	63 FR 28359
Fishes			
Bocaccio (*Sebastes paucispinis*) – Puget Sound/Georgia Basin DPS	E – 75 FR 22276 and 82 FR 7711	79 FR 68041*	81 FR 54556 (Draft) 10/2017
Eulachon (*Thaleichthys pacificus*) – Southern DPS	T – 75 FR 13012	76 FR 65323*	9/2017
Yelloweye Rockfish (*Sebastes rubberimus*) – Puget Sound/Georgia Basin DPS	T – 75 FR 22276 and 82 FR 7711	79 FR 68041*	81 FR 54556 (Draft) 10/2017
Green Sturgeon (*Acipenser medirostris*) – Southern DPS	T – 71 FR 17757	74 FR 52300*	2010 (Outline)
Chum Salmon (*Oncorhynchus keta*) – Columbia River ESU	T – 70 FR 37160	70 FR 52629*	78 FR 41911
Chum Salmon (*Oncorhynchus keta*) – Hood Canal Summer-Run ESU	T – 70 FR 37160	70 FR 52629*	72 FR 29121
Coho Salmon (*Oncorhynchus kisutch*) – Lower Columbia River ESU	T – 70 FR 37160	81 FR 9251*	78 FR 41911
Coho Salmon (*Oncorhynchus kisutch*) – Oregon Coast ESU	T – 73 FR 7816	73 FR 7816*	81 FR 90780
Coho Salmon (*Oncorhynchus kisutch*) – Southern Oregon and Northern California Coasts ESU	T – 70 FR 37160	64 FR 24049*	79 FR 58750
Coho Salmon (*Oncorhynchus kisutch*) – Central California Coast ESU	E – 70 FR 37160	64 FR 24049*	77 FR 54565

Species	ESA Status	Critical Habitat	Recovery Plan
Chinook Salmon (*Oncorhynchus tshawytscha)* – California Coastal ESU	T – 70 FR 37160	70 FR 52488*	81 FR 70666
Chinook Salmon (*Oncorhynchus tshawytscha)* – Central Valley Spring-Run ESU	T – 70 FR 37160	70 FR 52488*	79 FR 42504
Chinook Salmon (*Oncorhynchus tshawytscha)* – Upper Columbia River Spring-Run ESU	E – 70 FR 37160	70 FR 52629*	72 FR 57303
Chinook Salmon (*Oncorhynchus tshawytscha)* – Upper Willamette River ESU	T – 70 FR 37160	70 FR 52629*	76 FR 52317
Chinook Salmon (*Oncorhynchus tshawytscha)* – Lower Columbia River ESU	T – 70 FR 37160	70 FR 52629*	78 FR 41911
Chinook Salmon (*Oncorhynchus tshawytscha)* – Puget Sound ESU	T – 70 FR 37160	70 FR 52629*	72 FR 2493
Chinook Salmon (*Oncorhynchus tshawytscha)* – Sacramento River Winter-Run ESU	E – 70 FR 37160	58 FR 33212*	79 FR 42504
Chinook Salmon (*Oncorhynchus tshawytscha)* – Snake River Fall-Run ESU	T – 70 FR 37160	58 FR 68543*	80 FR 67386 (Draft)
Chinook Salmon (*Oncorhynchus tshawytscha)* – Snake River Spring/Summer Run ESU	T – 70 FR 37160	64 FR 57399*	81 FR 74770 (Draft) 11/2017 (Final)
Sockeye Salmon (*Oncorhynchus nerka*) – Ozette Lake ESU	T – 70 FR 37160	70 FR 52630*	74 FR 25706
Sockeye Salmon (*Oncorhynchus nerka*) – Snake River ESU	E – 70 FR 37160	58 FR 68543*	80 FR 32365
Steelhead Trout (*Oncorhynchus mykiss*) – Lower Columbia River DPS	T – 71 FR 834	70 FR 52629*	78 FR 41911
Steelhead Trout (*Oncorhynchus mykiss*) – Middle Columbia River DPS	T – 71 FR 834	70 FR 52629*	74 FR 50165
Steelhead Trout (*Oncorhynchus mykiss*) – Upper Columbia River DPS	T – 71 FR 834	70 FR 52629*	72 FR 57303
Steelhead Trout (*Oncorhynchus mykiss*) – Puget Sound DPS	T – 72 FR 26722	81 FR 9251*	-- --

Species	ESA Status	Critical Habitat	Recovery Plan
Steelhead Trout (*Oncorhynchus mykiss*) – Upper Willamette River DPS	T – 71 FR 834	70 FR 52629*	76 FR 52317
Steelhead Trout (*Oncorhynchus mykiss*) – Snake River Basin DPS	T – 71 FR 834	70 FR 52629*	81 FR 74770 (Draft) 11/2017 (Final)
Steelhead Trout (*Oncorhynchus mykiss*) – Northern California DPS	T – 71 FR 834	70 FR 52487*	81 FR 70666
Steelhead Trout (*Oncorhynchus mykiss*) – South-Central California Coast DPS	T – 71 FR 834	70 FR 52487*	78 FR 77430
Steelhead Trout (*Oncorhynchus mykiss*) – Southern California DPS	E – 71 FR 834	70 FR 52487*	77 FR 1669

*Critical habitat has been designated, but it is outside the action area and will not be affected by the proposed action.
E=Endangered
T=Threatened
DPS=Distinct Population Segment
ESU=Evolutionary Significant Unit

7.1 Endangered Species Act-Listed Cetaceans

The proposed action spatially overlaps with ESA-listed cetacean species including the Western North Pacific population of gray whale, Southern Resident DPS of killer whale, and North Pacific right whale and is discussed further below.

7.1.1 Gray Whale – Western North Pacific Population

The Western North Pacific population of gray whales exhibit extensive plasticity in the occurrence of animals, shifting use areas within and between years, as well as over longer time frames, such as in response to oceanic climate cycles (e.g., El Niño-Southern Oscillation, Pacific Decadal Oscillation, and Arctic Oscillation) (Gardner and Chavez-Rosales 2000; Meier et al. 2007b; Tyurneva et al. 2009; Vladimirov et al. 2006a; Vladimirov et al. 2006b; Vladimirov et al. 2005; Vladimirov et al. 2008; Vladimirov et al. 2009; Vladimirov et al. 2010; Weller et al. 2012; Yablokov and Bogoslovskaya 1984; Yakovlev and Tyurneva 2005). The population's typical distribution extends south along Japan, the Koreas, and China from Kamchatka Peninsula (IWC 2003; Kato and Kasuya. 2002; Omura 1988; Reeves et al. 2008; Weller et al. 2003). Other possible range areas include Vietnam, the Philippines, and Taiwan, although only historical whaling records support occurrence in these areas (Henderson 1990; Ilyashenko 2009). The range has likely contracted from the Koreas and other southern portions of the range versus pre-whaling periods. Prey availability and, to a lesser extent, sea ice extent, are probably strong influences on the habitats used by the Western North Pacific population of gray whales (Clarke and Moore 2002; Moore 2000).

The Eastern and Western North Pacific populations of gray whales were once considered geographically separated along either side of the ocean basin, but recent photo-identification, genetic, and satellite tracking data refute this. Two individuals from the Western North Pacific population of gray whales have been satellite tracked from Russian foraging areas east along the Aleutian Islands, through the Gulf of Alaska, and south to the Washington and Oregon coasts in one case (Mate et al. 2011), and to the southern tips of Baja California and back to Sakhalin Island in another (IWC 2012a). Comparisons of catalogues of Eastern and Western North Pacific populations of gray whales have thus far identified 24 individuals from the Western North Pacific population of gray whales occurring on the eastern side of the basin during winter and spring (Burdin et al. 2011; Weller et al. 2013). During one field season off Vancouver Island, individuals from the Western North Pacific population of gray whales were found to constitute six of 74 (8.1 percent) of photo-identifications (Weller et al. 2012). In addition, two genetic matches with the Western North Pacific population of gray whales off Santa Barbara, California have been made (Lang et al. 2011). Individuals have also been observed migrating as far as Central Baja Mexico (Weller et al. 2012).

From this overview, it is apparent that individuals from the Western North Pacific population of gray whales could be found within the action area. It is possible that an individual or individuals from the Western North Pacific population of gray whale could be unintentionally impacted by the proposed seismic survey activities. However, given their low occurrence in the action area (approximately 20 to 30 individuals) and relative size compared to individuals from the Eastern North Pacific population of gray whales (approximately 0.7 percent with 140 for Western North Pacific population of gray whales versus 20,125 for the Eastern North Pacific population of gray whales), we find it highly unlikely that any individuals from the Western North Pacific population of gray whales will be affected by the proposed seismic survey activities. The few photo-identification matches from collaborating researchers have occurred primarily in the spring during the migration (Weller et al. 2012), which is not when the field work will occur (the seismic survey activities are planned for summer 2019) and under the incidental harassment authorization. Also, there is still a low likelihood that individuals from the Western North Pacific population of gray whales are found in the proposed action area where the seismic survey activities will occur. In the Eastern North Pacific Ocean basin, gray whales prefer shallow coastal waters and primarily feed over oceanic continental shelves (Carretta et al. 2019). As a result, gray whales in the Eastern North Pacific Ocean are not usually found in deep offshore waters where the proposed seismic survey activities will be located. Due to this, Western North Pacific population of gray whales will have a very low likelihood of being exposed to acoustic stressors produced by the seismic airgun array, multi-beam echosounder, sub-bottom profiler, acoustic Doppler current profiler, and acoustic release transponder used during the seismic survey activities. These sound sources will only be used in the proposed action area where the seismic survey activities will take place. Therefore, we believe the potential impacts to the Western North Pacific population of gray whale as a result of the proposed seismic survey activities will be discountable. We conclude that the proposed seismic survey activities is not

likely to adversely affect ESA-listed Western North Pacific population of gray whales. As a result, this population will not be considered further in this consultation.

7.1.2 Killer Whale – Southern Resident Distinct Population Segment

The Southern Resident DPS of killer whales are not expected to occur in the area of the proposed seismic survey activities as the easternmost tracklines of the proposed seismic survey (those that approach nearest to shore) are further west than the migratory range of the Southern Resident DPS off Oregon and southern Washington (pers. comm. L. Barre, NMFS West Coast Regional Office to H. Goldstein, NMFS Office of Protected Resources, February 28, 2019). At the time the proposed seismic survey activities will occur, we expect Southern Resident DPS of killer whales to be outside of the action area. The summer range (i.e., May through September) of the Southern Resident DPS of killer whale is near Haro Strait, Boundary Pass, San Juan Island, and the Strait of Juan de Fuca, Washington and British Columbia. Souther Resident DPS of killer whales do occur off the Washington and Oregon coasts, (e.g., aound the Columbia River), but in winter, during the months of February and March. In 2012, NSF-funded seismic surveys occurred in the Pacific Ocean off the coast of Washington in June and July, and reported no killer whales during those seismic surveys.

Since the proposed seismic survey activities will take place in a location and time of year when we do not expect Southern Resident DPS of killer whales to be present, we do not expect the animals to be exposed to the proposed action, including the potential stressors related to vessel noise. As a result, potential acoustic noise to Southern Resident DPS of killer whales from the proposed seismic survey activities airgun array, multi-beam echosounder, sub-bottom profiler, acoustic Doppler durrent profiler, and acoustic release transponder is discountable. Therefore, we conclude that the National Science Foundation and Lamont-Doherty Earth Observatory's proposed seismic survey activities is not likely to adversely affect ESA-listed Southern Resident DPS of killer whales. As a result, the Southern Resident DPS of killer whales will not be considered further in this opinion.

7.1.3 North Pacific Right Whale

The North Pacific right whale remains one of the most endangered whale species in the world, and there are likely fewer than 1,000 individuals between the eastern and western populations. Historically, the endangered North Pacific right whale occurred in waters off the coast of British Columbia and Washington, Oregon, and California (Clapham et al. 2004b; Scarff 1986b). North Pacific right whales occur in subpolar to temperate waters. They are generally migratory, with at least a portion of the population moving between summer feeding grounds in temperate or high latitudes and winter calving areas in warmer waters (Clapham et al. 2004a; Kraus et al. 1986). Historical whaling records provide virtually the only information on North Pacific right whale distribution (Gregr 2011). This species historically occurred across the Pacific Ocean north of 35 degrees North, with concentrations in the Gulf of Alaska, eastern Aleutian Islands, south-central Bering Sea, Okhotsk Sea, and the Sea of Japan (Clapham et al. 2004a; Gregr 2011; Ivashchenko et al. 2013; Omura et al. 1969; Scarff 1986a; Shelden et al. 2005). North Pacific right whales

were probably never common along the west coast of North America (Brownell Jr. et al. 2001; Scarff 1986a). The rarity of reports for North Pacific right whales in more southern coastal areas in winter in either historical or recent times suggests that their breeding grounds may have been offshore (Clapham et al. 2004a). Presently, sightings are extremely rare, occurring primarily in the Okhotsk Sea and the eastern Bering Sea (Brownell Jr. et al. 2001; Shelden et al. 2005; Wade et al. 2006; Zerbini et al. 2010).

In October 2013, a North Pacific right whale sighting was made off the Strait of Juan de Fuca, with a group of humpback whales moving south into the offshore area of the U.S. Navy's Northwest Training and Testing action area (U.S. Department of the Navy 2015). There have also been four sightings, each of a single North Pacific right whale, in California waters within approximately the last 30 years (in 1988, 1990, 192, and 2017) (Brownell et al. 2001; Carretta et al. 1994; Price 2017). In addition, other various sightings of North Pacific right whales in the general vicinity of the action area have occurred on an irregular basis. Two North Pacific right whales were sighted in 1983 on Swifsure Bank at the entrance to the Strait of Juan de Fuca (Osborne et al. 1988). There were no sightings of North Pacific right whales during six vessel surveys conducted in summer and fall off California, Oregon, and Washington from 1991 through 2008 (Barlow 2010b).

Because of the low population numbers (likely less than 1,000) in the North Pacific Ocean and the few individuals that have been observed (Brownell Jr. et al. 2001; Wade et al. 2006), even given these recent sightings and detections, this species is considered extremely rare in the action area. Based on this information, there is a very low probability of encountering this species anywhere in the coastal and offshore waters in the action area. As a result, potential acoustic noise from the proposes seismic survey activities airgun array, multi-beam echosounder, sub-bottom profiler, acoustic Doppler current profiler, and acoustic release transponder on North Pacific right whales is discountable. Therefore, we conclude that the National Science Founation and Lamont-Doherty Earth Observatory's seismic survey activities is not likely to adversely affect ESA-listed North Pacific right whales. As a result, this species will not be considered durther in this consultation.

7.2 Endangered Species Act-Listed Sea Turtles

ESA-listed sea turtles (Eastern DPS of green, hawksbill, North Pacific DPS of loggerhead and Mexico's Pacific coast breeding colonies population of olive ridley turtles) may occur in the action area and be affected by acoustic noise generated by the airgun array, multi-beam echosounder, sub-bottom profiler, acoustic Doppler current profiler, and acoustic release transponder of the National Science Foundation and Lamont-Doherty Earth Obseratory's proposed seismic survey activities. Hawksbill and olive ridley turtles range broadly throughout the Pacific Ocean; however, both species have a circumtropical distribution restricted by ocean temperature, with southern California being the northern limit of their distribution. East Pacific DPS of green, North Pacific DPS of loggerhead, and Mexico's Pacific coast breeding colonies population of olive ridley turtles have been documented off the coast of Oregon, Washington,

and/or British Columbia, but these occurrences are considered extralimital as they are generally warm-water species (WDFW 2012). Strandings of turtles have increased in recent years, particularly for olive ridley turtles, possibly due to warmer ocean conditions or El Niño (Boyer 2017).

The rarity of reports from the waters of the Northeast Pacific Ocean and extralimital portion of their range suggests that the East Pacific DPS of green, hawksbill, North Pacific DPS of loggerhead, and Mexico's Pacific coast breeding colonies population of olive ridley turtles are not reasonably likely to be exposed to potential acoustic noise from seismic survey activities considered in this opinion. As a result, these species will not be considered further in this consultation. Because the likelihood of exposure is discountable, and no designated critical habitat for this species occurs in the action area, we have determined the East Pacific DPS of green, hawksbill, North Pacific DPS of loggerhead, and Mexico's Pacific coast breeding colonies population of olive ridley turtles is not likely to be adversely affected by the seismic survey activities and will not be considered further in this opinion.

7.3 Endangered Species Act-Listed Fish

The proposed action spatially overlaps with ESA-listed fish including salmonids, sturgeon, rockfish, and eulachon and is discussed further below.

7.3.1 Criteria and Thresholds to Predict Impacts to Fishes

A description of fish hearing according to the species' groups and sensitivity to sound is provided in Section 7.3.1 and Section 7.3.2. For many of the acoustic stressors affecting fishes in the action area during the National Science Foundation and Lamont-Doherty Earth Observatory's seismic survey activities, NMFS relied primarily on the recommendations in the 2014 *ANSI Guidelines* (Popper et al. 2014). Where applicable, NMFS developed or used other thresholds based upon what NMFS considers to be the most appropriate given our current understanding of the effects of anthropogenic sounds on fishes as well as the best available science on the subject. For fishes, permanent threshold shift has not been documented in any of the studies researching fish hearing and potential impairment from various sound sources. This is attributed to the ability for regeneration of inner ear hair cells in fishes, which differs from other marine animals. For this reason, thresholds for fish hearing impairment only includes the SPL related to the potential onset of temporary threshold shift (TTS). TTS in fishes is considered recoverable, although the rate of recovery is based upon the degree of the TTS sustained. Thus, auditory damage or impairment in fishes is considered recoverable over some duration; and auditory thresholds are based solely on the onset of TTS for fishes.

For auditory impairment (e.g., TTS) and barotrauma (e.g., physical injuries) in fishes, the NMFS apply dual metric criteria which includes both a peak pressure metric and cumulative sound exposure level (SELcum). As with other marine animals, NMFS also applies an rms threshold for some acoustic sources to assess whether behavioral responses may be elicited during some sound exposures.

7.3.2 Impulsive Sound Source Criteria (Airgun Arrays) for Fishes

Impulsive sound sources such as airguns are known to injure or kill fishes or elicit behavioral responses. For airguns, NMFS analyzed impacts from sound produced by airguns using the recommendations consistent with *ANSI Guidelines* (Popper et al. 2014). These dual metric criteria are utilized to estimate zones of effects related to mortality and injury from airgun exposure. NMFS assumes that a specified effect will occur when either metric is met or exceeded.

In the 2014 *ANSI Guidelines*, airgun thresholds are derived from the thresholds developed for impact pile-driving exposures (Halvorsen et al. 2012a; Halvorsen et al. 2011; Halvorsen et al. 2012b). This use of a dual metric criteria is consistent with the current impact hammer criteria NMFS applies for fishes with swim bladders (FHWG 2008; Stadler and Woodbury 2009). The interim criteria developed by the Fisheries Hydroacoustic Working Group include dual metric criteria wherein the onset of physical injury will be expected if either the peak SPL exceeds 206 dB re: 1 µPa, or the SEL_{cum}, exceeds 187 dB re: 1 μPa^2-s for fish two grams or larger, or 183 dB 1 μPa^2-s for fish smaller than two grams. However, at the same time the interim criteria were developed, very little information was available from airgun exposures. As such, it is also often applied to other impulsive sound sources. In addition, the 2008 interim criteria did not specifically separate thresholds according to severity of hearing impairment such as TTS to recoverable injury to mortality, which was done in the 2014 *ANSI Guidelines*. Nor do they differentiate between fish with swim bladders and those without, despite the presence of a swim bladder affecting hearing capabilities and fish sensitivity to sound. The 2008 interim criteria based the lower SEL_{cum} thresholds (187 dB re: 1 μPa^2-s and 183 dB re: 1 μPa^2-s) upon when TTS or minor injuries will be expected to occur. Therefore, these criteria establish the starting point when the whole spectrum of potential physical effects may occur for fishes, from TTS to minor, recoverable injury, up to lethal injury (i.e., either resulting in either instantaneous or delayed mortality). . Because some generalized groupings of fish species can be made regarding what is currently known about fish hearing sensitivities (Casper et al. 2012; Popper and Hastings 2009; Popper et al. 2014) and influence of a swim bladder, and the fact that none of the ESA-listed fish species in the action area have a swim bladder associated with hearing, our analysis of ESA-listed fishes considered in this consultation is focused upon fishes with swim bladders not used in hearing. Categories and descriptions of hearing sensitivities are further defined in this document (Popper and N. 2014) as the following[1]:

- Fishes with a swim bladder that is not involved in hearing, lack hearing specializations and primarily detect particle motion at frequencies below 1 kiloHertz include all Pacific salmonid species and green sturgeon.

[1] The 2014 ANSI Guidelines provide distinctions between fish with and without swim bladders and fish with swim bladders involved in hearing. None of the ESA-listed fish species considered in this consultation have swim bladders involved with their hearing abilities, but all do have swim bladders. Thus, we simplified the distinction to fishes with swim bladders.

For the National Science Foundation and Lamont-Doherty Earth Observatory's seismic survey activities, airgun thresholds for fishes with swim bladders not involved in hearing are 210 SEL_{cum} and greater than 207 SPL_{peak} for onset of mortality and 203 SEL_{cum} and greater than 207 SPL_{peak} for onset of injury[2]. Criteria and thresholds to estimate TTS in fishes exposed to sound produced by airguns are greater than186 SEL_{cum}[3]. Exposure to sound produced from airguns at a cumulative sound exposure level of 186 dB (re: 1 µPa^2-s) has resulted in TTS in fishes (Popper et al. 2005)[4]. For potential behavioral responses of fishes (i.e., sub-injury) from exposure to anthropogenic sounds, there are no formal criteria yet established. This is largely due to the sheer diversity of fishes, their life histories and behaviors, as well as the inherent difficulties conducting studies related to fish behavior in the wild. The NMFS applies a conservative threshold of 150 dB re: 1 µPa (rms) to assess potential behavioral responses of fishes from acoustic stimuli, described below.

In a study conducted by McCauley et al. (2003), fish were exposed to airgun arrays and observed to exhibit alarm responses from sound levels of 158 to 163 dB re: 1 µPa. In addition, when the 2008 criteria were being developed, one of the technical panel experts, Dr. Mardi Hastings, recommended a "safe limit" of fish exposure, meaning where no injury will be expected to occur to fishes from sound exposure, set at 150 dB re: 1 µPa (rms) based upon her research (Hastings 1990). This "safe limit" was also referenced in a document investigating fish effects from underwater sound generated from construction (Sonalysts 1997) where the authors mention two studies conducted by Dr. Mardi Hastings that noted no physical damage to fishes occurred when exposed to sound levels of 150 dB re: 1 µPa (rms) at frequencies between 100 to 2,000 Hertz. In that same report, the authors noted they also observed fish behavioral responses during sound exposure of 160 dB re: 1 µPa (rms), albeit at very high frequencies. More recently, exposed Fewtrell and McCauley (2012) exposed fishes to airgun sound between 147 to 151 dB SEL, and observed alarm responses in fishes as well as tightly grouped swimming or fast swimming speeds.

None of the current research available on fish behavioral response to sound make recommendations for a non-injury threshold. The studies mentioned here, as with most data available on behavioral responses to anthropogenic sound for fishes, have been obtained through controlled laboratory studies. In other cases, behavioral studies have been conducted in the field with caged fish. Research on fish behaviors has demonstrated that caged fish do not show normal behavioral responses which makes it difficult to extrapolate caged fish behavior to wild, unconfined fishes (Hawkins et al. 2014; Popper and Hawkins 2014). It is also important to

[2] Notes: SEL_{cum} = Cumulative sound exposure level (decibel referenced to 1 micropascal squared seconds [dB re 1 µPa2-s]), SPL_{peak} = Peak sound pressure level (decibel referenced to 1 micropascal [dB re: 1 µPa]), > indicates that the given effect would occur above the reported threshold.

[3] Notes: TTS = Temporary Threshold Shift, SEL_{cum} = Cumulative sound exposure level (decibel referenced to 1 micropascal squared seconds [dB re 1 µPa2-s]), NC = effects from exposure to sound produced by airguns is considered to be unlikely, therefore no criteria are reported, > indicates that the given effect would occur above the reported threshold.

[4] This is also slightly more conservative than the 2008 interim pile driving criteria of 187 SEL_{cum}.

mention, that some of the information regarding fish behavior while exposed to anthropogenic sounds has been obtained from unpublished documents such as monitoring reports, grey literature, or other non-peer reviewed documents with varying degrees of quality. Therefore, behavioral effects from anthropogenic sound exposure remains poorly understood for fishes, especially in the wild. Nonetheless, potential behavioral responses must be considered as an effect of acoustic stressors on ESA-listed fishes. For the reasons discussed, and until new data indicate otherwise, NMFS believes a 150 dB re: 1 µPa (rms) threshold for behavioral responses of fishes is appropriate. This criterion is used as a guideline to establish a sound level where responses of fishes may occur and could be a concern. For ESA-listed fishes, NMFS applies this criterion when considering the lifestage affected, and any adverse effects that could occur from behavioral responses such as attentional disruption, which could lead to reduced foraging success, impaired predatory avoidance, leaving protected cover, release of stress hormones affecting growth rates, poor reproductive success rates and disrupted migration.

7.3.3 Salmonids

The proposed action will take place in waters of the Northeast Pacific Ocean off Oregon and Washington. There are several DPSs or evolutionarily significant units (ESUs) of Pacific salmonids that could occur in the action area during their oceanic life phase, including Snake River Spring/Summer Run ESU of chinook salmon, Snake River Fall Run ESU of chinook salmon, California Coastal ESU of chinook salmon, Central Valey Spring Run ESU of chinook salmon, Sacramento River Winter Run ESU of Chinook salmon, Lower Columbia River ESU of Chinook salmon, Puget Sound ESU of Chinook salmon, Upper Willamette River ESU of Chinook salmon, Upper Columbia River Spring Run ESU of Chinook salmon, Columbia River ESU of chum salmon, Hood Canal Summer Run of chum salmon, Central California Coast ESU of coho salmon, Lower Columbia River ESU of coho salmon, Oregon Coast ESu of coho salmon, Southern Oregon Coast ESU of coho salmon, Ozette Lake ESU of sockeye salmon, Snake River ESU of sockeye salmon, Lower Columbia River DPS of steelhead trout, Middle Columbia River DPS of steelhead trout, Puget Sound DPS of steelhead trout, Snake River DPS of steelhead trout, Snake River Basin DPS of steelhead trout, Northern California DPS of steelhead trout, California Central Valley DPS of steelhead trout, Central California Coast DPS of steelhead trout, South-Central California Coast DPS of steelhead trout, Southern California DPS of steelhead trout, Upper Columbai River DPS of steelhead trout, and Upper Willamette River DPS of steelhead trout.

It is not well-understood where in the Pacific Ocean these (or any) salmonids go (Meyers 1998); the DPSs or ESUs noted above are those in the Oregon and Washington region, and thus closest to the action area, and more likely to be present. It is possible that other ESA-listed populations of Pacific salmonids that are father away (e.g., from California) could be present in the action area, though we consider that less likely due to the distance.

Data on sound production in species in the family Salmonidae is scarce, but they do appear to produce some sounds during spawning that may be used for intraspecific signally, including high

and low frequency drumming sounds likely produced by the swimbladder (Neproshin and Kulikova 1975, and Neproshin 1972 as reviewed in Kuznetsov 2009). Salmonidae are all thought to have similar auditory systems and hearing sensitivities (Popper 1977; Popper et al. 2007; Wysocki et al. 2007). Based on the information available, we assume that the ESA-listed salmonid species have hearing sensitivities ranging from less than 100 Hertz to about 580 Hertz (Hawkins and Johnstone 1978; Knudsen et al. 1992; Knudsen et al. 1994).

Some individual ESA-listed salmonid fish may experience TTS as a result of the National Science Foundation's seismic survey activities stressors. TTS is short term in duration with fish being able to replace hair cells when they are damaged (Lombarte et al. 1993; Smith et al. 2006). Furthermore, the fish species considered in this opinion lack notable hearing specialization, minimizing the likelihood of each instance of TTS affecting an individual's fitness. To our knowledge, no studies have examined the fitness implications when a fish, without notable hearing specialization, experiences TTS. Popper et al. (2014) suggested that fishes experiencing TTS may have a decreased ability to communicate detect predators or prey, or assess their environment. However, these species are able to rely on alternative mechanisms (e.g., sight, later line system) to detect prey, avoid predators, spawn, and to orient in the water column (Popper et al. 2014). Additionally, hearing is not thought to play a role in salmonid migration (Putnam et al. 2013). Because any TTS experienced will be temporary and the ESA-listed fish species considered in the opinion are able to rely on alternative mechanisms for these essential life functions, instances of TTS will not kill or injure any fish, nor will any such instances create the likelihood of injury by annoying a fish to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering.

The precise expected response of ESA-listed salmonids to low-frequency acoustic energy is not completely understood due to a lack of sufficient experimental and observational data for this taxon. Given the signal type and level of exposure to the low frequency sounds produced during the seismic survey activities (from the airgun array or the multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler), we do not expect frequent exposure or significant responses from any exposures (including significant behavioral adjustments, TTS or PTS, injury, or mortality). Based on the discussion above, it is likely that the proposed seismic survey activities will be audible to ESA-listed salmonids found in the action area, and as such, may elicit minor behavioral responses. The most likely response to the airgun array and multi-beam echosounder, sub-bottom profiler, acoustic Doppler current profiler, and acoustic release transponder, if any, will be minor temporary changes in behavior including increased swimming rate, avoidance of the sound source, or changes in orientation to the sound source, none of which rise to the level to take.

Based on the evidence provided above, acoustic noise resulting the the National Science Foundation and Lamont-Doherty Earth Observatory's proposed seismic survey activities are not expected to appreciably reduce the likelihood of the survival of ESA-listed salmonids by reducing the reproduction, numbers, or distribution of those DPSs and ESUs. Therefore, the

effect of exposure to acoustic noise stressors that may result in TTS and/or behavior response is insignificant. Any TTS or behavioral response experienced by these fish will not rise to the level of ESA take and will not have fitness level consequences at the individual or population level. Therefore, we conclude that the National Science Foundation and Lamont-Doherty Earth Observatory's proposed seismic survey activities is not likely to adversely affect ESA-listed salmonids. As a result, these species will not be considered further in this consultation.

7.3.4 Sturgeon

Sub-adult and adult Southern DPS of green sturgeon occur in the marine environment and may be exposed to the proposed action. There are gaps in our understanding about the offshore marine environment of green sturgeon. Southern DPS of green sturgeon consists of populations originating from coastal watersheds south of the Eel River, California. Sub-adult and adult green sturgeon spend most of their lives in the marine environment, at water depths between 20 to 70 meters (66 to 230 feet) (NMFS 2015a).

The research vessel associated with the proposed seismic survey activities will transit through waters that may be occupied by Southern DPS of green sturgeon when in route to the proposed seismic survey activities tracklines. However, all potential stressors resulting from the transit were discounted in Section 6. Furthermore, as stated in Section 4, the tracklines during the seismic survey will take place in water depths from 1,400 to 2,800 meters (4,593 to 9,186 feet). As a result, potential acoustic noise to Southern DPS of green sturgeon from the proposed seismic survey activities airgun array, multi-beam echosounder, sub-bottom profiler, acoustic Doppler current profiler, and acoustic release transponder is discountable. Therefore, we conclude that the National Science Foundation and Lamont-Doherty Earth Observatory's proposed seismic survey activities is not likely to adversely affect ESA-listed Southern DPS of green sturgeon. As a result, this species will not be considered further in this consultation.

7.3.5 Rockfish

ESA-listed Puget Sound/Georgia Basin DPS of bocaccio and Puget Sound/Georgia Basin DPS of yelloweye rockfish occur in the marine environment and may be exposed to the proposed action. Yelloweye rockfish use a broad depth range throughout their life history, with individuals recorded from 15 to 549 meters (49.2 to 1,801 feet). Juveniles settle in the shallowest depth of this range and move deeper as they get older. Adults are most commonly found from 91 to 180 meters (299 to 591 feet) (Drake et al. 2010). Boccacio adults inhabit waters from 12 to 478 meters (39 to 1,568 feet), but are most common depths of 50 to 250 meters (164 to 820 feet).

The R/V *Marcus G. Langseth* will transit through waters that may be occupied by ESA-listed rockfish when in route to the seismic survey activities tracklines. However, all potential stressors resulting from transit were discounted in Section 6. Furthermore, as stated in Section 4, the proposed tracklines during the seismic survey activities will take place in water depths from 1,400 to 2,800 meters (4,593 to 9,186 feet). As a result, potential acoustic noise from the proposed seismic survey activity's airgun array, multi-beam echosounder, sub-bottom profiler,

acoustic Doppler current profiler, and acoustic release tranponder is discountable. Therefore, we conclude that the National Science Foundation and Lamont-Doherty Earth Observatory's seismic survey activities is not likely to adversely affect ESA listed Puget Sound/Georgia Basin DPS of bocaccio and Puget Sound/Georgia Basin DPS of yelloweye rockfish. As a result, this species will not be considered further in this consultation.

7.3.6 Eulachon

ESA-listed Southern DPS of eulachon occur in the marine environment and may be exposed to the proposed action. Southern DPS of eulachon are found on the continental shelf off the U.S. West Coast and are most often at depth between 50 to 200 meters (164 to 656 feet) (Gustafson 2016).

The R/V *Marcus G. Langseth* will transit through waters that may be occupied by the Southern DPS of eulachon when in route to the seismic survey activities tracklines. However, all potential stressors resulting from transit were discounted in Section 6. Furthermore, as stated in Section 4, the proposed tracklines during the seismic survey activities will take place in water depths from 1,400 to 2,800 meters (4,593 to 9,186 feet). As a result, potential acoustic noise from the proposed seismic survey activity's airgun array, multi-beam echosounder, sub-bottom profiler, acoustic Doppler current profiler, and acoustic release tranponder is discountable. Therefore, we conclude that the National Science Foundation and Lamont-Doherty Earth Observatory's seismic survey activities is not likely to adversely affect ESA-listed Southern DPS of eulachon. As a result, this species will not be considered further in this consultation.

7.4 Designated Critical Habitat

As discussed in Section 4, the proposed action will take place in the Northeast Pacific Ocean, and include transit to and from Astoria, Oregon. Critical habitat has been designated for the leatherback turtle and Southern DPS of green sturgeon in the Pacific Ocean. and occurs in the action area and is discussed further below.

7.4.1 Leatherback Turtle Critical Habitat

In 2012, NMFS revised designated critical habitat for the leatherback turtle by designating additional areas within the Pacific Ocean (Figure 2). This designation includes approximately 43,798 square kilometers (16,910 square miles) stretching along the California coast from Point Arena to Point Arguello east of the 3,000 meter (9,842.4 feet) depth contour; and 64,760 square kilometers (25,004 square miles) stretching from Cape Flattery, Washington to Cape Blanco, Oregon east of the 2,000 meter (6,561.7 feet) depth contour. The designated areas comprise approximately 108,558 square kilometers (41,914 square miles) of marine habitat and include waters from the ocean surface down to a maximum depth of 80 meters (262 feet). NMFS has identified one physical and biological feature for the conservation of leatherback turtles in marine waters off the U.S. West Coast that includes the occurrence of prey species, primarily scyphomedusae (i.e., jellyfish) of the order Semaeostomeae (e.g., *Chrysaora*, *Aurelia*, *Phacellophora*, and *Cyanea*), of sufficient condition, distribution, diversity, abundance, and

density necessary to support individual as well as population growth, reproduction, and development of leatherback turtles (77 FR 4170).

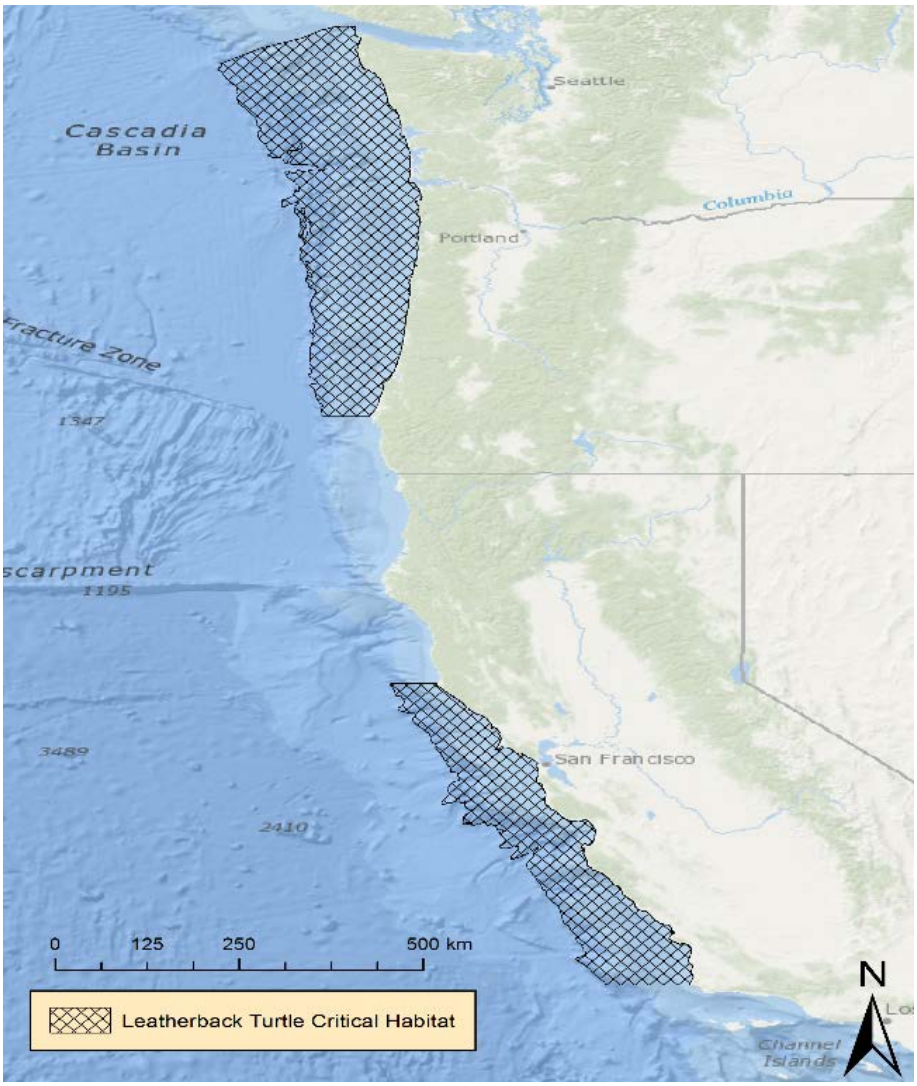

Figure 2. Map depicting leatherback turtle designated critical habitat along the United States Pacific Coast.

7.4.2 Green Sturgeon – Southern Distinct Population Segment Critical Habitat

In 2009, NMFS designated critical habitat for the Southern DPS of green sturgeon. Specific areas include coastal U.S. marine waters within 109.7 meters (359.9 feet) depth from Monterey Bay, California (including Monterey Bay), north to Cape Flattery, Washington, including the Strait of Juan de Fuca, Washington, to its U.S. boundary; the Sacramento River, lower Feather River, and lower Yuba River in California; the Sacramento-San Joaquin Delta and Suisun, San Pablo, and San Francisco bays in California; the lower Columbia River estuary; and certain coastal bays and estuaries in California (Humboldt Bay), Oregon (Coos Bay, Winchester Bay, Yaquina Bay, and Nehalem Bay), and Washington (Willapa Bay and Grays Harbor). NMFS designated

approximately 515 kilometers (320 miles) of freshwater river habitat, 2,323 square kilometers (11,421 square miles) of marine habitat, 784 kilometers (487 miles) of habitat within the Yolo and Sutter bypasses (Sacramento River, California) as critical habitat for Southern DPS of green sturgeon. The physical and biological features essential for Southern DPS of green sturgeon include freshwater riverine systems, estuarine habitats, and nearshore coastal marine areas that provide sufficient food resources, substrate type suitable for egg deposition, and development, water flow, water quality, migratory corridors, depth (greater than or equal to 5 meters [16.4 feet]), and sediment quality.

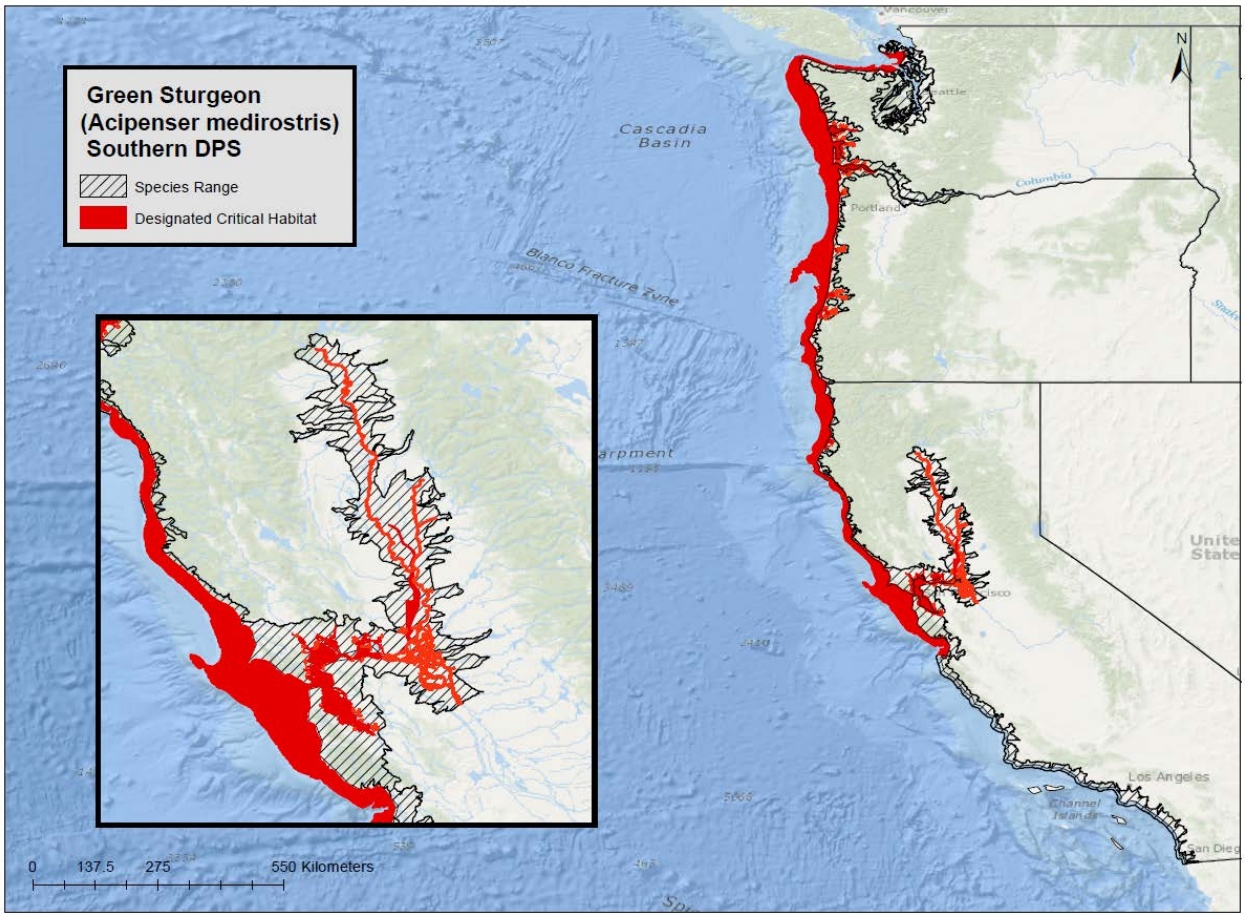

Figure 3. Map of geographic range (within the contiguous United States) and designated critical habitat for Southern distinct population segment of green sturgeon.

7.4.3 Effects to Designated Critical Habitat

7.4.3.1 Leatherback Turtle

While the proposed seismic survey activities transit will overlap with designated critical habitat for leatherback turtle described in Section 7.4.1, adverse effects to this critical habitat are unlikely to occur as a result of the proposed action. As shown in Figure 1 and Figure 2, the tracklines for the proposed seismic survey activities do not intersects with areas designated as

critical habitat for leatherback turtles in California, Oregon, and Washington. As a result, acoustic noise from the proposed seismic survey activities airgun array, multi-beam echosounder, sub-bottom profiler, acoustic Doppler current profiler, and acoustic release transponder are unlikely to impact the conservation value or reduction to prey species such as jellyfish (the only physical and biological feature for leatherback turtle critical habitat). Therefore, the effects of the proposed seismic survey activities is not likely to adversely affect critical habitat that has been designated for leatherback turtles and considered insignificant. As a result, we will not carry this critical habitat for this species further in this opinion.

7.4.3.2 Green Sturgeon – Southern Distinct Population Segment

While the proposed seismic survey activities transit will overlap with designated critical habitat for Southern DPS of gren sturgeon described in Section 7.4.2, adverse effects to this critical habitat are unlikely to occur as a result of the proposed action. As shown in Figure 1 and Figure 3, the tracklines for the proposed seismic survey activities do not intersect with areas designated as critical habitat for Southern DPS of green sturgeon in California, Oregon, and Washington. As a result, acoustic noise from the proposed seismic survey activities airgun array, multi-beam echosounder, sub-bottom profiler, acoustic Doppler current profiler, and acoustic release transponder are unlikely to impact the conservation value or physical and biological features for the critical habitat of Southern DPS of green sturgeon. Therefore, the effects of the proposed seismic survey activities are not likely to adversely affect critical habitat that has been designated for Southern DPS of green sturgeon and considered insignificant. As a result, we will not carry this critical habitat for this species further in this opinion.

8 SPECIES LIKELY TO BE ADVERSELY AFFECTED

This section identifies the ESA-listed species that occur within the action area (Figure 1) that may be affected by the proposed action (Table 9). All of the species potentially occurring within the action area are ESA-listed in Table 9, along with their regulatory status, designated critical habitat, and recovery plan references.

Table 9. Threatened and endangered species that may be affected by the National Science Foundation and Lamont-Doherty Earth Observatory's proposed action of a marine seismic survey in the Northeast Pacific Ocean.

Species	ESA Status	Critical Habitat	Recovery Plan
Marine Mammals – Cetaceans			
Blue Whale (*Balaenoptera musculus)*	E – 35 FR 18319	-- --	07/1998
Fin Whale (*Balaenoptera physalus)*	E – 35 FR 18319	-- --	07/2010 75 FR 47538
Humpback Whale (*Megaptera novaeangliae*) – Central America DPS	E – 81 FR 62259	-- --	11/1991

Species	ESA Status	Critical Habitat	Recovery Plan
Humpback Whale (*Megaptera novaeangliae*) – Mexico DPS	T – 81 FR 62259	-- --	11/1991
Sei Whale (*Balaenoptera borealis*)	E – 35 FR 18319	-- --	12/2011 76 FR 43985
Sperm Whale (*Physeter macrocephalus*)	E – 35 FR 18319	-- --	12/2010 75 FR 81584
Marine Mammals – Pinnipeds			
Guadalupe Fur Seal (*Arctocephalus townsendi*)	T – 50 FR 51252	-- --	-- --
Marine Reptiles			
Leatherback Turtle (*Dermochelys coriacea*)	E – 35 FR 8491	44 FR 17710 and 77 FR 4170*	63 FR 28359

*Critical habitat has been designated, but it is outside the action area and will not be affected by the proposed action.
DPS=Distinct Population Segment
E=Endangered
T=Threatened

9 Status of Species Likely to be Adversely Affected

This section identifies and examines the status of each species that would be adversely affected by the proposed action. The status includes the existing level of risk that the ESA-listed species face, based on parameters considered in documents such as recovery plans, status reviews, and ESA-listing decisions. The species' status section helps to inform the description of the species' current "reproduction, numbers, or distribution," which is part of the jeopardy determination as described in 50 C.F.R. §402.02. More detailed information on the status and trends of these ESA-listed species, and their biology and ecology can be found in the listing regulations and critical habitat designations published in the *Federal Register*, status reviews, recovery plans, and on this NMFS websites: http://www.nmfs.noaa.gov/pr/species/index.htm, among others.

This section also examines the condition of critical habitat throughout the designated area (such as various watersheds and coastal and marine environments that make up the designated area), and discusses the condition and current function of designated critical habitat, including the essential physical and biological features that contribute to that conservation value of the critical habitat.

One factor affecting the rangewide status of marine mammals, sea turtles, and aquatic habitat at large is climate change. Climate change will be discussed in the *Environmental Baseline* section (Section 10).

9.1 Blue Whale

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

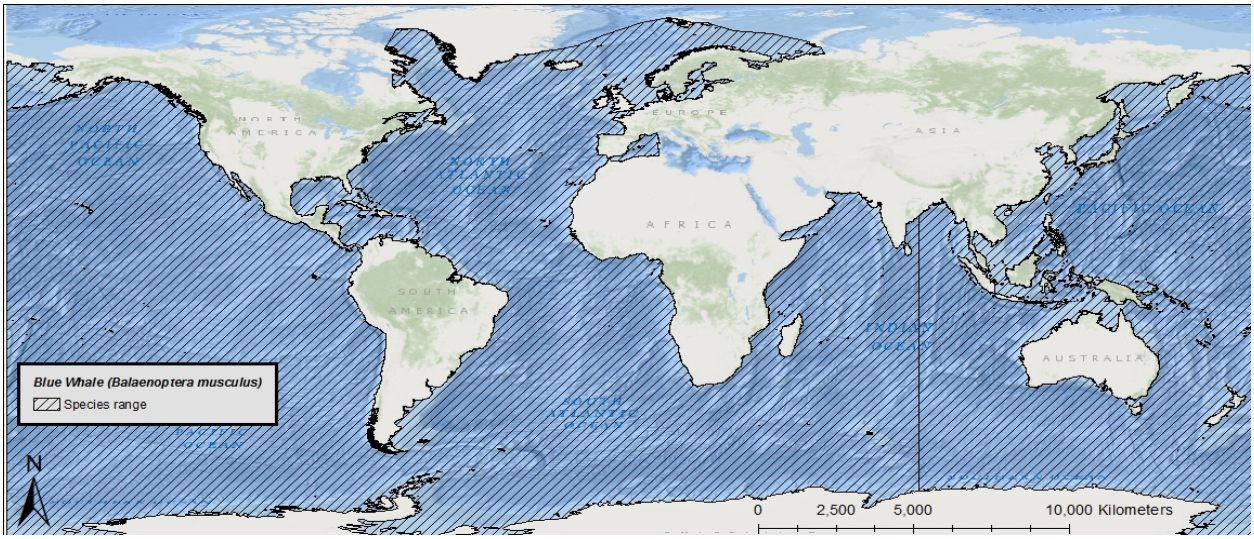

Figure 4. Map identifying the range of the endangered blue whale.

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

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

9.1.1 Life History

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

9.1.2 Population Dynamics

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

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

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

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

In general, distribution is driven largely by food requirements; blue whales are more likely to occur in waters with dense concentrations of their primary food source, krill. While they can be found in coastal waters, they are thought to prefer waters further offshore (Figure 4). In the North Atlantic Ocean, the blue whale range extends form the subtropics to the Greenland Sea. They are most frequently sighted in waters of eastern Canada with a majority of sightings taking place in the Gulf of St. Lawrence. In the North Pacific Ocean, blue whales range from Kamchatka to

southern Japan in the west and from the Gulf of Alaska and California to Costa Rica in the east. They primarily occur off the Aleutian Islands and the Bering Sea. In the northern Indian Ocean, there is a "resident" population of blue whales with sightings being reported from the Gulf of Aden, Persian Gulf, Arabian Sea, and across the Bay of Bengal to Burma and the Strait of Malacca. In the Southern Hemisphere, distributions of subspecies *(B. m. intermedia* and *B. m. brevicauda*) can be segregated. The subspecies *B. m. intermedia* occurs in relatively high latitudes south of the "Antarctic Convergence" (located between 48 and 61degrees South latitude) and close to the ice edge. The subspecies *B. m. brevicauda* is typically distributed north of the Antarctic Convergence.

9.1.3 Vocalization and Hearing

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

Calls are short-duration sounds (two to five seconds) that are transient and frequency-modulated, having a higher frequency range and shorter duration than song units and often sweeping down in frequency (20 to 80 Hertz), with seasonally variable occurrence. Blue whale calls have high acoustic energy, with reports of source levels ranging from 180 to 195 dB re: 1 µPa at 1 meter (Aburto et al. 1997; Berchok et al. 2006; Clark and Gagnon 2004; Cummings and Thompson 1971; Ketten 1998; Mcdonald et al. 2001; Samaran et al. 2010). Calling rates of blue whales tend to vary based on feeding behavior. For example, blue whales make seasonal migrations to areas of high productivity to feed, and vocalize less at the feeding grounds then during migration (Burtenshaw et al. 2004). Stafford et al. (2005) recorded the highest calling rates when blue whale prey was closest to the surface during its vertical migration. Wiggins et al. (2005) reported the same trend of reduced vocalization during daytime foraging followed by an increase at dusk as prey moved up into the water column and dispersed. Oleson et al. (2007c) reported higher calling rates in shallow diving (less than 30 meters [98.4 feet] whales), while deeper diving whales (greater than 50 meters [154 feet]) were likely feeding and calling less.

Although general characteristics of blue whale calls are shared in distinct regions (Mcdonald et al. 2001; Mellinger and Clark 2003; Rankin et al. 2005; Thompson et al. 1996), some variability appears to exist among different geographic areas (Rivers 1997). Sounds in the North Atlantic Ocean have been confirmed to have different characteristics (i.e., frequency, duration, and repetition) than those recorded in other parts of the world (Berchok et al. 2006; Mellinger and Clark 2003; Samaran et al. 2010). Clear differences in call structure suggestive of separate populations for the western and eastern regions of the North Pacific Ocean have also been reported (Stafford et al. 2001); however, some overlap in calls from the geographically distinct regions have been observed, indicating that the whales may have the ability to mimic calls (Stafford and Moore 2005). In Southern California, blue whales produce three known call types: Type A, B, and D. B calls are stereotypic of blue whale population found in the eastern North

Pacific (McDonald et al. 2006b) and are produced exclusively by males and associated with mating behavior (Oleson et al. 2007a). These calls have long durations (20 seconds) and low frequencies (10 to 100 Hertz); they are produced either as repetitive sequences (song) or as singular calls. The B call has a set of harmonic tonals, and may be paired with a pulsed Type A call. D calls are produced in highest numbers during the late spring and early summer and in diminished numbers during the fall, when A-B song dominates blue whale calling (Hildebrand et al. 2011; Hildebrand et al. 2012; Oleson et al. 2007c).

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

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

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

capability, blue whales belong to the low frequency group, which have a hearing range of 7 Hertz to 35 kiloHertz (NOAA 2018).

9.1.4 Status

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

9.1.5 Critical Habitat

No critical habitat has been designated for the blue whale.

9.1.6 Recovery Goals

In response to the current threats facing the species, NMFS developed goals to recover blue whale populations. These threats will be discussed in further detail in the *Environmental Baseline* section (Section 10) of this opinion. See the 1998 Final Recovery Plan for the Blue Whale for complete downlisting/delisting criteria for each of the following recovery goals.

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

9.2 Fin Whale

The fin whale is a large, widely distributed baleen whale found in all major oceans and comprised of three subspecies: *B. p. physalus* in the Northern Hemisphere, and *B. p. quoyi* and *B. p. patachaonica* (a pygmy form) in the Southern Hemisphere (Figure 5).

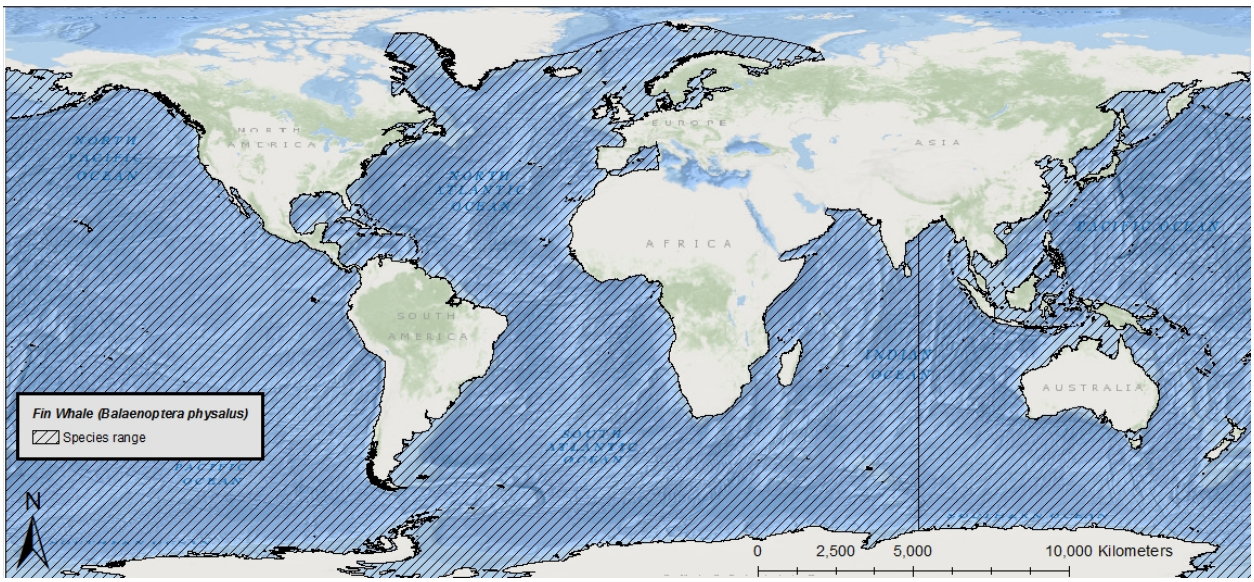

Figure 5. Map identifying the range of the endangered fin whale.

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

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

9.2.1 Life History

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

9.2.2 Population Dynamics

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

The pre-exploitation estimate for the fin whale population in the North Pacific Ocean was 42,000 to 45,000 (Ohsumi and Wada 1974). In the North Atlantic Ocean, at least 55,000 fin whales were

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

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

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

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

9.2.3 Vocalization and Hearing

Fin whales produce a variety of low frequency sounds in the 10 to 200 Hertz range (Edds 1988; Thompson et al. 1992; Watkins 1981; Watkins et al. 1987). Typical vocalizations are long, patterned pulses of short duration (0.5 to two seconds) in the 18 to 35 Hertz range, but only males are known to produce these (Clark et al. 2002; Patterson and Hamilton 1964). The most typically recorded call is a 20 Hertz pulse lasting about one second, and reaching source levels of 189 ±4 dB re: 1 µPa at 1 meter (Charif et al. 2002; Clark et al. 2002; Edds 1988; Richardson et

al. 1995b; Sirovic et al. 2007; Watkins 1981; Watkins et al. 1987). These pulses frequently occur in long sequenced patterns, are down swept (e.g., 23 to 18 Hertz), and can be repeated over the course of many hours (Watkins et al. 1987). In temperate waters, intense bouts of these patterned sounds are very common from fall through spring, but also occur to a lesser extent during the summer in high latitude feeding areas (Clark and Charif 1998). Richardson et al. (1995b) reported this call occurring in short series during spring, summer, and fall, and in repeated stereotyped patterns in winter. The seasonality and stereotype nature of these vocal sequences suggest that they are male reproductive displays (Watkins 1981; Watkins et al. 1987); a notion further supported by data linking these vocalizations to male fin whales only (Croll et al. 2002). In Southern California, the 20 Hertz pulses are the dominant fin whale call type associated both with call-counter-call between multiple animals and with singing (U.S. Navy 2010; U.S. Navy 2012). An additional fin whale sound, the 40 Hertz call described by Watkins (1981), was also frequently recorded, although these calls are not as common as the 20 Hertz fin whale pulses. Seasonality of the 40 Hertz calls differed from the 20 Hertz calls, since 40 Hertz calls were more prominent in the spring, as observed at other sites across the northeast Pacific Ocean (Sirovic et al. 2012). Source levels of Eastern Pacific Ocean fin whale 20 Hertz calls has been reported as 189 ± 5.8 dB re: 1 µPa at 1 meter (Weirathmueller et al. 2013). Some researchers have also recorded moans of 14 to 118 Hertz, with a dominant frequency of 20 Hertz, tonal vocalizations of 34 to 150 Hertz, and songs of 17 to 25 Hertz (Cummings and Thompson 1994; Edds 1988; Watkins 1981). In general, source levels for fin whale vocalizations are 140 to 200 dB re: 1 µPa at 1 meter (see also Clark and Gagnon 2004; as compiled by Erbe 2002b). The source depth of calling fin whales has been reported to be about 50 meters (164 feet) (Watkins et al. 1987). Although acoustic recordings of fin whales from many diverse regions show close adherence to the typical 20-Hertz bandwidth and sequencing when performing these vocalizations, there have been slight differences in the pulse patterns, indicative of some geographic variation (Thompson et al. 1992; Watkins et al. 1987).

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

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

maximum sensitivity to sounds in the 1 to 2 kiloHertz range. In terms of functional hearing capability, fin whales belong to the low-frequency group, which have a hearing range of 7 Hertz to 35 kiloHertz (NOAA 2018).

9.2.4 Status

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

9.2.5 Critical Habitat

No critical habitat has been designated for the fin whale.

9.2.6 Recovery Goals

In response to the current threats facing the species, NMFS developed goals to recover fin whale populations. These threats will be discussed in further detail in the *Environmental Baseline* section (Section 10) of this opinion. See the 2010 Final Recovery Plan for the fin whale for complete downlisting/delisting criteria for both of the following recovery goals.

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

9.3 Humpback Whale – Central America Distinct Population Segment

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

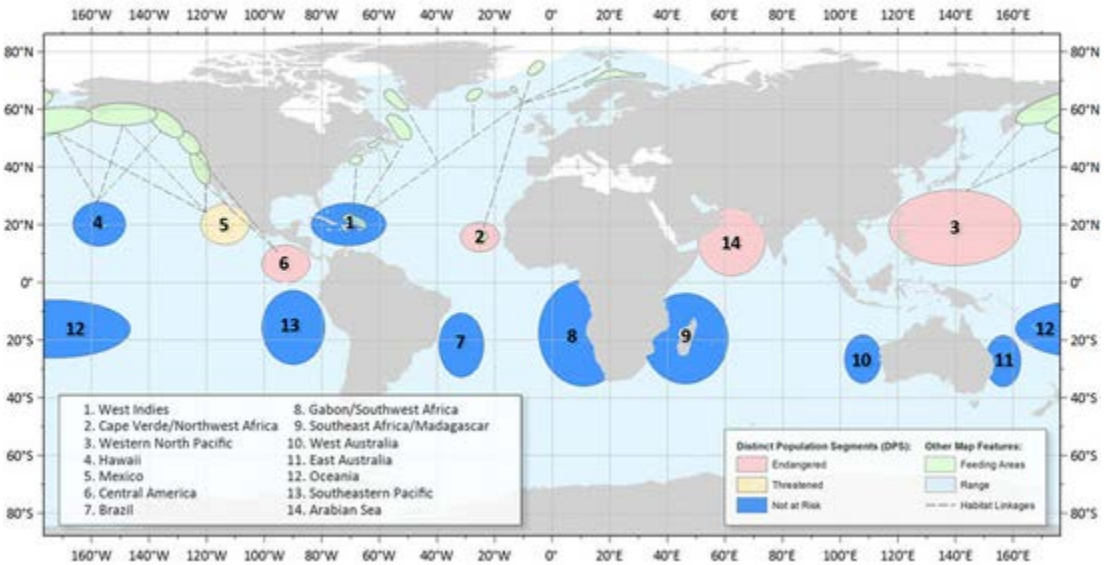

Figure 6. Map identifying 14 distinct population segments with one threatened and four endangered, based on primarily breeding location of the humpback whale, their range, and feeding areas (Bettridge et al. 2015).

Humpback whales are distinguishable from other whales by long pectoral fins and are typically dark grey with some areas of white. They humpback whale was originally listed as endangered on December 2, 1970 (35 FR 18319). Since then, NMFS has designated 14 DPSs with four identified as endangered (Cape Verde Islands/Northwest Africa, Western North Pacific, Central America, and Arabian Sea) and one as threatened (Mexico).

Information available from the recovery plan (NMFS 1991), recent stock assessment reports (Carretta et al. 2016a; Muto et al. 2016; Waring et al. 2016), the status review (Bettridge et al. 2015), and the final listing were used to summarize the life history, population dynamics and status of the species as follows.

9.3.1 Life History

Humpback whales can live, on average, 50 years. They have a gestation period of 11 to 12 months, and calves nurse for one year. Sexual maturity is reached between five to 11 years of age with an average calving interval of two to three years. Humpback whales mostly inhabit coastal and continental shelf waters. They winter at lower latitudes, where they calve and nurse, and summer at high latitudes, where they feed. Humpback whales exhibit a wide range of foraging behaviors and feed on a range of prey types, including: small schooling fishes, euphausiids, and other large zooplankton (Bettridge et al. 2015).

9.3.2 Population Dynamics

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

The global, pre-exploitation estimate for humpback whales is 1,000,000 (Roman and Palumbi 2003). The current abundance of the Central America DPS is 411. A population growth rate is currently unavailable for the Central America DPS of humpback whales.

For humpback whales, DPSs that have a total population size of 2,000 to 2,500 individuals or greater provide for maintenance of genetic diversity resulting in long-term persistence and protection from substantial environmental variance and catastrophes. Distinct population segments that have a total population of 500 individuals or less may be at a greater risk of extinction due to genetic risks resulting from inbreeding. Population at low densities (less than one hundred) are more likely to suffer from the 'Allee" effect, where inbreeding and the heightened difficulty of finding mates reduces the population growth rate in proportion with reducing density. The Central America DPS has just below 500 individuals and so may be subject to genetic risks due to inbreeding and moderate environmental variance (Bettridge et al. 2015).

The Central America DPS is composed of humpback whales that breed along the Pacific coast of Costa Rica, Panama, Guatemala, El Salvador, Honduras, and Nicaragua. This DPS feeds almost exclusively offshore of California and Oregon in the eastern Pacific Ocean, with only a few individuals identified at the northern Washington – southern British Columbia feeding grounds (Figure 6).

9.3.3 Vocalization and Hearing

Humpback whale vocalization is much better understood than is hearing. Different sounds are produced that correspond to different functions: feeding, breeding, and other social calls (Dunlop et al. 2008). Males sing complex sounds while in low-latitude breeding areas in a frequency range of 20 Hertz to 4 kiloHertz with estimated source levels from 144 to 174 dB (Au et al. 2006a; Au et al. 2000; Frazer and Mercado Iii 2000; Richardson et al. 1995d; Winn et al. 1970b). Males also produce sounds associated with aggression, which are generally characterized by frequencies between 50 Hertz to 10 kiloHertz with most energy below 3 kiloHertz (Silber 1986b; Tyack 1983b). Such sounds can be heard up to 9 kilometers (4.9 nautical miles) away (Tyack 1983b). Other social sounds from 50 Hertz to 10 kiloHertz (most energy below 3 kiloHertz) are also produced in breeding areas (Richardson et al. 1995d; Tyack 1983b). While in northern feeding areas, both sexes vocalize in grunts (25 Hertz to 1.9 kiloHertz), pulses (25 to 89 Hertz) and songs (ranging from 30 Hertz to 8 kiloHertz but dominant frequencies of 120 Hertz to 4 kiloHertz), which can be very loud (175 to 192 dB re: 1 µPa at 1 meter) (Au et al. 2000; Erbe 2002c; Payne 1985; Richardson et al. 1995d; Thompson et al. 1986b). However, humpback whales tend to be less vocal in northern feeding areas than in southern breeding areas (Richardson et al. 1995d). NMFS classified humpback whales in the low-frequency cetacean (i.e., baleen whale) functional hearing group. As a group, it is estimated that baleen whales can hear frequencies between 0.007 and 30 Hertz (NOAA 2013). Houser et al. (2001) produced a mathematical model of humpback whale hearing sensitivity based on the anatomy of the humpback whale ear. Based on the model, they concluded that humpback whales will be sensitive to sound in frequencies ranging from 0.7 to 10 kiloHertz, with a maximum sensitivity between 2 to 6 kiloHertz.

Humpback whales are known to produce three classes of vocalizations: (1) “songs” in the late fall, winter, and spring by solitary males; (2) social sounds made by calves (Zoidis et al. 2008) or within groups on the wintering (calving) grounds; and (3) social sounds made on the feeding grounds (Thomson and Richardson 1995a). The best-known types of sounds produced by humpback whales are songs, which are thought to be reproductive displays used on breeding grounds and sung only by adult males (Clark and Clapham 2004; Gabriele and Frankel. 2002; Helweg et al. 1992; Schevill et al. 1964; Smith et al. 2008). Singing is most common on breeding grounds during the winter and spring months, but is occasionally heard in other regions and seasons (Clark and Clapham 2004; Gabriele and Frankel. 2002; McSweeney et al. 1989). (Au et al. 2006b) noted that humpback whales off Hawaii tended to sing louder at night compared to the day. There is a geographical variation in humpback whale song, with different populations

singing a basic form of a song that is unique to their own group. However, the song evolves over the course of a breeding season but remains nearly unchanged from the end of one season to the start of the next (Payne et al. 1983). The song is an elaborate series of patterned vocalizations that are hierarchical in nature, with a series of songs (‘song sessions’) sometimes lasting for hours (Payne and Mcvay 1971). Components of the song range from below 20 Hz up to 4 kHz, with source levels measured between 151 and 189 dB re: 1 µPa-m and high frequency harmonics extending beyond 24 kHz (Au et al. 2006b; Winn et al. 1970b).Social calls range from 20 Hertz to 10 kiloHertz, with dominant frequencies below 3 kiloHertz (D'Vincent et al. 1985; Dunlop et al. 2008; Silber 1986b; Simao and Moreira 2005). Female vocalizations appear to be simple; Simao and Moreira (2005) noted little complexity.

“Feeding” calls, unlike song and social sounds are a highly stereotyped series of narrow-band trumpeting calls. These calls are 20 Hertz to 2 kiloHertz, less than one second in duration, and have source levels of 162 to 192 dB re: 1 µPa-m (D'Vincent et al. 1985; Thompson et al. 1986b). The fundamental frequency of feeding calls is approximately 500 Hz (D'Vincent et al. 1985; Thompson et al. 1986b). The acoustics and dive profiles associated with humpback whale feeding behavior in the northwest Atlantic Ocean has been documented with DTAGs (Stimpert et al. 2007). Underwater lunge behavior was associated with nocturnal feeding at depth and with multiple boats of broadband click trains that were acoustically different from toothed whale echolocation: (Stimpert et al. 2007) termed these sounds “mega-clicks” which showed relatively low received levels at the DTAGs (143 to 154 dB re: 1 µPa), with the majority of acoustic energy below 2 kiloHertz.

In terms of functional hearing capability, humpback whales belong to low frequency cetaceans which have a hearing range of 7 Hertz to 22 kiloHertz (Southall et al. 2007a). Humpback whale audiograms using a mathematical model based on the internal structure of the ear estimate sensitivity is from 700 Hertz to 10 kiloHertz, with maximum relative sensitivity between 2 kiloHertz and 6 kiloHertz (Ketten and Mountain 2014). Research by Au et al. (2001) and Au et al. (2006b) off Hawaii indicated the presence of high frequency harmonics in vocalizations up to and beyond 24 kiloHertz. While recognizing this was the upper limit of the recording equipment, it does not demonstrate that humpback whales can actually hear those harmonics, which may simply be correlated harmonics of the frequency fundamental in the humpback whale song. The ability of humpback whales to hear frequencies around 3 kiloHertz may have been demonstrated in a playback study. Maybaum (1990b) reported that humpback whales showed a mild response to a handheld sonar marine mammal detection and location device with frequency of 3.3 kiloHertz at 219 dB re: 1 µPa-m or frequency sweep of 3.1 to 3.6 kiloHertz. In addition, the system had some low frequency components (below 1 kiloHertz) which may have been an artifact of the acoustic equipment. This possible artifact may have affected the response of the whales to both the control and sonar playback conditions.

9.3.4 Status

Humpback whales were originally listed as endangered because of past commercial whaling, and the five DPSs that remain listed (Cape Verde Islands/Northwest Africa, Western North Pacific, Central America, Arabian Sea, and Mexico) have likely not yet recovered from this. Prior to commercial whaling, hundreds of thousands of humpback whales existed. Global abundance declined to the low thousands by 1968, the last year of substantial catches (IUCN 2012). Humpback whales may be killed under "aboriginal subsistence whaling" and "scientific permit whaling" provisions of the International Whaling Commission. Additional threats include ship strikes, fisheries interactions (including entanglement), energy development, harassment from whaling watching noise, harmful algal blooms, disease, parasites, and climate change. The species' large population size and increasing trends indicate that it is resilient to current threats, but the Central America DPS still faces a risk of extinction.

9.3.5 Critical Habitat

No critical habitat has been designated for humpback whales.

9.3.6 Recovery Goals

In response to the current threats facing the species, NMFS developed goals to recover humpback whale populations. These threats will be discussed in further detail in the *Environmental Baseline* section (Section 10) of this opinion. See the 1991 Final Recovery Plan for the humpback whale for the complete downlisting/delisting criteria for each of the four following recovery goals:

1. Maintain and enhance habitats used by humpback whales currently or historically.
2. Identify and reduce direct human-related injury and mortality.
3. Measure and monitor key population parameters.
4. Improve administration and coordination of recovery program for humpback whales.

9.4 Humpback Whale – Mexico Distinct Population Segment

The humpback whale is a widely distributed baleen whale found in all major oceans (Figure 6). Humpback whales are distinguishable from other whales by long pectoral fins and are typically dark grey with some areas of white. They humpback whale was originally listed as endangered on December 2, 1970 (35 FR 18319). Since then, NMFS has designated 14 DPSs with four identified as endangered (Cape Verde Islands/Northwest Africa, Western North Pacific, Central America, and Arabian Sea) and one as threatened (Mexico).

Information available from the recovery plan (NMFS 1991), recent stock assessment reports (Carretta et al. 2016a; Muto et al. 2016; Waring et al. 2016), the status review (Bettridge et al. 2015), and the final listing were used to summarize the life history, population dynamics and status of the species as follows.

9.4.1 Life History

Humpback whales can live, on average, 50 years. They have a gestation period of 11 to 12 months, and calves nurse for one year. Sexual maturity is reached between five to 11 years of age with an average calving interval of two to three years. Humpback whales mostly inhabit coastal and continental shelf waters. They winter at lower latitudes, where they calve and nurse, and summer at high latitudes, where they feed. Humpback whales exhibit a wide range of foraging behaviors and feed on a range of prey types, including: small schooling fishes, euphausiids, and other large zooplankton (Bettridge et al. 2015).

9.4.2 Population Dynamics

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

The global, pre-exploitation estimate for humpback whales is 1,000,000 (Roman and Palumbi 2003). The current abundance of the Mexico DPS is unavailable. A population growth rate is currently unavailable for the Mexico DPS of humpback whales.

For humpback whales, DPSs that have a total population size of 2,000 to 2,500 individuals or greater provide for maintenance of genetic diversity resulting in long-term persistence and protection from substantial environmental variance and catastrophes. Distinct population segments that have a total population of 500 individuals or less may be at a greater risk of extinction due to genetic risks resulting from inbreeding. Population at low densities (less than one hundred) are more likely to suffer from the 'Allee" effect, where inbreeding and the heightened difficulty of finding mates reduces the population growth rate in proportion with reducing density. The Mexico DPS is estimated to have more than 2,000 individuals and thus, should have enough genetic diversity for long-term persistence and protection from substantial environmental variance and catastrophes (Bettridge et al. 2015).

The Mexico DPS is composed of humpback whales that breed along the Pacific coast of mainland Mexico, and the Revillagigedos Islands, and transit through the Baja California Peninsula coast. This DPS feeds across a broad geographic range from California to the Aleutian Islands, with concentrations in California-Oregon, northern Washington-southern British Columbia, northern and western Gulf of Alaska, and Bering Sea feeding grounds (Figure 6) (81 FR 62259).

9.4.3 Vocalization and Hearing

Humpback whale vocalization is much better understood than is hearing. Different sounds are produced that correspond to different functions: feeding, breeding, and other social calls (Dunlop et al. 2008). Males sing complex sounds while in low-latitude breeding areas in a frequency range of 20 Hertz to 4 kiloHertz with estimated source levels from 144 to 174 dB (Au et al. 2006a; Au et al. 2000; Frazer and Mercado Iii 2000; Richardson et al. 1995d; Winn et al. 1970b).

Males also produce sounds associated with aggression, which are generally characterized by frequencies between 50 Hertz to 10 kiloHertz with most energy below 3 kiloHertz (Silber 1986b; Tyack 1983b). Such sounds can be heard up to 9 kilometer (4.9 nautical miles) away (Tyack 1983b). Other social sounds from 50 Hertz to 10 kiloHertz (most energy below 3 kiloHertz) are also produced in breeding areas (Richardson et al. 1995d; Tyack 1983b). While in northern feeding areas, both sexes vocalize in grunts (25 Hertz to 1.9 kiloHertz), pulses (25 to 89 Hertz) and songs (ranging from 30 Hertz to 8 kiloHertz but dominant frequencies of 120 Hertz to 4 kiloHertz), which can be very loud (175 to 192 dB re: 1 µPa at 1 meter) (Au et al. 2000; Erbe 2002c; Payne 1985; Richardson et al. 1995d; Thompson et al. 1986b). However, humpback whales tend to be less vocal in northern feeding areas than in southern breeding areas (Richardson et al. 1995d). NMFS classified humpback whales in the low-frequency cetacean (i.e., baleen whale) functional hearing group. As a group, it is estimated that baleen whales can hear frequencies between 0.007 and 30 Hertz (NOAA 2013). Houser et al. (2001) produced a mathematical model of humpback whale hearing sensitivity based on the anatomy of the humpback whale ear. Based on the model, they concluded that humpback whales would be sensitive to sound in frequencies ranging from 0.7 to 10 kiloHertz, with a maximum sensitivity between 2 to 6 kiloHertz.

Humpback whales are known to produce three classes of vocalizations: (1) “songs” in the late fall, winter, and spring by solitary males; (2) social sounds made by calves (Zoidis et al. 2008) or within groups on the wintering (calving) grounds; and (3) social sounds made on the feeding grounds (Thomson and Richardson 1995a). The best-known types of sounds produced by humpback whales are songs, which are thought to be reproductive displays used on breeding grounds and sung only by adult males (Clark and Clapham 2004; Gabriele and Frankel. 2002; Helweg et al. 1992; Schevill et al. 1964; Smith et al. 2008). Singing is most common on breeding grounds during the winter and spring months, but is occasionally heard in other regions and seasons (Clark and Clapham 2004; Gabriele and Frankel. 2002; McSweeney et al. 1989). (Au et al. 2006b) noted that humpback whales off Hawaii tended to sing louder at night compared to the day. There is a geographical variation in humpback whale song, with different populations singing a basic form of a song that is unique to their own group. However, the song evolves over the course of a breeding season but remains nearly unchanged from the end of one season to the start of the next (Payne et al. 1983). The song is an elaborate series of patterned vocalizations that are hierarchical in nature, with a series of songs (‘song sessions’) sometimes lasting for hours (Payne and Mcvay 1971). Components of the song range from below 20 Hertz up to 4 kiloHertz, with source levels measured between 151 and 189 dB re: 1 µPa-meter and high frequency harmonics extending beyond 24 kiloHertz (Au et al. 2006b; Winn et al. 1970b). Social calls range from 20 Hertz to 10 kiloHertz, with dominant frequencies below 3 kiloHertz (D'Vincent et al. 1985; Dunlop et al. 2008; Silber 1986b; Simao and Moreira 2005). Female vocalizations appear to be simple; Simao and Moreira (2005) noted little complexity.

“Feeding” calls, unlike song and social sounds are a highly stereotyped series of narrow-band trumpeting calls. These calls are 20 Hertz to 2 kiloHertz, less than one second in duration, and

have source levels of 162 to 192 dB re: 1 µPa-m (D'Vincent et al. 1985; Thompson et al. 1986b). The fundamental frequency of feeding calls is approximately 500 kiloHertz (D'Vincent et al. 1985; Thompson et al. 1986b). The acoustics and dive profiles associated with humpback whale feeding behavior in the northwest Atlantic Ocean has been documented with DTAGs (Stimpert et al. 2007). Underwater lunge behavior was associated with nocturnal feeding at depth and with multiple boats of broadband click trains that were acoustically different from toothed whale echolocation: (Stimpert et al. 2007) termed these sounds “mega-clicks” which showed relatively low received levels at the DTAGs (143 to 154 dB re: 1 µPa), with the majority of acoustic energy below 2 kiloHertz.

In terms of functional hearing capability, humpback whales belong to low frequency cetaceans which have a hearing range of 7 Hertz to 22 kiloHertz (Southall et al. 2007a). Humpback whale audiograms using a mathematical model based on the internal structure of the ear estimate sensitivity is from 700 Hertz to 10 kiloHertz, with maximum relative sensitivity between 2 kiloHertz and 6 kiloHertz (Ketten and Mountain 2014). Research by Au et al. (2001) and Au et al. (2006b) off Hawaii indicated the presence of high frequency harmonics in vocalizations up to and beyond 24 kiloHertz. While recognizing this was the upper limit of the recording equipment, it does not demonstrate that humpback whales can actually hear those harmonics, which may simply be correlated harmonics of the frequency fundamental in the humpback whale song. The ability of humpback whales to hear frequencies around 3 kiloHertz may have been demonstrated in a playback study. Maybaum (1990b) reported that humpback whales showed a mild response to a handheld sonar marine mammal detection and location device with frequency of 3.3 kiloHertz at 219 dB re: 1 µPa-meter or frequency sweep of 3.1 to 3.6 kiloHertz. In addition, the system had some low frequency components (below 1 kiloHertz) which may have been an artifact of the acoustic equipment. This possible artifact may have affected the response of the whales to both the control and sonar playback conditions.

9.4.4 Status

Humpback whales were originally listed as endangered because of past commercial whaling, and the five DPSs that remain listed (Cape Verde Islands/Northwest Africa, Western North Pacific, Central America, Arabian Sea, and Mexico) have likely not yet recovered from this. Prior to commercial whaling, hundreds of thousands of humpback whales existed. Global abundance declined to the low thousands by 1968, the last year of substantial catches (IUCN 2012). Humpback whales may be killed under “aboriginal subsistence whaling” and “scientific permit whaling” provisions of the International Whaling Commission. Additional threats include ship strikes, fisheries interactions (including entanglement), energy development, harassment from whaling watching noise, harmful algal blooms, disease, parasites, and climate change. The species’ large population size and increasing trends indicate that it is resilient to current threats, but the Mexico DPS still faces a risk of becoming endangered within the foreseeable future throughout all or a significant portion of its range.

9.4.5 Critical Habitat

No critical habitat has been designated for humpback whales.

9.4.6 Recovery Goals

In response to the current threats facing the species, NMFS developed goals to recover humpback whale populations. These threats will be discussed in further detail in the *Environmental Baseline* section (Section 10) of this opinion. See the 1991 Final Recovery Plan for the humpback whale for the complete downlisting/delisting criteria for each of the four following recovery goals:

1. Maintain and enhance habitats used by humpback whales currently or historically.
2. Identify and reduce direct human-related injury and mortality.
3. Measure and monitor key population parameters.
4. Improve administration and coordination of recovery program for humpback whales.

9.5 Sei Whale

The sei whale is a widely distributed baleen whale found in all major oceans (Figure 7).

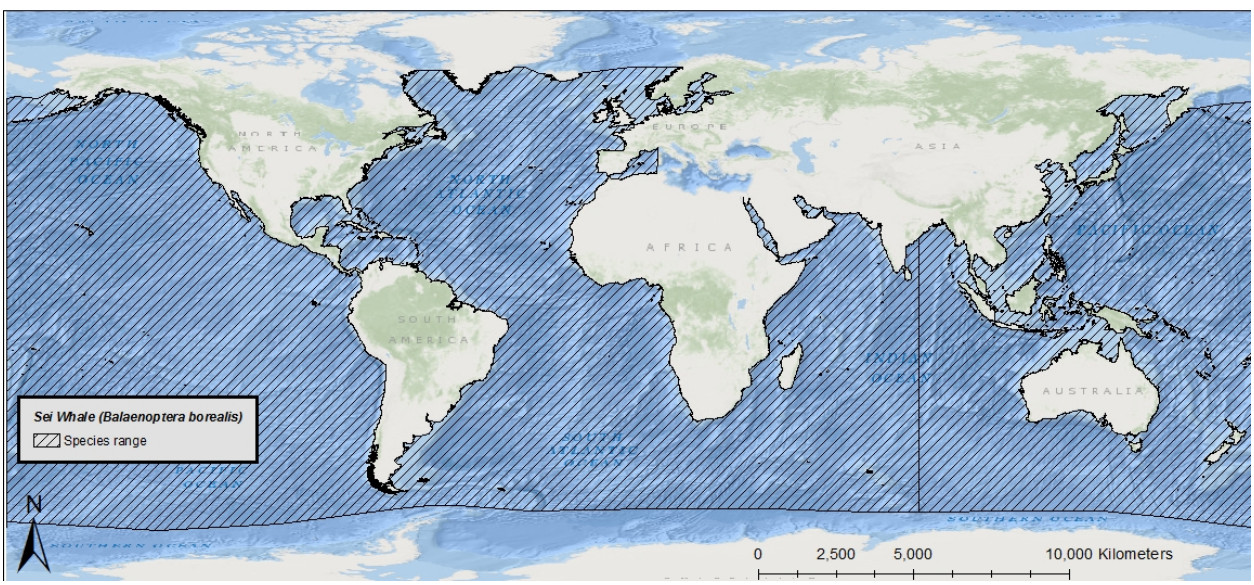

Figure 7. Map identifying the range of the endangered sei whale.

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

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

9.5.1 Life History

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

9.5.2 Population Dynamics

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

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

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

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

9.5.3 Vocalization and Hearing

Data on sei whale vocal behavior is limited, but includes records off the Antarctic Peninsula of broadband sounds in the 100 to 600 Hertz range with 1.5 second duration and tonal and upsweep

calls in the 200 to 600 Hertz range of one to three second durations (McDonald et al. 2005). Vocalizations from the North Atlantic Ocean consisted of paired sequences (0.5 to 0.8 seconds, separated by 0.4 to 1.0 seconds) of 10 to 20 short (4 milliseconds) frequency modulated sweeps between 1.5 to 3.5 kiloHertz (Thomson and Richardson 1995b). Source levels of 189 ±5.8 dB re: 1 µPa at 1 meter have been established for sei whales in the northeastern Pacific Ocean (Weirathmueller 2013).

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

9.5.4 Status

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

9.5.5 Critical Habitat

No critical habitat has been designated for the sei whale.

9.5.6 Recovery Goals

In response to the current threats facing the species, NMFS developed goals to recover sei whale populations. These threats will be discussed in further detail in the *Environmental Baseline* section (Section 10) of this opinion. See the 2011 Final Recovery Plan for the sei whale for complete downlisting/delisting criteria for both of the following recovery goals.

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

9.6 Sperm Whale

The sperm whale is a widely distributed species found in all major oceans (Figure 8).

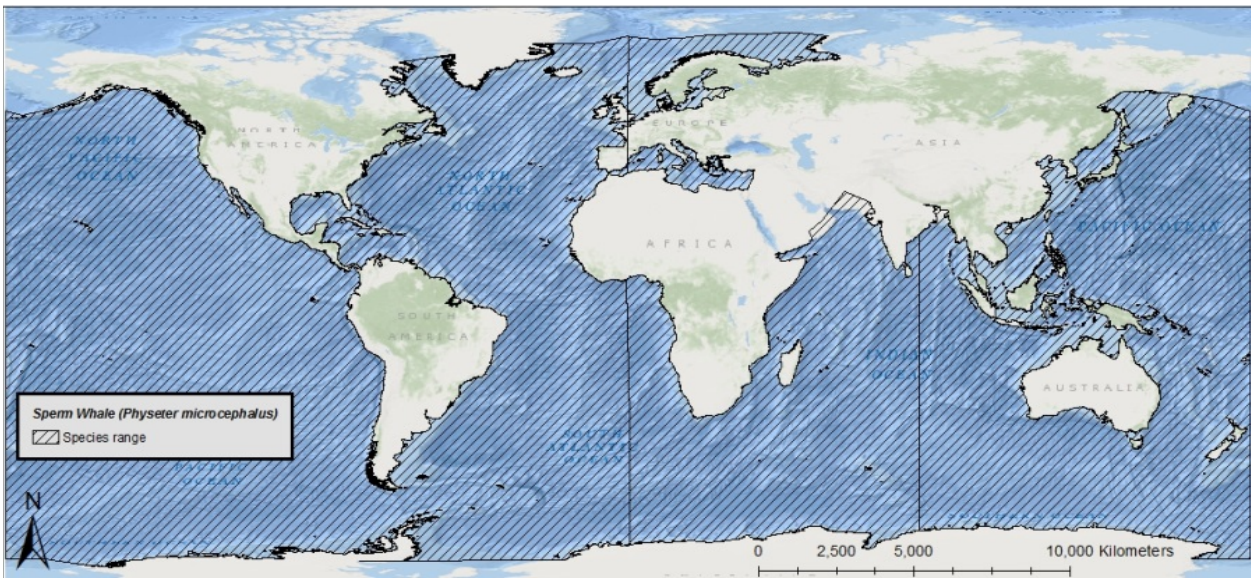

Figure 8: Map identifying the range of the endangered sperm whale.

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

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

9.6.1 Life History

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

9.6.2 Population Dynamics

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

The sperm whale is the most abundant of the large whale species, with total abundance estimates between 200,000 and 1,500,000. The most recent estimate indicated a global population of

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

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

9.6.3 Vocalization and Hearing

Sound production and reception by sperm whales are better understood than in most cetaceans. Recordings of sperm whale vocalizations reveal that they produce a variety of sounds, such as clicks, gunshots, chirps, creaks, short trumpets, pips, squeals, and clangs (Goold 1999). Sperm whales typically produce short duration repetitive broadband clicks with frequencies below 100 Hertz to greater than 30 kiloHertz (Watkins 1977) and dominant frequencies between 1 to 6 kiloHertz and 10 to 16 kiloHertz. Another class of sound, “squeals,” are produced with frequencies of 100 Hertz to 20 kiloHertz (e.g., Weir et al. 2007). The source levels of clicks can reach 236 dB re: 1 µPa at 1 meter, although lower source level energy has been suggested at around 171 dB re: 1 µPa at 1 meter (Goold and Jones 1995; Mohl et al. 2003; Weilgart and

Whitehead 1993; Weilgart and Whitehead 1997a). Most of the energy in sperm whale clicks is concentrated at around 2 to 4 kiloHertz and 10 to 16 kiloHertz (Goold and Jones 1995; Weilgart and Whitehead 1993). The clicks of neonate sperm whales are very different from typical clicks of adults in that they are of low directionality, long duration, and low frequency (between 300 Hertz and 1.7 kiloHertz) with estimated source levels between 140 to 162 dB re: 1 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 (Goold and Jones 1995; Miller et al. 2004; Weilgart and Whitehead 1993; Weilgart and Whitehead 1997a; Whitehead and Weilgart 1991). Creaks (rapid sets of clicks) are heard most frequently when sperm whales are foraging and engaged in the deepest portion of their dives, with inter-click intervals and source levels being altered during these behaviors (Laplanche et al. 2005; Miller et al. 2004). Clicks are also used during social behavior and intragroup interactions (Weilgart and Whitehead 1993). When sperm whales are socializing, they tend to repeat series of group-distinctive clicks (codas), which follow a precise rhythm and may last for hours (Watkins and Schevill 1977). Codas are shared between individuals in a social unit and are considered to be primarily for intragroup communication (Rendell and Whitehead 2004; Weilgart and Whitehead 1997a). Research in the South Pacific Ocean suggests that in breeding areas the majority of codas are produced by mature females (Marcoux et al. 2006). Coda repertoires have also been found to vary geographically and are categorized as dialects (Pavan et al. 2000; Weilgart and Whitehead 1997a). For example, significant differences in coda repertoire have been observed between sperm whales in the Caribbean Sea and those in the Pacific Ocean (Weilgart and Whitehead 1997a). Three coda types used by male sperm whales have recently been described from data collected over multiple years: these codas are associated with dive cycles, socializing, and alarm (Frantzis and Alexiadou 2008).

Our understanding of sperm whale hearing stems largely from the sounds they produce. The only direct measurement of hearing was from a young stranded individual from which auditory evoked potentials were recorded (Carder and Ridgway 1990). From this whale, responses support a hearing range of 2.5 to 60 kiloHertz and highest sensitivity to frequencies between 5 to 20 kiloHertz. Other hearing information consists of indirect data. For example, the anatomy of the sperm whale's inner and middle ear indicates an ability to best hear high-frequency to ultrasonic hearing (Ketten 1992). The sperm whale may also possess better low-frequency hearing than other odontocetes, although not as low as many baleen whales (Ketten 1992). Reactions to anthropogenic sounds can provide indirect evidence of hearing capability, and several studies have made note of changes seen in sperm whale behavior in conjunction with these sounds. For example, sperm whales have been observed to frequently stop echolocating in the presence of underwater pulses made by echosounders and submarine sonar (Watkins et al. 1985; Watkins and Schevill 1975a). In the Caribbean Sea, Watkins et al. (1985) observed that sperm whales exposed to 3.25 to 8.4 kiloHertz pulses (presumed to be from submarine sonar) interrupted their activities and left the area. Similar reactions were observed from artificial sound

generated by banging on a boat hull (Watkins et al. 1985). André et al. (1997) reported that foraging whales exposed to a 10 kiloHertz pulsed signal did not ultimately exhibit any general avoidance reactions: when resting at the surface in a compact group, sperm whales initially reacted strongly, and then ignored the signal completely. Thode et al. (2007) observed that the acoustic signal from the cavitation of a fishing vessel's propeller (110 dB re: 1 μPa^2-s between 250 Hertz and one kiloHertz) interrupted sperm whale acoustic activity and resulted in the animals converging on the vessel. Sperm whales have also been observed to stop vocalizing for brief periods when codas are being produced by other individuals, perhaps because they can hear better when not vocalizing themselves (Goold and Jones 1995). Because they spend large amounts of time at depth and use low frequency sound, sperm whales are likely to be susceptible to low frequency sound in the ocean (Croll et al. 1999). Nonetheless, sperm whales are considered to be part of the mid-frequency marine mammal hearing group, with a hearing range between 150 Hertz and 160 kiloHertz (NOAA 2018).

9.6.4 Status

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

9.6.5 Critical Habitat

No critical habitat has been designated for the sperm whale.

9.6.6 Recovery Goals

In response to the current threats facing the species, NMFS developed goals to recover sperm whale populations. These threats will be discussed in further detail in the *Environmental Baseline* section (Section 10) of this opinion. See the 2010 Final Recovery Plan for the sperm whale for complete downlisting/delisting criteria for both of the following recovery goals.

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

9.7 Guadalupe Fur Seal

Guadalupe fur seals were once found throughout Baja California, Mexico and along the California coast. Currently, the species breeds mainly on Guadalupe Island, Mexico, off the coast of Baja California. A smaller breeding colony, discovered in 1997, appears to have been established at Isla Benito del Este in the San Benito Archipelago, Baja California, Mexico (Belcher and T.E. Lee 2002) (Figure 9).

Figure 9. Map identifying the range of the threatened Guadalupe fur seal.

Guadalupe fur seals are medium sized, sexually dimorphic otariids (Belcher and T.E. Lee 2002; Reeves et al. 2002). Distinguishing characteristics of the Guadalupe fur seal include the digits on their hind flippers (all of similar length), large, long foreflippers, and unique vocalizations (Reeves et al. 2002). Guadalupe fur seals are dark brown to black, with the adult males having tan or yellow hairs at the back of their mane. Guadalupe fur seals were listed as threatened under the ESA on December 16, 1985 (50 FR 51252). Information available from recent stock assessment reports and available literature were used to summarize the life history, population dynamics and status of the species as follows.

9.7.1 Life History

Guadalupe fur seals prefer rocky habitats and can be found in natural recesses and caves (Fleischer 1978). Female Guadalupe fur seals arrive on beaches in June, with births occurring between mid-June to July (Pierson 1978); the pupping season is generally over by late July (Fleischer 1978). Females stay with pups for seven to eight days after parturition, and then alternate between foraging trips at sea and lactation on shore; nursing lasts about eight months

(Figureroa-Carranza 1994). Guadalupe fur seals feed mainly on squid species (Esperon-Rodriguez and Gallo-Reynoso 2013). Foraging trips can last between four to 24 days (average of 14 days). Tracking data show that adult females spend 75 percent of their time sea, and 25 percent at rest (Gallo-Reynoso et al. 1995).

9.7.2 Population Dynamics

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

At the time of listing, the population was estimated at 1,600 individuals, compared to approximately 30,000 before hunting began. A population was "rediscovered" in 1928 with the capture of two males on Guadalupe Island; from 1949 on, researchers reported sighting Guadalupe fur seals at Isla Cedros (near the San Benito Archipelago), and Guadalupe Island (Bartholomew Jr. 1950; Peterson et al. 1968). In 1994, the population at Guadalupe Island was estimated at 7,408 individuals (Gallo-Reynoso 1994b).

All Guadalupe fur seals represent a single population, with two known breeding colonies in Mexico, and a purported breeding colony in the United States. When the most recent stock assessment report for Guadalupe fur seals was published in 2000, the breeding colonies in Mexico were increasing; more recent evidence indicates that this trend is continuing (Aurioles-Gamboa et al. 2010; Esperon-Rodriguez and Gallo-Reynoso 2012). After compiling data from counts over 30 years, Gallo calculated that the population of Guadalupe fur seals in Mexico was increasing, with an average annual growth rate of 13.3 percent on Guadalupe Island (Gallo-Reynoso 1994b). More recent estimates of the Guadalupe fur seal population of the San Benito Archipelago (from 1997-2007) indicates that it is increasing as well at an annual rate of 21.6 percent (Esperon-Rodriguez and Gallo-Reynoso 2012), and that this population is at a phase of exponential increase (Aurioles-Gamboa et al. 2010). The most recent NMFS stock assessment report states that Guadalupe fur seals are increasing at an average annual growth rate of 10.3 percent. Direct counts of animals at Isla Guadalupe and Isla San Benito during 2010 resulted in a minimum of 13,327 animals and 2,503 animals respectively, for a minimum population size of 15,380 animals (Carretta et al. 2017b).

Bernardi et al. (1998) compared the genetic divergence in the nuclear fingerprint of samples taken from 29 Guadalupe fur seals, and found an average similarity of 0.59 of the DNA profiles. This average is typical of outbreeding populations. Although the relatively high levels of genetic variability are encouraging, it is important to note that commercial harvest still influenced the population. Later studies comparing mitochondrial DNA found in the bones of pre-exploitation Guadalupe fur seals against the extant population showed a loss of genotypes, with 25 genotypes in pre-harvest fur seals, and seven present today (Weber et al. 2004).

Guadalupe fur seals have been known to travel great distances, with sightings occurring thousands of kilometers away from the main breeding colonies (Aurioles-Gamboa et al. 1999).

Guadalupe fur seals are infrequently observed in U.S. waters. They can be found on California's Channel Islands, with as many 15 individuals being sighted since 1997 on San Miguel Island, including three females and reared pups.

9.7.3 Vocalization and Hearing

Though there has been no auditory assessment of the Guadalupe fur seal, its hearing likely falls within similar range as that of the Northern fur seal 2 to 40 kiloHertz (Moore and Schusterman 1987).

9.7.4 Status

A number of human activities may have contributed to the current status of this species, historic commercial hunting was likely the most devastating. Commercial sealers in the 19th century decimated the Guadalupe fur seal population, taking as many 8,300 fur seals from San Benito Island (Townsend 1924). The species was presumed extinct, until 1926, when a small herd was found on Guadalupe Island by commercial fishermen, who later returned and killed all that could be found. In 1954, during a survey of the island Hubbs (1956) discovered at least 14 individuals. Although population surveys occurred on an irregular basis in subsequent years, evidence shows that the Guadalupe fur seal has been increasing ever since. Although commercial hunting occurred in the past, and has since ceased, the effects of these types of exploitations persist today. Other human activities, such as entanglements from commercial fishing gear, are ongoing and continue to affect these species. Because that over the last 50 years the population has been increasing since being severely depleted, we believe that the Guadalupe fur seal population is resilient to future perturbations.

9.7.5 Critical Habitat

No critical habitat has been designated for the Guadalupe fur seal.

9.7.6 Recovery Goals

There has been no Recovery Plan prepared for Guadalupe fur seals.

9.8 Leatherback 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. It ranges from tropical to subpolar latitudes, worldwide (Figure 10).

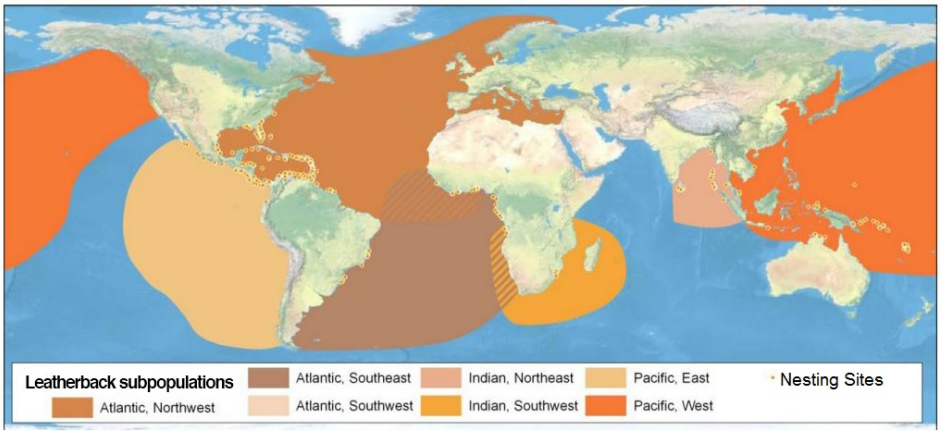

Figure 10. Map identifying the range of the endangered leatherback turtle. Adapted from (Wallace et al. 2013).

Leatherback turtles are the largest living turtle, reaching lengths of 2 meters (6.5 feet) long, and weighing up to 907.2 kilograms (2,000 pounds). Leatherback turtles have a distinct black leathery skin covering their carapace with pinkish white skin on their belly. The species was first listed under the Endangered Species Conservation Act (35 FR 8491) and listed as endangered under the ESA since 1973.

We used information available in the five year review (NMFS and USFWS 2013b) and the critical habitat designation (77 FR 61573) to summarize the life history, population dynamics and status of the species, as follows.

9.8.1 Life History

Age at maturity has been difficult to ascertain, with estimates ranging from five to 29 years (Avens et al. 2009; Spotila et al. 1996). Females lay up to seven clutches per season, with more than sixty-five eggs per clutch and eggs weighing greater than 80 grams (0.17 pounds) (Reina et al. 2002; Wallace et al. 2007). The number of leatherback turtle hatchlings that make it out of the nest on to the beach (i.e., emergent success) is approximately 50 percent worldwide (Eckert et al. 2012). Females nest every one to seven years. Natal homing, at least within an ocean basin, results in reproductive isolation between five broad geographic regions: eastern and western Pacific, eastern and western Atlantic, and Indian Ocean. Leatherback 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 leatherback turtles must consume large quantities to support their body weight. Leatherback turtles weigh about 33 percent 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).

9.8.2 Population Dynamics

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

Leatherback turtles are globally distributed, with nesting beaches in the Atlantic, Indian, and Pacific Oceans. Detailed population structure is unknown, but is likely dependent upon nesting beach location. Based on estimates calculated from nest count data, there are between 34,000 and 94,000 adult leatherback turtles in the North Atlantic Ocean (TEWG 2007). In contrast, leatherback turtle populations in the Pacific Ocean are much lower. Overall, Pacific populations have declined from an estimated 81,000 individuals to less than 3,000 total adults and subadults (Spotila et al. 2000). Population abundance in the Indian Ocean is difficult to assess due to lack of data and inconsistent reporting. Available data from southern Mozambique show that approximately ten females nest per year from 1994 through 2004, and about 296 nests per year counted in South Africa (NMFS and USFWS 2013b).

Population growth rates for leatherback turtles vary by ocean basin. Counts of leatherback turtles at nesting beaches in the western Pacific Ocean indicate that the subpopulation has been declining at a rate of almost six percent per year since 1984 (Tapilatu et al. 2013). Leatherback turtle subpopulations in the Atlantic Ocean, however, are showing signs of improvement. Nesting females in South Africa are increasing at an annual rate of four to 5.6 percent, and from nine to 13 percent in Florida and the U.S. Virgin Islands (TEWG 2007), believed to be a result of conservation efforts.

Analyses of mitochondrial DNA from leatherback 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 and USFWS 2013b).

Leatherback turtles are distributed in oceans throughout the world (Figure 10). 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. 2011b).

9.8.3 Vocalization and Hearing

Sea turtles are low frequency hearing specialists, typically hearing frequencies from 30 Hertz to 2 kiloHertz, with a range of maximum sensitivity between 100 and 800 Hertz (Bartol et al. 1999; Lenhardt 1994; Lenhardt 2002; Moein Bartol and Ketten 2006; Ridgway et al. 1969). 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 Hertz and 1.6

kiloHertz in air between 50 Hertz and 1.2 kiloHertz in water (lowest sensitivity recorded was 93 dB re: 1 µPa at 300 Hertz).

These hearing sensitivities are similar to those reported for two terrestrial species: pond and wood turtles. Pond turtles respond best to sounds between 200 and 700 Hertz, with slow declines below 100 Hertz and rapid declines above 700 Hertz, and almost no sensitivity above 3 kiloHertz (Wever and Vernon 1956). Wood turtles are sensitive up to about 500 Hertz, followed by a rapid decline above 1 kiloHertz and almost no responses beyond 3 to 4 kiloHertz (Patterson 1966).

9.8.4 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. 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.

9.8.5 Critical Habitat

On March 23, 1979, leatherback turtle critical habitat was identified adjacent to Sandy Point, St. Croix, Virgin Islands from the 183 meters (600 feet) isobath to mean high tide level between 17° 42' 12" North and 65° 50' 00" West (Figure 11). This habitat is essential for nesting, which has been increasingly threatened since 1979, when tourism increased significantly, bringing nesting habitat and people into close and frequent proximity. The designated critical habitat is within the Sandy Point National Wildlife Refuge. Leatherback turtle nesting increased at an annual rate of thirteen percent from 1994 to 2001; this rate has slowed according to nesting data from 2001 through 2010 (NMFS 2013).

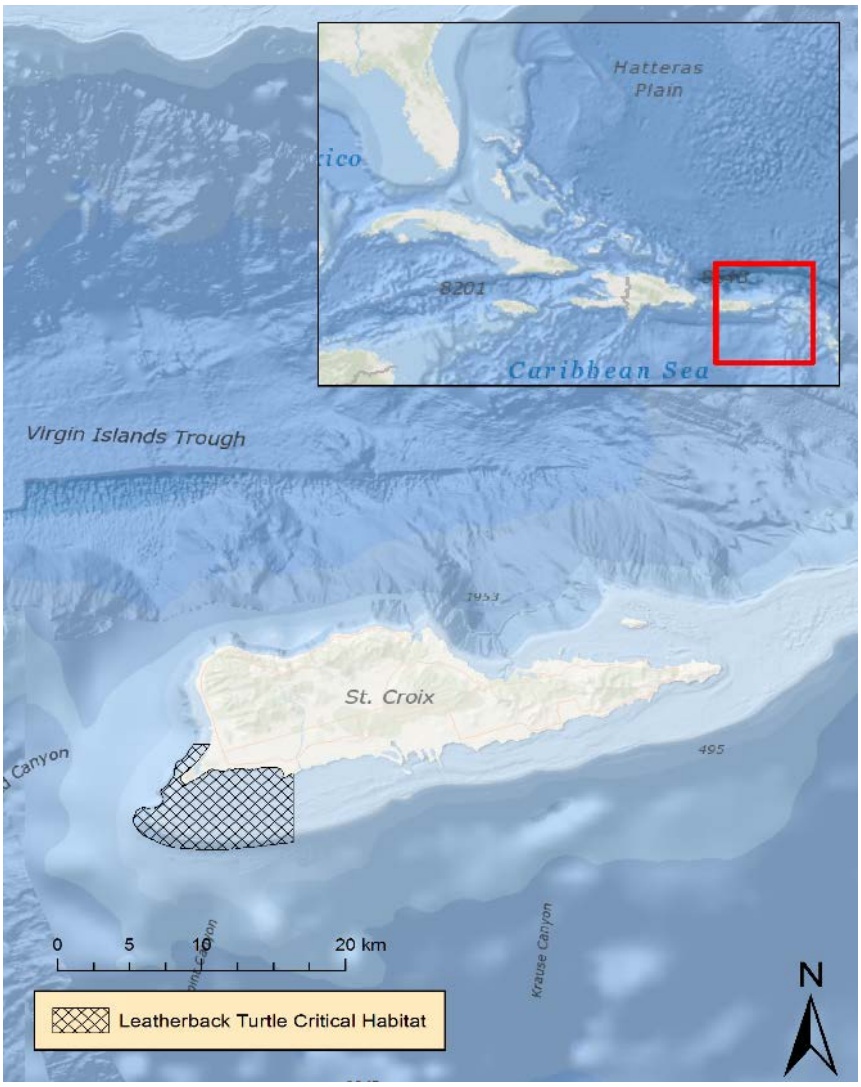

Figure 11. Map depicting leatherback turtle designated critical habitat in the United States Virgin Islands.

On January 20, 2012, NMFS issued a final rule to designate additional critical habitat for the leatherback turtle (50 C.F.R. §226). This designation includes approximately 43,798 square kilometers (12,769 square nautical miles) stretching along the California coast from Point Arena to Point Arguello east of the 3,000 meters (9,842 feet) depth contour; and 64,760 square kilometers (18,881 square nautical miles) stretching from Cape Flattery, Washington to Cape Blanco, Oregon east of the 2,000 meter (6,562 feet) depth contour (Figure 12). The designated areas comprise approximately 108,558 square kilometers (31,650 square nautical miles) of marine habitat and include waters from the ocean surface down to a maximum depth of 80 meters (262 feet). They were designated specifically because of the occurrence of prey species, primarily *scyphomedusae* of the order *Semaeostomeae* (i.e., jellyfish), of sufficient condition, distribution, diversity, abundance and density necessary to support individual as well as population growth, reproduction, and development of leatherback turtles.

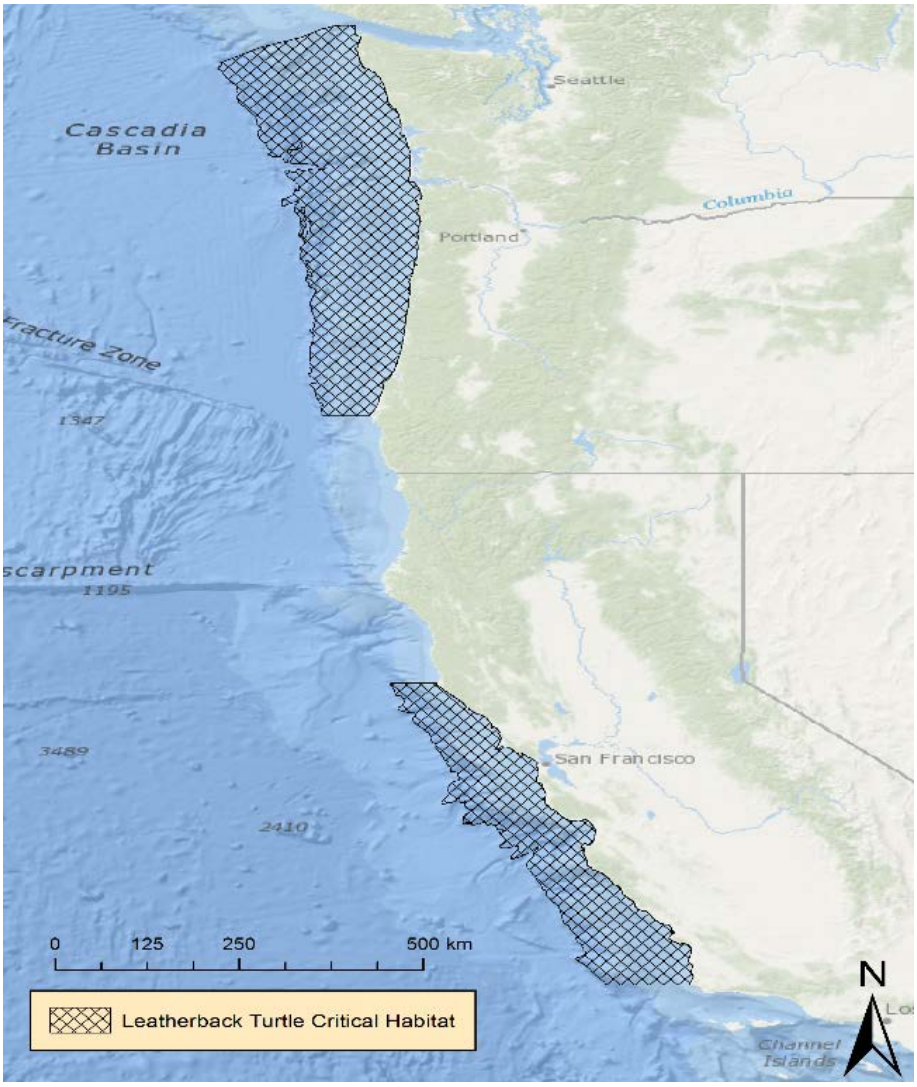

Figure 12. Map depicting leatherback turtle designated critical habitat along the United States Pacific Coast.

The designated critical habitat in the Atlantic Ocean is outside the action area. Accordingly, we find that the proposed action will have no effect on designated critical habitat in the Atlantic Ocean and will not be considered further in this opinion.

9.8.6 Recovery Goals

In response to the current threats facing the species, NMFS developed goals to recover leatherback turtle populations. These threats will be discussed in further detail in the *Environmental Baseline* section of this opinion. See the 1998 and 1991 Recovery Plans for the U.S. Pacific and U.S Caribbean, Gulf of Mexico and Atlantic leatherback turtles for complete down listing/delisting criteria for each of their respective recovery goals. The following items were the top five recovery actions identified to support 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

10 ENVIRONMENTAL BASELINE

The "environmental baseline" includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process (50 C.F.R. §402.02). In this section, we discuss the environmental baseline within the action are 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 and sea turtles 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, oceanic temperature regimes, whaling and subsistence harvest, sea turtle harvesting, vessel strike, whale watching, fisheries (fisheries interactions and aquaculture), pollution (marine debris, pesticides and contaminants, and hydrocarbons), aquatic nuisance species, disease, anthropogenic sound (vessel sound and commercial shipping, aircraft, seismic surveys, and marine construction), military activities, and scientific research activities.

10.1 Climate Change

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

In order to evaluate the implications of different climate outcomes and associated impacts throughout the 21st century, many factors have to be considered. The amount of future greenhouse gas emissions is a key variable. Developments in technology, changes in energy

generation and land use, global and regional economic circumstances, and population growth must also be considered.

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

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

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

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

Several of the most important threats contributing to the extinction risk of ESA-listed species, particularly those with calcium carbonate skeleton such as corals and mollusks as well as species for which these animals serve as prey or habitat, are related to global climate change. The main concerns regarding impacts of global climate change on coral reefs and other calcium carbonate

habitats generally, and on ESA-listed corals and mollusks in particular, are the magnitude and the rapid pace of change in greenhouse gas concentrations (e.g., carbon dioxide and methane) and atmospheric warming since the Industrial Revolution in the mid-19th century. These changes are increasing the warming of the global climate system and altering the carbonate chemistry of the ocean (ocean acidification (IPCC 2014)). As carbon dioxide concentrations increase in the atmosphere, more carbon dioxide is absorbed by the oceans, causing lower pH and reduced availability of calcium carbonate. Because of the increase in carbon dioxide and other greenhouse gases in the atmosphere since the Industrial Revolution, ocean acidification has already occurred throughout the world's oceans, including in the Caribbean Sea, and is predicted to increase considerably between now and 2100 (IPCC 2014). These impacts are particularly concerning for those animals which serve as prey for ESA-listed species.

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

The Atlantic Ocean appears to be warming faster than all other ocean basins except perhaps the southern oceans (Cheng et al. 2017). In the western North Atlantic Ocean surface temperatures have been unusually warm in recent years (Blunden and Arndt 2016). A study by (Polyakov et al. 2009) suggest that the North Atlantic Ocean overall has been experiencing in general warming trend over the last 80 years of 0.031±0.0006 degrees Celsius per decade in the upper 2,000 meters (6,561.7 feet) of the ocean. Additional consequences of climate change include increased ocean stratification, decreased sea-ice extent, altered patterns of ocean circulation, and decreased ocean oxygen levels (Doney et al. 2012). Since the early 1980s, the annual minimum sea ice extent (observed in September each year) in the Arctic Ocean has decreased at a rate of 11 to 16 percent per decade (Jay et al. 2018). Further, ocean acidity has increased by 26 percent since the beginning of the industrial era (IPCC 2014) and this rise has been linked to climate change. Climate change is also expected to increase the frequency of extreme weather and climate events including, but not limited to, cyclones, tropical storms, heat waves, and droughts (IPCC 2014).

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

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

Changes in the marine ecosystem caused by global climate change (e.g., ocean acidification, salinity, oceanic currents, dissolved oxygen levels, nutrient distribution) could influence the distribution and abundance of lower trophic levels (e.g., phytoplankton, zooplankton, submerged aquatic vegetation, crustaceans, mollusks, forage fish), ultimately affecting primary foraging areas of ESA-listed species including marine mammals, sea turtles, and fish. Marine species ranges are expected to shift as they align their distributions to match their physiological tolerances under changing environmental conditions (Doney et al. 2012). (Hazen et al. 2012) examined top predator distribution and diversity in the Pacific Ocean in light of rising sea surface temperatures using a database of electronic tags and output from a global climate model. They predicted up to a 35 percent change in core habitat area for some key marine predators in the Pacific Ocean, with some species predicted to experience gains in available core habitat and some predicted to experience losses. Notably, leatherback turtles were predicted to gain core habitat area, whereas loggerhead turtles and blue whales were predicted to experience losses in available core habitat. (McMahon and Hays 2006) predicted increased ocean temperatures will expand the distribution of leatherback turtles into more northern latitudes. The authors noted this is already occurring in the Atlantic Ocean. (Macleod 2009) estimated, based upon expected shifts in water temperature, 88 percent of cetaceans will be affected by climate change, with 47 percent predicted to experience unfavorable conditions (e.g., range contraction). (Willis-Norton et al. 2015) acknowledged there will be both habitat loss and gain, but overall climate change could result in a 15 percent loss of core pelagic habitat for leatherback turtles in the eastern South Pacific Ocean.

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

by changing ocean temperatures, regimes, the timing of migration can change or negatively impact population sustainability (Simmonds and Eliott 2009).

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

10.2 Oceanic Temperature Regimes

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

The North Atlantic oscillation is a large-scale, dynamic phenomenon that exemplifies the relationship between the atmosphere and the ocean. The North Atlantic oscillation has global significance as it affects sea surface temperatures, wind conditions, and ocean circulation of the North Atlantic Ocean (Stenseth et al. 2002). The North Atlantic oscillation is an alteration in the intensity of the atmospheric pressure difference between the semi-permanent high-pressure center over the Azores Islands and the sub-polar low-pressure center over Iceland (Stenseth et al. 2002). Sea-level atmospheric pressure in the two regions tends to vary in a “see-saw” pattern – when the pressure increases in Iceland it decreases in the Azores and vice-versa (i.e., the two systems tend to intensify or weaken in synchrony). The North Atlantic oscillation is the dominant mode of decadal-scale variability in weather and climate in the North Atlantic Ocean region (Hurrell 1995).

Since ocean circulation is wind and density driven, it is not surprising to find that the North Atlantic oscillation appears to have a direct effect on the position and strength of important North Atlantic Ocean currents. The North Atlantic oscillation influences the latitude of the Gulf Stream Current and accounts for a great deal of the interannual variability in the location of the current; in years after a positive North Atlantic oscillation index, the north wall of the Gulf Stream (south of New England) is located farther north (Taylor et al. 1998). Not only is the location of the Gulf Stream Current and its end-member, the North Atlantic Current, affected by the North Atlantic oscillation, but the strength of these currents is also affected. During negative North Atlantic oscillation years, the Gulf Stream System (i.e., Loop, Gulf Stream, and North Atlantic Currents) not only shifted southward but weakened, as witnessed during the predominantly negative North Atlantic oscillation phase of the 1960s; during the subsequent 25-

year period of predominantly positive North Atlantic oscillation, the currents intensified to a record peak in transport rate, reflecting an increase of 25 to 33 percent (Curry and McCartney 2001). The location and strength of the Gulf Stream System are important, as this major current system is an essential part of the North Atlantic climate system, moderating temperatures and weather from the U.S. to Great Britain and even the Mediterranean Sea region. Pershing et al. (2001) also found that the upper slope-water system off the east coast of the U.S. was affected by the North Atlantic oscillation and was driven by variability in temperature and transport of the Labrador Current. During low North Atlantic oscillation periods, especially that seen in the winter of 1996, the Labrador Current intensified, which led to the advance of cold slope water along the continental shelf as far south as the mid-Atlantic Bight in 1998 (Greene and Pershing 2003; Pershing et al. 2001). Variability in the Labrador Current intensity is linked to the effects of winter temperatures in Greenland and its surroundings (e.g., Davis Strait, Denmark Strait), on sea-ice formation, and the relative balance between the formation of deep and intermediate water masses and surface currents.

A strong association has been established between the variability of the North Atlantic oscillation and changes affecting various trophic groups in North Atlantic marine ecosystems on both the eastern and western sides of the basin (Drinkwater et al. 2003; Fromentin and Planque 1996). For example, the temporal and spatial patterns of *Calanus* copepods (zooplankton) were the first to be linked to the phases of the North Atlantic oscillation (Fromentin and Planque 1996; Stenseth et al. 2002). When the North Atlantic oscillation index was positive, the abundance of *Calanus* copepods in the Gulf of Maine increased, with the inverse true in years when the North Atlantic oscillation index was negative (Conversi et al. 2001; Greene et al. 2003a). This pattern is opposite off the European coast (Fromentin and Planque 1996). Such a shift in copepod patterns has a tremendous significance to upper-trophic-level species, including the North Atlantic right whale, which feeds principally on *Calanus finmarchicus*. North Atlantic right whale calving rates are linked to the abundance of *Calanus finmarchicus*; when the abundance is high, the calving rate remains stable but fell in the late 1990s when the abundance of its favored copepod also declined (Greene et al. 2003b). When the North Atlantic oscillation index is low with subsequently warmer water temperatures off Labrador and the Scotian Shelf, recruitment of cod is higher; direct links to the North Atlantic oscillation phase have also been found for recruitment in the North Atlantic of herring, two tuna species, Atlantic salmon (*Salmo salar*), and swordfish (*Xiphias gladius*) (Drinkwater et al. 2003).

The Pacific decadal oscillation is the leading mode of variability in the North Pacific Ocean and operates over longer periods than either El Niño or La Niña/Southern Oscillation events and is capable of altering sea surface temperature, surface winds, and sea level pressure (Mantua and Hare 2002; Stabeno et al. 2004). During positive Pacific decadal oscillations, the northeastern Pacific experiences above average sea surface temperatures while the central and western Pacific Ocean undergoes below-normal sea surface temperatures (Royer 2005). Warm Pacific decadal oscillation regimes, as occurs in El Niño events, tends to decrease productivity along the U.S. west coast, as upwelling typically diminishes (Childers et al. 2005; Hare et al. 1999). Recent

sampling of oceanographic conditions just south of Seward, Alaska has revealed anomalously cold conditions in the Gulf of Alaska from 2006 through 2009, suggesting a shift to a colder Pacific decadal oscillation phase. More research needs to be done to determine if the region is indeed shifting to a colder Pacific decadal oscillation phase in addition to what effects these phase shifts have on the dynamics of prey populations important to ESA-listed cetaceans throughout the Pacific action area. A shift to a colder decadal oscillation phase would be expected to impact prey populations, although the magnitude of this effect is uncertain.

The Indian Ocean Dipole, which is also known as the Indian Niño, is an irregular oscillation of sea surface temperature in which the western Indian Ocean becomes alternately warmer and then colder than the eastern part of the ocean (Saji et al. 1999). The Indian Ocean dipole, only identified recently in 1999, is one aspect of the general cycle of global climate, interacting with similar phenomena like the El Niño Southern Oscillation in the Pacific Ocean. As in the Pacific decadal oscillation and North Atlantic oscillation, the Indian Ocean dipole fluctuates between phases of positive, negative, and neutral conditions. During a positive Indian Ocean dipole, the western Indian Ocean experiences higher than normal sea surface temperature and greater precipitation while cooler sea surface temperature occur in the eastern Indian Ocean, often leading to droughts on land in the region (Saji et al. 1999). The negative phase of the Indian Ocean dipole brings about the opposite conditions, with warmer sea surface temperatures and greater precipitation in the eastern Indian Ocean and cooler and drier conditions in the western Indian Ocean. The Indian Ocean dipole also affects the strength of monsoons over the Indian subcontinent. An average of four positive and negative Indian Ocean dipole events occurs during each 30-year period, with each Indian Ocean dipole event lasting about six months. However, since 1980 there have been 12 positive Indian Ocean dipoles with no negative Indian Ocean dipole events from 1992 until late in 2010, when a strong negative event began (Nakamura et al. 2009). This strong negative Indian Ocean dipole event coupled with a strong La Niña event in the western Pacific Ocean to cause catastrophic flooding in parts of Australia. In 1998, an El Niño even interacted with a positive Indian Ocean dipole event with devastating effect on Western Indian Ocean corals: 75 to 99 percent of live corals were lost in the western Indian Ocean during this event (Graham et al. 2006).

In addition to period variation in weather and climate patterns that affect oceanographic conditions in the action area, longer term trends in climate change and/or variability also have the potential to alter habitat conditions suitable for ESA-listed species in the action area on a much longer time scale. For example, from 1906 through 2006, global surface temperatures have risen 0.74 degrees C and this trend is continuing at an accelerating pace. Twelve of the warmest years on record since 1850 have occurred since 1995 (Poloczanska et al. 2009). Possible effects of this trend in climate change and/or variability for ESA-listed marine species in the action area include the alteration of community composition and structure, changes to migration patterns or community structure, changes to species abundance, increased susceptibility to disease and contaminants, altered timing of breeding and nesting, and increased stress levels (Kintisch 2006; Learmonth et al. 2006a; Macleod et al. 2005; McMahon and Hays 2006; Robinson et al. 2005).

Climate change can influence reproductive success by altering prey availability, as evidenced by the low success of Northern elephant seals (*Mirounga angustirostris*) during El Niño periods (McMahon and Burton 2005) as well as data suggesting that sperm whale females have lower rates of conception following periods of unusually warm sear surface temperature (Whitehead et al. 1997). However, gaps in information and the complexity of climatic interactions complicate the ability to predict the effects that climate change and/or variability may have to these species from year to year in the action area (Kintisch 2006; Simmonds and Isaac 2007b).

10.3 Whaling and Subsistence Harvesting

Large whale population numbers in the action area have historically been impacted by aboriginal hunting and early commercial exploitation, and some stocks were already reduced by 1864 (the beginning of the era of modern commercial whaling using harpoon guns as opposed to harpoons simply thrown by men). From 1864 to 1985, at least 2.4 million baleen whales (excluding minke whales) and sperm whales were killed (Gambell 1999). The large number of baleen whales harvested during the 1930s and 1940s has been shown to correspond to increased cortisol levels in earplugs collected from baleen whales, suggesting that anthropogenic activities, such as those associated with whaling, may contribute to increased stress levels in whales (Trumble et al. 2018). Prior to current prohibitions on whaling most large whale species were significantly depleted to the extent it was necessary to list them as endangered under the Endangered Species Preservation Act of 1966. In 1982, the International Whaling Commission issued a moratorium on commercial whaling beginning in 1986. There is currently no legal commercial whaling by International Whaling Commission Member Nations party to the moratorium; however, whales are still killed commercially by countries that field objections to the moratorium (i.e., Iceland and Norway). Presently three types of whaling take place: (1) aboriginal subsistence whaling to support the needs of indigenous people; (2) special permit whaling; and (3) commercial whaling conducted either under objection or reservation to the moratorium. The reported catch and catch limits of large whale species from aboriginal subsistence whaling, special permit whaling, and commercial whaling can be found on the International Whaling Commission's website at: https://iwc.int/whaling. The Japanese whaling fleet left the International Whaling Commission in December 2018 and plans to resume commercial whaling in July 2019.

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

Under current International Whaling Commission regulations, aboriginal subsistence whaling is permitted for Denmark (Greenland, fin and minke whales, *Balaenoptera* spp.), the Russian

Federation (Siberia, gray, and bowhead [*Balaena mysticetus*] whales), St. Vincent and the Grenadines (Bequia, humpback whales) and the U.S. (Alaska, bowhead and gray whales). It is the responsibility of national governments to provide the International Whaling Commission with evidence of the cultural and subsistence needs of their people. The Scientific Committee provides scientific advice on safe catch limits for such stocks (IWC 2012b). Based on the information on need and scientific advice, the International Whaling Commission then sets catch limits, recently in five-year blocks.

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

Most current whaling activities occur outside of the action area. Regardless, prior exploitation is likely to have altered population structure and social cohesion of all whale species within the action area, such that effects on abundance and recruitment continued for years after harvesting has ceased. ESA-listed whale mortalities since 1986 resulting from these activities can be seen below in Table 10 (IWC 2017a; IWC 2017b; IWC 2017c).

Table 10. Endangered Species Act-listed marine mammal mortalities as the result of whaling since 1985.

Species	Commercial Whaling	Scientific Research	Subsistence
Blue Whale	-- --	-- --	-- --
Fin Whale	706	310	385
Humpback Whale – Multiple ESA-listed DPSs	-- --	-- --	123
Sei Whale	-- --	1,563	3
Sperm Whale	388	56	-- --
Guadalupe Fur Seal	-- --	-- --	-- --

DPS=Distinct Population Segment

Many of the whaling numbers reported represent minimum catches, as illegal or underreported catches are not included. For example, recently uncovered Union of Soviet Socialists Republics catch records indicate extensive illegal whaling activity between 1948 and 1979 (Ivashchenko et al. 2014). Additionally, despite the moratorium on large-scale commercial whaling, catch of some of these species still occurs in the Pacific Ocean whether it be under objection of the

International Whaling Commission, for aboriginal subsistence purposes, or under International Whaling Commission scientific permit 1985 through 2013. Some of the whales killed in these fisheries are likely part of the same population of whales occurring within the action area for this consultation.

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

10.4 Sea Turtle Harvesting

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 leatherback turtles considered in this opinion. 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. 2011a).

At present, despite conservation efforts such as bans and moratoriums by the responsible governments, the harvest of sea turtles and their eggs on nesting beaches still occurs throughout parts of their range. Harvest of green turtles and their eggs continues in the Caribbean Sea and at beaches in the eastern Atlantic Ocean (Seminoff 2015). Harvest of leatherback turtles females and eggs in the Atlantic Ocean is not as severe a threat as it is in the Pacific Ocean, but still may occur (NMFS 2013). Countries including Papua Barat Indonesia, Mexico, Peru, and the Philippines have attempted to reduce the threats to sea turtles, but illegal harvesting still occurs (NMFS 2016). In Vietnam and Fiji, harvest of sea turtle meat and eggs remains unregulated.

10.5 Vessel Strike

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

Vessel strikes are considered a serious and widespread threat to ESA-listed marine mammals (especially large whales) and sea turtles and are the most well-documented “marine road” interaction with large whales (Pirotta et al. 2019). This threat is increasing as commercial shipping lanes cross important breeding and feeding habitats and as whale populations recover and populate new areas or areas where they were previously extirpated (Swingle et al. 1993; Wiley et al. 1995). In the region, blue whales are especially susceptible where shipping lanes overlap with common feeding areas, as they do in the Santa Barbara Channel (Redfern 2013). As vessels to become faster and more widespread, an increase in vessel interactions with cetaceans is to be expected. All sizes and types of vessels can hit whales, but most lethal and sever injuries are caused by vessels 80 meters (262.5 feet) or longer (Laist et al. 2001). For whales, studies show that the probability of fatal injuries from vessel strikes increases as vessels operate at speeds above 26 kilometers per hour (14 knots) (Laist et al. 2001). Evidence suggests that not all whales killed as a result of vessel strike are detected, particularly in offshore waters, and some detected carcasses are never recovered while those that are recovered may be in advanced stages of decomposition that preclude a definitive cause of death determination (Glass et al. 2010). The vast majority of commercial vessel strike mortalities of cetaceans are likely undetected and unreported, as most are likely never reported. Most animals killed by vessel strike likely end up sinking rather than washing up on shore (Cassoff 2011). Kraus et al. (2005) estimated that 17 percent of vessel strikes are actually detected. Therefore, it is likely that the number of documented cetacean mortalities related to vessel strikes is much lower than the actual number of moralities associated with vessel strikes, especially for less buoyant species such as blue, humpback, and fin whales (Rockwood et al. 2017). Rockwood et al. (2017) modeled vessel strike mortalities of blue, humpback, and fin whales off California using carcass recovery rates of five and 17 percent and conservatively estimated that vessel strike mortality may be as high as 7.8, 2.0, and 2.7 times the recommended limit for blue, humpback, and fin whale stocks in this area, respectively.

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

The potential lethal effects of vessel strikes are particularly profound on species with low abundance. However, all whale species have the potential to be affected by vessel strikes. The latest five-year average mortalities and serious injuries related to vessel strikes for the ESA-listed cetacean stocks within U.S. waters likely to be found in the action area are and experience adverse effects as a result of the proposed action are given in Table 11 below (Carretta et al. 2018; Carretta et al. 2017b; Carretta et al. 2016b; Hayes et al. 2017; Helker et al. 2017; Henry et al. 2017; Henry et al. 2016). Data represent only known mortalities and serious injuries of NMFS

stock area. It is probable that more undocumented mortalities and serious injuries for these and other stocks found within the action area have likely occurred.

Table 11. Five-year annual average mortalities and serious injuries related to vessel strikes for Endangered Species Act-listed marine mammals within the action area.

Species	Pacific Stock
Blue Whale	0.6
Fin Whale	1.8
Humpback Whale – Multiple ESA-listed DPSs	1
Sei Whale	0
Sperm Whale	0
Guadalupe Fur Seal	0

DPS=Distinct Population Segment

Vessel strikes are a poorly-studied threat to sea turtles, but have the potential to be highly significant given that they can result in serious injury and mortality (Work et al. 2010a). All sea turtles must surface to breathe and several species are known to bask at the sea surface for long periods. Although sea turtles can move somewhat rapidly, they apparently are not adept at avoiding vessels that are moving at more than 4 kilometers per hour (2.6 knots); most vessels move far faster than this in open water (Hazel and Gyuris 2006; Hazel et al. 2007; Work et al. 2010a). Both live and dead sea turtles are often found with deep cuts and fractures indicative of a collision with a vessel hull or propeller (Hazel et al. 2007). Hazel et al. (2007) suggests that green turtles may use auditory clues to react to approaching vessels rather than visual cues, making them more susceptible to strike or vessel speed increases.

10.6 Whale Watching

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

Although considered by many to be a non-consumptive use of marine mammals with economic, recreational, educational and scientific benefits, whale watching is not without potential negative impacts (reviewed in Parsons 2012). Whale watching has the potential to harass whales by altering feeding, breeding, and social behavior, or even injure them if the vessel gets too close or strikes the animal. Preferred habitats may be abandoned if disturbance levels are too high.

Animals may also become more vulnerable to vessel strikes if they habituate to vessel traffic (Swingle et al. 1993; Wiley et al. 1995).

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

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

It is difficult to precisely quantify or estimate the magnitude of the risks posed to marine mammals in general from vessel approaches associated with whale watching. Given the proposed seismic survey activities will not occur within approximately 370.1 kilometers (230 miles) of land, few (if any) whale watching vessels will be expected to co-occur with the proposed action's research vessel.

10.7 Fisheries

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

Fisheries can have a profound influence on fish populations. In a study of retrospective data, Jackson et al. (2001) concluded that ecological extinction caused by overfishing precedes all other pervasive human disturbance of coastal ecosystems, including pollution and anthropogenic climatic change. Marine mammals are known to feed on several species of fish that are harvested by humans (Waring et al. 2008). Thus, competition with humans for prey is a potential concern. Reductions in fish populations, whether natural or human-caused, may affect the survival and recovery of several populations.

10.7.1 Fisheries Interactions

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

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

The latest five-year average mortalities and serious injuries related to fisheries interactions for the ESA-listed cetacean stocks within U.S. waters likely to be found in the action area are given in Table 12 below (Carretta et al. 2018; Hayes et al. 2017; Henry et al. 2017). Data represent only known mortalities and serious injuries; more, undocumented moralities and serious injuries for these and other stocks found within the action area have likely occurred.

Table 12. Five-year mortalities and serious injuries related to fisheries interactions for Endangered Species Act-listed marine mammals within the action area.

Species	Pacific Stock
Blue Whale	0
Fin Whale	0.2
Humpback Whale – Multiple ESA-listed DPSs	1.2
Sei Whale	20

Sperm Whale	1.7
Guadalupe Fur Seal	16

DPS=Distinct Population Segment

In addition to these direct impacts, cetaceans may also be subject to indirect impacts from fisheries. Marine mammals probably consume at least as much fish as is harvested by humans (Kenney et al. 1985). Many cetacean species (particularly fin and humpback whales) are known to feed on species of fish that are harvested by humans (Carretta et al. 2016a). Thus, competition with humans for prey is a potential concern. Reductions in fish populations, whether natural or human-caused, may affect the survival and recovery of ESA-listed marine mammal populations. Even species that do not directly compete with human fisheries could be indirectly affected by fishing activities through changes in ecosystem dynamics. However, in general the effects of fisheries on whales through changes in prey abundance remain unknown in the action area.

Fishery interaction remains a major factor in sea turtle recovery and, frequently, the lack thereof. 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 to sea turtles and other marine species in U.S. waters, mortality still occurs.

Leatherback turtles in the Pacific Ocean migrate about 11,265.4 kilometers (6,082.9 nautical miles) from nesting beaches in the tropical Pacific Ocean (e.g., Indonesia, Papua New Guinea, Costa Rica, Mexico) to foraging grounds (e.g., off the U.S. West Coast). This migration puts leatherback turtles in proximity of numerous fisheries, especially longlines, increasing bycatch risk. Roe (2014) found areas of high bycatch risk in the North and Central Pacific Ocean. By far, however, the greatest areas of bycatch risk were in the jurisdictional waters of several Indo-Pacific nations, largely affecting nesting individuals. The authors pointed to the difficultly in coordinating management efforts between several countries as a barrier to reducing risk of bycatch and supporting leatherback turtle recovery.

10.7.2 Aquaculture

Aquaculture has the potential to impact protected species via entanglement and/or other interaction with aquaculture gear (i.e., buoys, nets, and lines), introduction or transfer of pathogens, increased vessel traffic and noise, impacts to habitat and benthic organisms, and water quality (Clement 2013; Lloyd 2003; Price et al. 2017; Price and Morris 2013). Current data suggest that interactions and entanglements of ESA-listed marine mammals and sea turtles with aquaculture gear are rare (Price et al. 2017). This may be because worldwide the number and density of aquaculture farms are low, and thus there is a low probability of interactions, or because they pose little risk of ESA-listed marine mammals and sea turtles. Nonetheless, given that in some aquaculture gear, such as that used in longline mussel farming, is similar to gear used in commercial fisheries, aquaculture may impact similar to fisheries and bycatch, as discussed above in Section 10.7, respectively. There are very few reports of marine mammal

interactions with aquaculture gear in the U.S. Pacific Ocean, although it is not always possible to determine if the gear animals become entangled in it from aquaculture or commercial fisheries (Price et al. 2017). There are relatively few studies on the impacts of aquaculture on sea turtles.

10.8 Pollution

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

10.8.1 Marine Debris

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

Marine debris affects marine habitats and marine life worldwide, primarily by entangling or choking individuals that encounter it (Gall and Thompson 2015). Entanglement in marine debris can lead to injury, infection, reduced mobility, increased susceptibility to predation, decreased feeding ability, fitness consequences, and morality for ESA-listed species in the action area. Entanglement can also result in drowning for air breathing marine species including marine mammals 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. (2010) presented a time series of plastic content at the surface of the western North Atlantic Ocean and Caribbean Sea from 1986 through 2008. More than 60 percent of 6,136 surface plankton net tows collected small, buoyant plastic pieces. Data on marine debris in some locations of the action area is largely lacking; therefore, it is difficult to draw conclusions as to the extent of the problem and its impacts on populations of ESA-listed species in the Northeast Pacific Ocean, but we assume similar effects from marine debris documented within other ocean basins could also occur to species from marine debris.

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

containing marine debris in their guts and being the cause of death for up to 22 percent of individuals found stranded on shorelines (Baulch and Perry 2014b).

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

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. One study found plastic in 37 percent of dead leatherback turtles and determined that nine percent of those deaths were a direct result of plastic ingestion (Mrosovsky et al. 2009). Plastic ingestion is very common in leatherback turtles and can block gastrointestinal tracts leading to death (Mrosovsky et al. 2009). 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.

In a study on marine debris ingestion in 115 green and hawksbill turtles stranded in Queensland, Schuyler et al. (2012) found that the probability of debris ingestion was inversely correlated with size (curved carapace length), and when broken down into size classes, smaller pelagic sea turtles were significantly more likely to ingest debris than larger benthic feeding turtles. Parker et al. (2005) conducted a diet analysis of 52 loggerhead turtles collected as bycatch from 1990 through 1992 in the high seas drift gillnet fishery in the central North Pacific Ocean. The authors found that 34.6 percent of the individuals sampled had anthropogenic debris in their stomachs (e.g., plastic, Styrofoam, paper, rubber, etc.). Similarly, a study of green turtles found that 61 percent of those observed stranded that ingested some form of marine debris, including rope or string, which may have originated from fishing gear (Bugoni et al. 2001). In a study looking at oceanic-stage juvenile loggerhead turtles on a feeding ground near the Azores, 83 percent (20 turtles) had ingested plastic marine debris (Pham et al. 2017). Green turtles in their oceanic life

stage are also vulnerable to pollutants like tar balls because they tend to accumulate in *Sargassum* mats at convergence zones, where young green turtles associate (Seminoff 2015).

Plastic debris is a major concern because it degrades slowly and many plastics float. The floating debris is transported by currents throughout the oceans and has been discovered accumulating in oceanic gyres (Law et al. 2010). Additionally, plastic waste in the ocean chemically attracts hydrocarbon pollutants such as polychlorinated biphenyl and dichlorodiphenyltrichloroethane. Marine mammals, 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 over the course of the action although the risk of ingestion or entanglement and the resulting impacts are uncertain at the time of this consultation.

10.8.2 Pesticides and Contaminants

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

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

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

In sea turtles, a variety of heavy metals (e.g., arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, silver and zinc) have been found in tissues in levels that increase with sea turtle size (Anan et al. 2001; Barbieri 2009; Fujihara et al. 2003; Garcia-Fernandez et al. 2009; Gardner et al. 2006; Godley et al. 1999; Saeki et al. 2000; Storelli et al. 2008). Cadmium has been found in leatherback turtles at the highest concentration compared to any other marine vertebrate (Caurant et al. 1999; Gordon et al. 1998). Newly emerged hatchlings have higher concentrations than are present when laid, suggesting that metals may be accumulated during incubation from surrounding sands (Sahoo et al. 1996).

Sea turtle tissues have been found to contain organochlorines and many other persistent organic pollutants. Polychlorinated biphenyl (better known as PCB, found in engine coolants) concentrations in sea turtles are reportedly equivalent to those in some marine mammals, with liver and adipose levels of at least one congener being exceptionally high (PCB 209: 500-530 ng/g wet weight; Davenport 1990; Oros 2009). PCBs have been found in leatherback turtles at concentrations lower than expected to cause acute toxic effects, but might cause sub-lethal effects on hatchlings (Stewart 2011).

The contaminants (organochlorines) can cause deficiencies in endocrine, developmental, and reproductive health (Storelli et al. 2007) and are known to depress immune function in loggerhead turtles (Keller et al. 2006). Females from sexual maturity through reproductive life should have lower levels of contaminants than males because contaminants are shared with progeny through egg formation. Exposure to sewage effluent may also result in green turtle eggs harboring antibiotic resistant strains of bacteria (Al-Bahry et al. 2009).

10.8.3 Hydrocarbons

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

Exposure to hydrocarbons released into the environment via oil spills and other discharges pose risks to marine species. Marine mammals are generally able to metabolize and excrete limited amounts of hydrocarbons, but exposure to large amounts of hydrocarbons and chronic exposure over time pose greater risks (Grant and Ross 2002). Acute exposure of marine mammals to petroleum products causes changes in behavior and may directly injure animals (Geraci 1990).

Perhaps the most famous oil spill in U.S. history occurred in the Gulf of Alaska when, in 1989 the *Exxon Valdez* released at least 11 million gallons of Alaska crude oil into one of the largest

and most productive estuaries in North America. The Alaska Department of Environmental Conservation estimated that 149 kilometers (92.6 miles) of shoreline was heavily oiled and 459 kilometers (285.2 miles) were at least lightly oiled. Oil spills, both small and large, occur widely along U.S. shores at refining and transfer facilities and extraction sites. The *Exxon Valdez* oil spill was the worst in U.S. history until the 2010 *Deepwater Horizon* event.

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

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

Oil can also be hazardous to sea turtles, with fresh oil causing significant mortality and morphological changes in hatchlings, but aged oil having no detectable effects (Fritts and McGehee 1981). For example, the *Deepwater Horizon* oil spill extensively oiled vital foraging, migratory, and breeding habitats of sea turtles throughout the northern Gulf of Mexico (Deepwater Horizon Trustees 2016). *Sargassum* habitats, benthic foraging habitats, surface and water column waters, and sea turtle nesting were all affected by the *Deepwater Horizon* oil spill. Sea turtles may have been exposed to *Deepwater Horizon* oil in contaminated habitats, through breathing oil droplets, oil vapors, and smoke, by ingesting oil-contaminated water and prey, and through maternal transfer of oil compounds to developing embryos. Translocation of eggs from the Gulf of Mexico to the Atlantic Ocean coast of Florida resulted in the loss of sea turtle hatchlings. High numbers of small oceanic and large sea turtles are estimated to have been exposed to oil resulting from the *Deepwater Horizon* oil spill due to the duration and large footprint of the oil spill. It was estimated that as many as 7,590 large juvenile and adult sea turtles (Kemp's ridley, loggerhead, and unidentified hardshelled sea turtles) and up to 158,900 small juvenile sea turtles (hawksbill, Kemp's ridley, loggerhead, and hardshelled sea turtles not identified to species) were killed by the *Deepwater Horizon* oil spill. Small juveniles were

affected in the greatest numbers and suffered a higher mortality rate than large sea turtles. Leatherback turtle foraging and migratory habitat was also affected and though impacts to leatherback turtles were unquantified, it is likely some died as a result of the *Deepwater Horizon* oil spill and spill response (Deepwater Horizon NRDA Trustees 2016; NMFS and USFWS 2013b).

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

10.9 Aquatic Nuisance Species

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

10.10 Anthropogenic Sound

The ESA-listed species that occur in the action area are regularly exposed to several sources of anthropogenic sounds. These include, but are not limited to maritime activities, aircraft, seismic surveys (exploration and research), and marine construction (dredging and pile-driving). These activities occur to varying degrees throughout the year. Cetaceans generate and rely on sound to navigate, hunt, and communicate with other individuals and anthropogenic sound can interfere with these important activities (Nowacek et al. 2007). Noise generated by human activity has the potential to affect sea turtles as well, although effects to sea turtles are not well understood. The

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

The addition of anthropogenic sound to the marine environment is a known stressor that can possibly harm marine animals or significantly interfere with their normal activities (NRC 2005). Within the action area, ESA-listed marine mammals and sea turtles may be impacted by anthropogenic sound in various ways. For example, some sounds may produce a behavioral response, including but not limited to, avoidance of impacted habitat areas affected by irritating sounds, changes in diving behavior, or (for cetaceans) changes in vocalization patterns (MMC 2007).

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

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

10.10.1 Vessel Sound and Commercial Shipping

Much of the increase in sound in the ocean environment is due to increased shipping, as vessels become more numerous and of larger tonnage (Hildebrand 2009b; McKenna et al. 2012; NRC 2003b). Commercial shipping continues a major source of low-frequency sound in the ocean, particularly in the Northern Hemisphere where the majority of vessel traffic occurs. Although large vessels emit predominantly low frequency sound, studies report broadband sound from

large cargo vessels above 2 kiloHertz. The low frequency sounds from large vessels overlap with many mysticetes predicted hearing ranges (7 Hertz to 35 kiloHertz) (NOAA 2018) and may mask their vocalizations and cause stress (Rolland et al. 2012a). The broadband sounds from large vessels may interfere with important biological functions of odontocetes, including foraging (Blair et al. 2016; Holt 2008). At frequencies below 300 Hertz, ambient sound levels are elevated by 15 to 20 dB when exposed to sounds from vessels at a distance (McKenna et al. 2013). Analysis of sound from vessels revealed that their propulsion systems are a dominant source of radiated underwater sound at frequencies less than 200 Hertz (Ross 1976). Additional sources of vessel sound include rotational and reciprocating machinery that produces tones and pulses at a constant rate. Other commercial and recreational vessels also operate within the action area and may produce similar sounds, although to a lesser extent given their much smaller size.

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

Sonar systems are used on commercial, recreational, and military vessels and may also affect cetaceans (NRC 2003a). Although little information is available on potential effects of multiple commercial and recreational sonars to cetaceans, the distribution of these sounds would be small because of their short durations and the fact that the high frequencies of the signals attenuate quickly in seawater (Nowacek et al. 2007). However, military sonar, particularly low frequency active sonar, often produces intense sounds at high source levels, and these may impact cetacean behavior (Southall et al. 2016). For further discussion of military sound on the ESA-listed species considered in this opinion, see Section 10.11.

10.10.2 Aircraft

Aircraft within the action area may consist of small commercial or recreational airplanes or helicopters, to large commercial airliners. These aircraft produce a variety of sounds that could potentially enter the water and impact marine mammals or sea turtles. While it is difficult to assess these impacts, several studies have documented what appear to be minor behavioral disturbances in response to aircraft presence (Nowacek et al. 2007).

10.10.3 Seismic Surveys

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

There is one known high-energy seismic survey for research purposes scheduled to occur in the Pacific Ocean (Western Gulf of Alaska) in June 2019. This is funded by the National Science Foundation. Each of these seismic surveys include a MMPA incidental take authorization and are each subject to a separate ESA section 7 consultation. This action is the subject of a separate ESA section 7 consultation. The finalized consultation resulted in a “no jeopardy” opinion.

10.10.4 Marine Construction

Marine construction in the action area that produces sound includes drilling, dredging, pile-driving, cable-laying, and explosions. These activities are known to cause behavioral disturbance and physical damage to marine mammals (NRC 2003a). While most of these activities are coastal, offshore construction does occur. All or some of these activities may occur within the action area and can affect ESA-listed marine mammals and sea turtles.

10.11 Military Activities

The U.S. Navy conducts training, testing, and other military readiness activities on range complexes throughout coastal and offshore areas in the United States and on the high seas. The U.S. Navy's activities are conducted off the coast of the Pacific Ocean and elsewhere throughout the world. The U.S. Navy's Northwest Training and Testing range complex overlaps with the action area for the National Science Foundation's seismic survey. During training, existing and established weapon systems and tactics are used in realistic situations to simulate and prepare for combat. Activities include: routine gunnery, missile, surface fire support, amphibious assault and landing, bombing, sinking, torpedo, tracking, and mine exercises. Testing activities are conducted for different purposes and include at-sea research, development, evaluation, and experimentation. The U.S. Navy performs testing activities to ensure that its military forces have the latest technologies and techniques available to them. The majority of the training and testing activities the U.S. Navy conducts in the action area are similar, if not identical to activities that have been occurring in the same locations for decades, therefore the ESA-listed species located within the action area have been exposed to these military activities often and repeatedly.

The U.S. Navy's activities produce sound and visual disturbance to marine mammals and sea turtles throughout the action area. Anticipated impacts from harassment due to the U.S. Navy's activities include changes from foraging, resting, milling, and other behavioral states that require low energy expenditures to traveling, avoidance, and behavioral states that require higher energy expenditures. Based on the currently available scientific information, behavioral responses that result from stressors associated with these training and testing activities are expected to be temporary and will not affect the reproduction, survival, or recovery of these species. Sound produced during U.S. Navy activities is also expected to result in instances of TTS and PTS to marine mammals and sea turtles. Sound produced during U.S. Navy activities is also expected to result in instances of TTS and PTS to marine mammals and sea turtles. The U.S. Navy's activities constitute a federal action and take of ESA-listed marine mammals and sea turtles considered for these activities have previously undergone separate ESA section 7 consultation. Through these consultations with NMFS, the U.S. Navy has implemented monitoring and conservation measures to reduce the potential effects of underwater sound from activities on ESA-listed resources in the Pacific Ocean. Conservation measures include employing visual observers and implementing mitigation zones during activities using active sonar and explosives.

10.12 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 Northeast Pacific Ocean, 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.

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

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 sub-lethal "takes," with some resulting mortality.

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 all over the world, including for research in the action area. The consultations which took place on the issuance of these ESA scientific research permits each found that the authorized research activities will have no more than short-term effects and were not determined to result in jeopardy to the species or adverse modification of designated critical habitat.

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

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

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

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

We consider the best indicator of the aggregate impact of the *Environmental Baseline* on ESA-listed resources to be the status and trends of those species. As noted in Section 9, some of the

species considered in this consultation are experiencing increases in population abundance, some are declining, and for others, their status remains unknown. Taken together, this indicates that the *Environmental Baseline* is impacting species in different ways. The species experiencing increasing population abundances are doing so despite the potential negative impacts of the activities described in the *Environmental Baseline*. Therefore, while the *Environmental Baseline* may slow their recovery, recovery is not being prevented. For the species that may be declining in abundance, it is possible that the suite of conditions described in the *Environmental Baseline* is preventing their recovery. However, is also possible that their populations are at such low levels (e.g., due to historical commercial whaling) that even when the species' primary threats are removed, the species may not be able to achieve recovery. At small population sizes, species may experience phenomena such as demographic stochasticity, inbreeding depression, and Allee effects, among others, that cause their limited population size to become a threat in and of itself. A thorough review of the status and trends of each species is discussed in the *Status of Species Likely to be Adversely Affected* section of this opinion and what this means for the populations and critical habitats is discussed in the *Integration and Synthesis* (Section 12).

11 EFFECTS OF THE ACTION

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

In this section, we further describe the potential stressors associated with the proposed action, the probability of individuals of ESA-listed species being exposed to these stressors based on the best scientific and commercial evidence available, and the probable responses of those individuals (give probable exposures) based on the available evidence. As described in Section 11.3.2, for any responses that would be expected to reduce an individual's fitness (i.e., growth, survival, annual reproductive success, or lifetime reproductive success), the assessment would consider the risk posed to the viability of the population(s) those individuals comprise and to the ESA-listed species those populations represent. For this consultation, we are particularly concerned about behavioral and stress-related physiological disruptions and potential unintentional mortality that may result in animals that fail to feed, reproduce, or survive because these responses are likely to have population-level consequences. The purpose of this assessment and, ultimately, of this consultation is to determine if it is reasonable to expect the proposed action to have effects on ESA-listed species that could appreciably reduce their likelihood of surviving and recovering in the wild.

11.1 Stressors Associated with the Proposed Action

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

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

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

Based on a review of available information, during consultation we determined which of these possible stressors will be likely to occur and which will be discountable or insignificant for the species and habitats affected by these activities. These species and habitats were discussed in Section 7, 8, and 9. Stressors (i.e., sound fields produced by the airgun array, multi-beam echosounder, sub-bottom profiler, acoustic Doppler current profiler, and acoustic release transponder) that are likely to adversely affect ESA-listed species are discussed in the *Exposure and Response Analysis* sections.

During consultation we determined that sound fields produced by the airgun array, multi-beam echosounder, and sub-bottom profiler, and acoustic Doppler current profiler may adversely affect ESA-listed species by introducing acoustic energy introduced into the marine environment. This stressor and the likely effects on ESA-listed species are discussed starting in Section 11.3.2.

11.2 Mitigation to Minimize or Avoid Exposure

As described in the *Description of the Proposed Action* (Section 3), the National Science Foundation and Lamont-Doherty Earth Observatory's proposed action and NMFS Permits and Conservation Division's proposed incidental harassment authorization requires monitoring and mitigation measures that includes the use of proposed exclusion and buffer zones, power-down procedures, shut-down procedures, ramp-up procedures, visual monitoring with NMFS-approved protected species observers, passive acoustic monitoring, vessel strike avoidance measures, and additional mitigation measures considered in the presence of ESA-listed as species to minimize or avoid exposure. The NMFS Permits and Conservation Division's proposed incidental harassment authorization will contain additional mitigation measures to minimize or avoid exposure that are described in Appendix A (see Section 19.1).

Also, the National Science Foundation and Lamont-Doherty Earth Observatory will use a 100 meter (328.1 feet) exclusion zone for the 18 airgun array and 181 meter (593.8 feet) exclusion zone for the 36 airgun array as the shut-down distance for sea turtles. If a sea turtle is detected in

or about to enter the exclusion zone, the airgun array will be shut-down (i.e., shut off) immediately.

11.3 Exposure and Response Analysis

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

11.3.1 Exposure Analysis

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

In this section, we quantify the likely exposure of ESA-listed species to sound from the airgun array and multi-beam echosounder, sub-bottom profiler, acoustic Doppler current profiler, and acoustic release transponder. For this consultation, the National Science Foundation, Lamont-Doherty Earth Observatory, and NMFS Permits and Conservation Division estimated exposure to the sounds from the airgun array that will result in take, as defined under the MMPA, for all marine mammal species including those listed under the ESA. Neither the National Science Foundation, Lamont-Doherty Earth Observatory nor the NMFS Permits and Conservation Division estimated exposure or take to sounds from the airgun array that will result in take under the ESA for ESA-listed sea turtles.

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

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

- Feeding or attempting to feed a marine mammal in the wild."

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

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

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

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

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

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

under the ESA and all forms of Level A harassment under the MMPA constitute harm under the ESA (e.g., NMFS 2017).

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

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

11.3.1.1 Exposure Estimates of Endangered Species Act-Listed Marine Mammals

As discussed in the *Status of Species Likely to be Adversely Affected* section, there are six ESA-listed marine mammal species that are likely to be adversely affected by the proposed action: blue, fin, Central America DPS of humpback, Mexico DPS of humpback, sei, and sperm whales and Guadalupe fur seals.

During the proposed action, ESA-listed marine mammals may be exposed to sound from five sound sources: the airgun array, multi-beam echosounder, sub-bottom profiler, acoustic Doppler current profiler, and acoustic release transponder. The National Science Foundation, Lamont-Doherty Earth Observatory, and NMFS Permits and Conservation Division provided estimates of the expected number of ESA-listed marine mammals exposed to received levels greater than or equal to 160 dB re: 1 µPa (rms) for these sound sources. Our exposure estimates stem from the best available information on marine mammal densities and a predicted radius (rms) (

Table 15 and Table 16) along seismic survey tracklines. Based upon information presented in the *Response Analysis*, ESA-listed marine mammals exposed to these sound sources could be harmed, exhibit changes in behavior, suffer stress, or even strand.

11.3.1.2 Exposure of Endangered Species Act-Listed Marine Mammals to Airguns

The National Science Foundation and Lamont-Doherty Earth Observatory applied acoustic thresholds to determine at what point during exposure to the airgun arrays marine mammals are "harassed," based on definitions provided in the MMPA (16 U.S.C. §1362(18)(a)). As part of the application for the incidental harassment authorization pursuant to the MMPA, the National Science Foundation and Lamont-Doherty Earth Observatory provided an estimate of the number of marine mammals that will be exposed to levels of sound in which they should be considered "taken" under the MMPA during the proposed seismic survey. We used the same values to determine the type and extent of take for ESA-listed marine mammals. An estimate of the number of marine mammals that will be exposed to sounds from the airgun array is also included in the National Science Foundation's draft environmental analysis. The National Science Foundation, Lamont-Doherty Earth Observatory, and NMFS Permits and Conservation Division did not provide any take estimates from sound sources other than the airgun array, although other equipment producing sound will be used during airgun array operations (e.g., the multi-beam echosounder, sub-bottom profiler, acoustic Doppler current profiler, and acoustic release transponder).

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

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

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

During the development of the incidental harassment authorization, the NMFS Permits and Conservation Division conducted an independent exposure analysis that was informed by

comments received during the public comment period that was required on the proposed incidental harassment authorization and a draft environmental analysis prepared under Executive Order 12114. The exposure analysis also included estimates of the number of ESA-listed marine mammals likely to be exposed to received levels at MMPA Level A harassment thresholds in the absence of monitoring and mitigation measures.

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

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

Acoustic Thresholds

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

For physiological responses to active acoustic sources, such as TTS and PTS, the NMFS Permits and Conservation Division relied on NMFS' recently issued technical guidance for auditory injury of marine mammals (NOAA 2018). Unlike NMFS' 160 dB re: 1 µPa (rms) MMPA Level B harassment threshold (which does not include TTS or PTS), these TTS and PTS auditory thresholds differ by species hearing group (Table 13). Furthermore, these acoustic thresholds are

a dual metric for impulsive sounds, with one threshold based on peak sound pressure level (0 to peak SPL) that does not include the duration of exposure. The other metric, the cumulative sound exposure criteria incorporate auditory weighting functions based upon a species group's hearing sensitivity, and thus susceptibility to TTS and PTS, over the exposed frequency range and duration of exposure. The metric that results in a largest distance from the sound source (i.e., produces the largest field of exposure) is used in estimating total range to potential exposure and effect, since it is the more precautionary criteria. In recognition of the fact that the requirement to calculate ESA harm (MMPA Level A harassment) ensonified areas can be more technically challenging to predict due to the duration component and the use of weighting functions in the new SEL_{cum} thresholds, NMFS developed an optional user spreadsheet that includes tools to help predict a simple isopleth that can be used in conjunction with marine mammal density or occurrence to facilitate the estimation of take numbers.

In using these acoustic thresholds to estimate the number of individuals that may experience auditory injury, the NMFS Permits and Conservation Division classify any exposure equal to or above the acoustic threshold for the onset of PTS (see Table 13) as auditory injury, and thus MMPA Level A harassment, and harm under the ESA. Any exposure below the threshold for the onset of PTS, but equal to or above the 160 dB re: 1 µPa (rms) acoustic threshold is classified as MMPA Level B harassment, which will also be considered ESA harassment. Among ESA harassment (MMPA Level B harassment) exposures, the NMFS Permits and Conservation Division does not distinguish between those individuals that are expected to experience TTS and those that will only exhibit a behavioral response.

Table 13. Functional hearing groups, generalized hearing ranges, and acoustic thresholds identifying the onset of permanent threshold shift and temporary threshold shift for marine mammals exposed to impulsive sounds (NOAA 2018).

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

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

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

Exposure Estimates

In this section, we first evaluate the likelihood that marine mammals will be exposed to sound fields from the seismic survey at or above 160 dB re: 1 µPa (rms) based upon the information described above, and the acoustic thresholds correlating to onset of PTS or TTS provide in Table 13. If we find that such exposure above any particular threshold is likely, we then estimate the number of instances in which we expect marine mammals to be exposed to these sound levels, based on the ensonified areas at or above these sound levels and information on marine mammal density.

The methodology for estimating the number of ESA-listed species that might be exposed to the sound field used by the National Science Foundation, Lamont-Doherty Earth Observatory, and NMFS Permits and Conservation Division were largely the same. Both estimated the number of marine mammals predicted to be exposed to sound levels that will result in MMPA Level A and Level B harassment by using radial distances to predicted isopleths. Both used those distances to calculate the ensonified area around the airgun array for the 160 dB re: 1 µPa (rms) zone, which corresponds to the MMPA Level B harassment threshold for ESA-listed marine mammals. To account for possible delays during the seismic survey (e.g., weather, equipment malfunction) and additional seismic survey activities, a 25 percent contingency (associated with turns, airgun array testing, and repeat coverage for any areas where initial data quality is sub-standard) was added to the number of exposures using the ArcGIS-based quantitative method devised by the National Science Foundation and Lamont-Doherty Earth Observatory and used by the NMFS Permits and Conservation Division. This calculation assumes 100 percent turnover of individuals within the ensonified area on a daily basis, that is, each individual exposed to the seismic survey activities is a unique individual.

Based on information provided by the National Science Foundation and Lamont-Doherty Earth Observatory, we have determined that marine mammals are likely to be exposed to sound levels at or above the threshold at which TTS and behavioral harassment will occur. From modeling by the Lamont-Doherty Earth Observatory, the National Science Foundation and Lamont-Doherty Earth Observatory provided sound source levels of the airgun array (Table 14) and estimated distances for the 160 dB re: 1 µPa (rms) sound levels as well as MMPA Level A harassment thresholds generated by the two airgun array configurations and water depth. The predicted and modeled radial distances for the various MMPA Level A and B harassment thresholds for marine mammals for the R/V *Marcus G. Langseth*'s airgun arrays can be found in Table 15 and Table 16.

Table 14. Modeled sound source levels for the R/V *Marcus G. Langseth*'s single 40 cubic inch airgun, 3,300 cubic inch airgun array, and 6,600 cubic inch airgun array.

Functional Hearing Group	Single (40 in^3) Airgun Array (Peak SPL_{flat})	Single (40 in^3) Airgun Array (SEL_{cum})	18 (3,300 in^3) Airgun Array (Peak SPL_{flat})	18 (3,300 in^3) Airgun Array (SEL_{cum})	36 (6,600 in^3) Airgun Array (Peak SPL_{flat})	36 (6,600 in^3) Airgun Array (SEL_{cum})
Low Frequency Cetaceans (L_{pk} flat: 219 dB; LE,LF,24_h: 183 dB)	223.93 dB	202.99 dB	245.29 dB	226.38 dB	252.06 dB	232.98 dB
Mid Frequency Cetaceans (L_{pk} flat: 230 dB; LE,MF,24_h: 185 dB)	224.09 dB	202.89 dB	250.97 dB	226.33 dB	252.65 dB	232.83 dB
Otariid Pinnipeds (L_{pk} flat: 232 dB; LE,MF,24_h: 203 dB)	223.95 dB	202.35 dB	251.92 dB	227.07 dB	252.52 dB	232.07 dB

Table 15. Predicted radial distances in meters from the R/V *Marcus G. Langseth* seismic sound sources to isopleth corresponding to greater than or equal to 160 dB re: 1 µPa (rms) threshold.

Source	Volume (in^3)	Maximum Tow Depth (m)	Water Depth (m)	Predicted Distance to Threshold (160 dB re: 1 µPa [rms]) (m)[1]
Single Bolt Airgun	40	12	>1,000	431
18 Airguns	3,300	10	>1,000	3,758
36 Airguns	6,600	12	>1,000	6,733

in^3=cubic inches
m=meters
[1]Distances for depths greater than 1,000 meters (3,281 feet) are based on Lamont-Doherty Earth Observatory's model results.

Table 16. Modeled radial distances in meters from the R/V *Marcus G. Langseth*'s single airgun, 18 airgun array, and 36 airgun array corresponding to harm (Marine Mammal Protection Act Level A harassment) thresholds.

Functional Hearing Group	Single Bolt Airgun Peak SPL_{flat} SEL_{cum}	18 Airgun Array Peak SPL_{flat} SEL_{cum}	36 Airgun Array Peak SPL_{flat} SEL_{cum}
Low Frequency Cetaceans (L_{pk} flat: 219 dB; LE,LF,24_h: 183 dB)	1.76 0.5	23.2 75.6	38.9 426.9
Mid Frequency Cetaceans (L_{pk} flat: 230 dB; LE,MF,24_h: 185 dB)	0.51 0	11.2 0	13.6 0
Otariid Pinnipeds (L_{pk} flat: 232 dB; LE,MF,24_h: 203 dB)	0.4 0	9.9 0	10.6 0

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

In developing the National Science Foundation's draft environmental analysis and Lamont-Doherty Earth Observatory's incidental harassment authorization application, they utilized estimates of cetacean densities in the action area synthesized by Barlow (2016) and pinniped densities based on U.S. Navy (2010). Updated density information from the U.S. Navy (2018) became available after submission of the draft environmental analysis and incidental harassment authorization application. Extensive systematic aerial and vessel surveys have been conducted for marine mammals in offshore waters of Oregon and Washington. Oceanographic conditions, including occasional El Niño and La Niña events, influence the distribution and numbers of marine mammals present in the North Pacific Ocean, resulting in considerable year-to-year variation in the distribution and abundance of many marine mammal species (Escorza-Trevino 2009; Ferrero et al. 2002; Forney and Barlow 1998; Philbrick et al. 2003). Observations from vessel-based surveys conducted by NMFS Southwest Fisheries Science Center in slope and offshore waters of Oregon and Washington from 1991 through 2014 were pooled. The vessel surveys were conducted up to approximately 556 kilometers (300.2 nautical miles) from shore from June or August through November or December.

Systematic, offshore, at-sea survey data for pinnipeds are more limited. To calculate pinniped densities in the action area, the National Science Foundation and Lamont-Doherty Earth Observatory utilized methods described in U.S. Navy (2010), which calculated density estimates for pinnipeds off Washington at different times of the year using information on breeding and migration, population estimates from shore counts, and areas used by different species while at sea. The densities calculated by the U.S. Navy were updated by the National Science Foundation and Lamont-Doherty Earth Observatory using stock abundances presented in the latest stock assessment reports (Carretta et al. 2018).

After the National Science Foundation and Lamont-Doherty Earth Observatory submitted the draft environmental analysis and incidental harassment authorization application, the U.S. Navy published the Marine Species Density Database Phase III for the Northwest Training and Testing Study Area (Navy 2018). The action area is located near the western boundary of the defined Northwest Training and Testing Offshore Study Area.

For several cetacean species, the U.S. Navy updated densities estimated by line-transect surveys or mark-recapture studies (Barlow 2016). These methods usually produce a single value for density that is an averaged estimate across very large geographical areas, such as waters within the U.S. Exclusive Economic Zone off California, Oregon, and Washington (referred to as a "uniform" density estimate). This is the general approach applied in estimating cetacean abundance in the NMFS stock assessment reports. The disadvantage of these methods is that they do not provide information on varied concentrations of species in sub-regions of very large areas, and do not estimate density for other seasons or timeframes that were not surveyed. More recently, a newer method called spatial habitat modeling has been used to estimate cetacean densities that address some of these shortcomings (Becker et al. 2012; Becker et al. 2010; Becker et al. 2014; Ferguson et al. 2006; Forney et al. 2012). Note that spatial habitat models are also

referred to as “species distribution models” or habitat-based density models.” These models estimate density as a continuous function of habitat variables (e.g., sea surface temperature, seafloor depth) and thus, within the action area that was modeled, densities can be predicted at all locations where these habitat variables can be measured or estimated. Spatial habitat models therefore allow estimates of cetacean densities on fine scales than traditional line-transit or mark-recapture analyses.

The methods used to estimate pinniped at-sea densities are typically different than those used for cetaceans, because pinnipeds are not limited to the water and spend a significant amount of time on land (e.g., at haulouts and rookeries). Pinniped abundance is generally estimated via shore counts of animals on land at known haulout sites or by counting the number of pups weaned at rookeries and applying a correction factor to estimate the abundance of the population (Harvey et al. 1990; Lowry 2002; Sepulveda et al. 2009). Estimating in-water densities from land-based counts is difficult given the variability in foraging ranges, migration, and haulout behavior between species and within each species, and is driven by factors such a age class, sex class, breeding cycles, and seasonal variation. Data such as age class, sex class, and seasonal variation are often used in conjunction with abundance estimates from known haulout sites to assign an in-water abundance estimate for a given area. The total abundance divided by the area of the region provides a representative in-water density estimate for each species in a different location, which enables analyses of in-water stressors resulting from at-sea U.S. Navy training and testing activities. In addition to using shore counts to estimate pinniped density, traditional line-transect derived estimates are also used, particularly in open ocean areas.

Because the U.S. Navy’s density calculations for many species included spatial habitat modeling and demographic information, the U.S. Navy Marine Species Density Database was utilized to estimate densities and resulting take of marine mammals from the proposed seismic survey activities. Where available, the appropriate seasonal density estimate from the U.S. Navy Marine Species Density Database was used in the exposure estimates (i.e., summer). For species with a quantitative density range within or around the action area, the maximum presented density was conservatively used. Background information on the density calculations for each species/guild as well as reported sightings in nearby waters are reported here. Density estimates for each species are found in Table 17. The approach used here is based on the best available data.

To determine exposures, the National Science Foundation, Lamont-Doherty Earth Observatory, and NMFS Permits and Conservation Division calculated ESA harm and harassment (MMPA Level A and Level B harassment) by using the radial distances from the airgun array to the predicted isopleths corresponding to the ESA harm and harassment (MMPA Level A and Level B harassment). The area estimated to be ensonified in a single day (187 kilometers [101 nautical miles] for the two-deimensional seismic survey, 200 kilometers [108 nautical miles] for the three-dimensional seismic survey) of the seismic survey is then calculated, based on the areas predicted to be ensonified around the airgun array and representative trackline distances traveled per day. The ensonified areas were then multiplied by the number of survey days. The product is

then multiplied by 1.25 to account for the additional 25 percent contingency. This results in an estimate of the total area expected to be ensonified to the ESA harm and harassment thresholds. The total area ensonified at 160 dB re: 1 µPa (rms) is 18,861.26 square kilometers (5,499.1 square nautical miles), which was calculated in the geographic information system mapping program by multiplying the ESA harassment (MMPA Level B harassment) buffer zone widths for the different airgun array configurations by the trackline distance. The number of marine mammals that can be exposed to the sounds from the airgun array on one or more occasions is estimated for the calculated marine area along with the expected density of animals in the area. Summing exposures along all of the tracklines yields the total exposures for each species for the proposed action for the 18 airgun array (three-dimensional) and 36 airgun array (two-dimensional) configurations for the seismic survey activities. The method also yields exposures for each seismic survey trackline individually, allowing examination of those exemplary tracklines that will yield the largest or smallest exposures. For species where exposures by ESA harm (MMPA Level A harassment) have been calculated, the takes by ESA harm have been subtracted from the total exposures within the ESA harassment (MMPA Level B harassment) isopleths. The estimated exposure of ESA-listed marine mammals at the ESA harm and harassment (MMPA Level A and Level B harassment threshold during the National Science Foundation and Lamont-Doherty Earth Observatory's seismic survey on the R/V *Marcus G. Langseth* in the Northeast Pacific Ocean can be found in Table 20. The approach assumes that no marine mammals will move away or toward the trackline in response to increasing sound levels before the levels reach the specific thresholds as the R/V *Marcus G. Langseth* approaches.

Table 17. Densities of ESA-listed marine mammals in the action area during National Science Foundation's seismic survey in the Northeast Pacific Ocean.

Species	Reported Density (number per km^2)	Mean Group Size
Blue Whale	0.001096	1
Fin Whale	0.004249	2
Humpback Whale – Multiple ESA-listed DPSs	0.001829	2
Sei Whale	0.0004	2
Sperm Whale	0.002561	6
Guadalupe Fur Seal	0.00343	NA

km^2=square kilometers
NA=Not available
Note: Pinniped densities are from shore counts and calculations

Blue Whale – NMFS Southwest Fisheries Science Center developed a California Current Ecosystem habitat-based density model for blue whales which provides spatially explicit density estimates off the U.S. West Coast for summer and fall based on survey data collected from 1991 through 2014 (Becker et al. in prep.). Density data are not available for the Northwest Training

and Testing Offshore Area northwest of the NMFS Southwest Fisheries Science Center strata, so the habitat-based density values in the northernmost pixels adjoining this region were interpolated based on the nearest-neighbor approach to provide representative density estimates for this area.

The nearest sighting of blue whales is approximately 55 kilometers (29.7 nautical miles) to the southwest, and there are several other sightings in adjacent waters (Carretta et al. 2018). Satellite telemetry suggests that blue whales are present in waters offshore of Oregon and Washington during fall and winter (Bailey and Thompson 2009; Hazen et al. 2017).

Fin Whale – NMFS Southwest Fisheries Science Center developed a California Current Ecosystem habitat-based density model for fin whales which provides spatially explicit density estimates off the U.S. West Coast for summer and fall based on survey data collected from 1991 through 2014 (Becker et al. in prep.). Density data are not available for the Northwest Training and Testing Offshore Area northwest of the NMFS Southwest Fisheries Science Center strata, so the habitat-based density values in the northernmost pixels adjoining this region were interpolated based on the nearest-neighbor approach to provide representative density estimates for this area.

Fin whales are routinely sighted during survey off Oregon and Washington (Adams et al. 2014; Barlow 2010a; Barlow and Forney 2007; Carretta et al. 2017a; Edwards et al. 2015)., including in coastal as well as offshore waters. They have also been detected acoustically near the action area during June through August (Edwards et al. 2015). There is one sighting of a fin whale in the Ocean Biogeographic Information System database within the action area, which was made in August 2005 during the NMFS Southwest Fisheries Science Center Collaborative Survey of Cetacean Abundance and the Pelagic Ecosystem Marine Mammal Survey, and several other sightings in adjacent waters. Eight fin whale sightings (19 animals) were made off Oregon and Washington during the June through July 2012 Lamont-Doherty Earth Observatory seismic survey of the Juan de Fuca plate, including two sightings (four animals) in the vicinity of the action area; sightings were made in waters 2,369 to 3,940 meters (7,772.3 to 12,926.5 feet) deep. Fourteen fin whale sightings (28 animals) were made during the July 2012 Lamont-Doherty Earth Observatory seismic survey off southern Washington, northeast of the action area. No fin whales were sighted during the July 2012 Lamont-Doherty Earth Observatory seismic surveys off Oregon, southeast of the action area. Fin whales were also seen off southern Oregon during July 2012 in water depths greater than 2,000 meters (6,561.7 feet) during surveys by (Adams et al. 2014).

Humpback Whale – NMFS Southwest Fisheries Science Center developed a California Current Ecosystem habitat-based density model for humpback whales which provides spatially explicit density estimates off the U.S. West Coast for summer and fall based on survey data collected from 1991 through 2014 (Becker et al. in prep.). Density data are not available for the Northwest Training and Testing Offshore Area northwest of the NMFS Southwest Fisheries Science Center strata, so the habitat-based density values in the northernmost pixels adjoining this region were

interpolated based on the nearest-neighbor approach to provide representative density estimates for this area.

Six humpback whale sightings (eight animals) were made off Washington and Oregon during June through July 2012 during Lamont-Doherty Earth Observatory's seismic survey of the Juan de Fuca plate. All sightings were well inshore of the action area. There were 98 humpback whale sightings (213 animals) made during the July 2012 Lamont-Doherty Earth Observatory's seismic survey off southern Washington, northeast of the action area, and 11 humpback whale sightings (23 animals during the July 2012 Lamont-Doherty Earth Observatory's seismic survey off Oregon, southeast of the action area. No sightings were made near the action area in the 2014 NMFS Southwest Fisheries Science Center California Current Ecosystem vessel survey (Barlow 2016).

Sei Whale – Density values for sei whales are available for the NMFS Southwest Fisheries Science Center Northern California, Oregon, and Washington offshore strata for summer/fall (Barlow 2016). Density data are not available for the Northwest Training and Testing Offshore Area northwest of the NMFS Southwest Fisheries Science Center strata, so data from the NMFS Southwest Fisheries Science Center Oregon and Washington stratum were used as representative estimates.

Sei whales are rare in waters off California, Oregon, and Washington (Brueggeman et al. 1990; Green et al. 1992; Barlow 1994, 1997). Only 16 confirmed sightings were reported for California, Oregon, and Washington during extensive surveys from 1991 through 2014 (Barlow 2003; Barlow 2010a; Carretta and Forney 1993; Carretta et al. 2017a; Forney 2007; Green et al. 1992; Green et al. 1993; Hill and Barlow 1992; Mangels and Gerrodette 1994; Von Saunder and Barlow 1999). Based on surveys conducted from 1991 through 2008, the estimated abundance of sei whales off the coasts of Oregon and Washington was 51 (Barlow 2010); for 2014, the abundance estimate was 468 (Barlow 2016). Two sightings (four animals) were made during the June through July 2012 Lamont-Doherty Earth Observatory seismic survey of the Juan de Fuca plane off Washington; these were well inshore of the action area (approximately 125 degrees West). No sei whales were sighted during the July 2012 Lamont-Doherty Earth Observatory seismic surveys north and south of the action area.

Sperm Whale – NMFS Southwest Fisheries Science Center developed a California Current Ecosystem habitat-based density model for sperm whales which provides spatially explicit density estimates off the U.S. West Coast for summer and fall based on survey data collected from 1991 through 2014 (Becker et al. in prep.). Density data are not available for the Northwest Training and Testing Offshore Area northwest of the NMFS Southwest Fisheries Science Center strata, so the habitat-based density values in the northernmost pixels adjoining this region were interpolated based on the nearest-neighbor approach to provide representative density estimates for this area.

There is one sighting of a sperm whale in the vicinity of the action area in the Ocean Biogeographic Information System database that was made in July 1996 during the NMFS

Southwest Fisheries Science Center ORCAWALE Marine Mammal Survey, and several other sightings in adjacent waters (Caretta et al. 2018). Sperm whale sightings were made in the vicinity of the action area during the 2014 NMFS Southwest Fisheries Science Center vessel survey (Barlow 2016). A single sperm whale was sighted during the August 2019 Lamont-Doherty Earth Observatory seismic survey off Canada, north of the action area. Sperm whales were detected acoustically in waters near the action area in August 2016 during the NMFS Southwest Fisheries Science Center Passive Acoustics Survey of Cetacean Abundance Levels study using drifting passive acoustic recorders (J.L. et al. 2018).

Guadalupe Fur Seal – Adult male Guadalupe fur seals are expected to be ashore at breeding areas over the summer, and are not expected to be present during the proposed seismic survey activities (Carretta et al. 2017a). Additionally breeding females are unlikely to be present within the Northwest Training and Testing Offshore Area as they remain ashore to nurse their pups through the fall and winter, making only short foraging trips from rookeries (Stewart et al. 1987). To estimate the total abundance of fur seals, the U.S. Navy adjusted the population reported in the 2016 NMFS stock assessment report (Carretta et al. 2017a) of 20,000 animals by applying the average annual growth rate of 7.64 percent over the seven years between 2010 through 2017. The resulting 2017 projected abundance was 33,485 animals. Using the reported composition of the breeding population of Guadalupe fur seals (Gallo-Reynoso 1994a) and satellite telemetry data (pers. comm. T. Norris, The Marine Mammal Center, and C. Erkelens, Mantech International Corporation, to Amy Fowler, NMFS Office of Protected Resources, 2017), the U.S. Navy established seasonal and demographic abundances of Guadalupe fur seals expected to occur within the Northwest Training and Testing Offshore Area.

The distribution of Guadalupe fur seals in the Northwest Training and Testing Offshore Area was stratified by distance from shore (or water depth) to reflect their preferred pelagic habitat(pers. comm. T. Norris, The Marine Mammal Center, and M. Zickel, Mantech International Corporation, to Amy Fowler, NMFS Office of Protected Resources, August 18, 2017). Ten percent of Guadalupe fur seals in the Northwest Training and Testing Offshore Area are expected to use waters over the continental shelf (approximated as waters with depths between ten and 200 meters [656.2 feet]). A depth of 10 meters (32.8 feet) is used as the shoreward extent of the shelf (rather than extending to shore), because Guadalupe fur seals in the Offshore Study Area are not expected to haulout and will not be likely to come close to shore. All Guadalupe fur seals (i.e., 100 percent) will use waters off the shelf (beyond the 200 meters [656.2 feet] isobaths) out to 300 kilometers (162 nautical miles) from shore, and 25 percent of Guadalupe fur seals will be expected to use waters between 300 to 700 kilometers (162 to 378 nautical miles) from shore (including the action area). The second stratum (200 meters to 300 kilometers [656.2 feet to 162 nautical miles] from shore) is the preferred habitat where Guadalupe fur seals are most likely to occur most of the time. Individuals may spend a portion of their time over the continental shelf or farther than 300 kilometers (162 nautical miles) from shore, necessitating a density estimate for those areas, but all Guadalupe fur seals will be expected to be in the central stratum most of the time, which is the reason 100 percent is used in

the density estimate for the central stratum (pers. comm. T. Norris, The Marine Mammal Center, and M. Zickel, Mantech International Corporation, to Amy Fowler, NMFS Office of Protected Resources, August 18, 2017). Spatial areas for the three strata were estimated in geographic information systems and used to calculate the densities. Guadalupe fur seals have not previously been observed in the action area, nor on previous Lamont-Doherty Earth Observatory seismic surveys off Oregon and Washington.

Table 18. Relevant isopleths, daily ensonified area, number of survey days, percent increase, and total ensonified areas during the National Science Foundation and Lamont-Doherty Earth Observatory's seismic survey in the Northeast Pacific Ocean.

Seismic Survey	Criteria	Relevant Isopleth (m)	Daily Ensonified Area (km^2)	Total Survey Days	25 Percent Increase	Total Ensonified Area (km^2)
Two-Dimensional Seismic Survey	ESA Harassment					
	160 dB	6,733	1,346.9	3	1.25	5,050.86
	ESA Harm					
	LF Cetaceans – Blue Whale, Fin Whale, Humpback Whale, and Sei Whale	426.9	158.67	3	1.25	595.01
	MF Cetaceans – Sperm Whale	13.6	5.06	3	1.25	18.97
	Otariids – Guadalupe Fur Seal	10.6	3.94	3	1.25	14.79
Three-Dimensional Seismic Survey	ESA Harassment					
	160 dB	3,758	690.52	16	1.25	13,810.4
	ESA Harm					
	LF Cetaceans – Blue Whale, Fin Whale, Humpback	118.7	47.39	16	1.25	947.74

	Whale, and Sei Whale					
	MF Cetaceans – Sperm Whale	11.2	4.45	16	1.25	89.01
	Otariids – Guadalupe Fur Seal	9.9	3.93	16	1.25	78.67

m=meters
km^2=square kilometers
LF=low frequency
MF=mid-frequency

Table 19. Total ensonified areas for ESA-listed marine mammals in the action area during National Science Foundation and Lamont-Doherty Earth Observatory's seismic survey in the Northeast Pacific Ocean.

Species	160 dB re: 1 µPa (rms) Ensonified Area (km^2)	Potential Harm Ensonified Area (km^2)
Blue Whale	18,861.26	1542.75
Fin Whale	18,861.26	1542.75
Humpback Whale – Multiple ESA-listed DPSs	18,861.26	1542.75
Sei Whale	18,861.26	1542.75
Sperm Whale	18,861.26	1542.75
Guadalupe Fur Seal	18,861.26	93.46

km^2=square kilometers

Table 20. Estimated exposure of Endangered Species Act-listed marine mammals calculated by the National Science Foundation, Lamont-Doherty Earth Observatory, and National Marine Fisheries Service Permits and Conservation Division during the seismic survey in the Northeast Pacific Ocean.

Species	Potential Permanent Threshold Shift and Harm	Potential Temporary Threshold Shift and Behavioral Harassment	Total
Blue Whale	2	19	21
Fin Whale	7	74	81
Humpback Whale – Multiple ESA-listed DPSs	3	32	35

Sei Whale	2	6	8
Sperm Whale	0	48	48
Guadalupe Fur Seal	0	65	65

Blue, fin, Central America DPS of humpback, Mexico DPS of humpback, sei, and sperm whales of all age classes are likely to be exposed during the proposed seismic survey activities. Given that the proposed seismic survey will take place in July and August, we expect that most animals will be on or migrating to/from their feeding grounds. Whales are expected to be feeding, traveling, or migrating in the action area and some females will have young-of-the-year accompanying them. These individuals can be exposed to the proposed seismic survey activities while they are transiting through the action area. We will normally assume that sex distribution is even for blue, fin, humpback, and sei whales and sexes are exposed at a relatively equal level. However, sperm whales in the action area likely consist of more females than males in the group. Therefore, we expect a female bias to sperm whale exposure. For sperm whales, exposure for adult male sperm whales is expected to be lower than other age and sex class combinations as they are generally solitary and may migrate toward the northern portion of the range (poleward of about 40 to 50 degrees latitude).

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

The seasonality of the seismic survey activities will likely not affect the exposure analysis because the best available species densities for any time of the year have been used for most species (with the exception of fin whales and pinnipeds, for which summer/fall densities were used. For all other species, summer/fall densities were either not available or the same as for other seasons.

Blue Whale – The estimated potential instances of take under the ESA of the Eastern North Pacific stock of blue whales is a total of 21 (two harm and 19 harassment), which is approximately 1.28 percent of the population. For reasons previously described, this estimate is conservative, that is, it is likely higher than the actual exposures and a fewer number are not likely to be harmed or harassed given the mitigation measures that will be implemented. Because

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

Fin Whale – The estimated potential instances of take under the ESA of the California/Oregon/Washington stock of fin whales is a total of 81 (seven harm and 74 harassment), which is approximately 0.9 percent of the population. For reasons previously described, this estimate is conservative, that is, it is likely higher than the actual exposures and a fewer number are not likely to be harmed or harassed given the mitigation measures that will be implemented Because of the large range of this species compared to the relatively small size of the National Science Foundation and Lamont-Doherty Earth Observatory's action area, combined with the relatively short duration of the seismic survey activities, it is more likely that there will be multiple takes of a smaller number of individuals that will occur within the action area.

Humpback Whale – The estimated potential instances of take under the ESA of the California/Oregon/Washington stock of humpback whales in the MMPA incidental harassment authorization is a total of 35 (three harm and 32 harassment), which is approximately 1.21 percent of the population. For reasons previously described, this estimate is conservative, that is, it is likely higher than the actual exposures and a fewer number are not likely to be harmed or harassed given the mitigation measures that will be implemented. Because of the large range of this species compared to the relatively small size of the National Science Foundation and Lamont-Doherty Earth Observatory's action area, combined with the relatively short duration of the seismic survey activities, it is more likely that there will be multiple takes of smaller number of individuals that will occur within the action area.

For humpback whales of the California/Oregon/Washington stock, takes are apportioned between different DPSs (i.e., Hawaii DPS, Mexico DPS, and Central America DPS) present off Oregon and Washington based on Wade et al. (2016) and NMFS guidance (Table 21). For Washington and Oregon, which in Wade et al. (2016) is composed of several smaller sub-locations, we use the percentage estimates from Wade et al. (2016) into the greater Northeast Pacific Ocean area from which the National Science Foundation, Lamont-Doherty Earth Observatory, and NMFS Permits and Conservation Division estimated takes. The seismic survey activities will take place in International Waters outside of the U.S. Exclusive Economic Zone off Oregon and Washington. We use each location specified in Wade et al. (2016) (Southern British Columbia/Washington and Oregon/California) and the probability of encountering the DPS breakdown percentages across the action area. We recognize that that these percentages sum to greater than 100 percent in some cases, but this overestimation is necessary in order to conservatively address uncertainty in the percentage estimates likely to be taken for each DPS and to protect the small, endangered Central America DPS and threatened Mexico DPS of humpback whales. Furthermore, percentages are rounded up, as partial numbers of individuals

were not acceptable in our calculations. The percentages are directly multiplied by the takes specified in Table 21 to estimate the number of individual humpback whales from each DPS that will be exposed to seismic survey activities under the MMPA incidental harassment authorization. At this time, this method of estimating humpback whale DPS exposure represent the best available data and method given the granularity of the National Science Foundation, Lamont-Doherty Earth Observatory, and NMFS Permits and Conservation Division is able to project in their seismic survey activities and MMPA incidental harassment authorization.

Table 21. Probability of encountering humpback whales from each distinct population segment of humpback whales in the North Pacific Ocean in various feeding areas. Adapted from Wade et al. (2016).

Summer Feeding Areas	Western North Pacific Distinct Population Segment	Hawaii Distinct Population Segment	Mexico Distinct Population Segment	Central America Distinct Population Segment
Aleutian Islands, Bering Sea, Chukchi Sea, Beaufort Sea	4.4%	86.5%	11.3%	0%
Gulf of Alaska	0.5%	89.0%	10.5%	0%
Southeast Alaska, Northern British Columbia	0%	93.9%	6.1%	0%
Southern British Columbia, Washington	0%	52.9%	41.9%	14.7%
Oregon, California	0%	0%	89.6%	19.7%

Using Geographic Information Systems analyses, all of the tracklines in the action area for the seismic survey activities are off Washington and north of the boundary line (https://www.boem.gov/Administrative-Boundaries/) for the state of Oregon that extends to the end of the U.S. Exclusive Economic Zone. Therefore, we will use the percentages in the Southern British Columbia/Washington summer feeding area for proportioning the number of exposures of ESA-listed Central America DPS and Mexico DPS of humpback whales (52.9 percent from the Hawaii DPS, 41.9 percent from the Mexico DPS, and 14.7 percent from the Central America DPS). Using the percentages from Wade et al. (2016), the expected potential instances of take under the ESA is one harm (0.441 rounded up) and five harassments (4.7 rounded up) for the Central America DPS of humpback whales and two harm (1.257 rounded up) and 14 (13.408 rounded up) for the Mexico DPS of humpback whales for a total of 22 (three harm and 19 harassments). The remainder of the expected potential instances of take will be for non-ESA-listed Hawaii DPS of humpback whales.

Sei Whale – The expected potential instances of take under the ESA of the Eastern North Pacific stock of sei whales is a total of 8 (two harm and six harassment), which is approximately 1.54 percent of the population. For reasons previously described, this estimate is conservative, that is, it is likely higher than the actual exposures and a fewer number are not likely to be harmed or harassed given the mitigation measures that will be implemented. Because of the large range of this species compared to the relatively small size of the National Science Foundation and Lamont-Doherty Earth Observatory's action area, combined with the relatively short duration of the seismic survey activities, it is more likely that there will be multiple takes of a smaller number of individuals that will occur within the action area.

Sperm Whale – The estimated potential instances of take under the ESA of the California/Oregon/Washington stock of sperm whales is a total of 48 (zero harm and 48 harassment), which is approximately 2.40 percent of the population. For reasons previously described, this estimate is conservative, that is, it is likely higher than the actual exposures and a fewer number are not likely to be harmed or harassed given the mitigation measures that will be implemented. Because of the large range of this species compared to the relatively small size of the National Science Foundation and Lamont-Doherty Earth Observatory's action area, combined with the relatively short duration of the seismic survey activities, it is more likely that there will be multiple takes of a smaller number of individuals that will occur within the action area.

Guadalupe Fur Seal – The estimated potential instances of take under the ESA of the Mexico stock of Guadalupe fur seals is a total of 65 (zero harm and 65 harassment), which is approximately 0.33 percent of the population. For reasons previously described, this estimate is conservative, that is, it is likely higher than the actual exposures and a fewer number are not likely to be harmed or harassed given the mitigation measures that will be implemented. Because of the large range of this species compared to the relatively small size of the National Science Foundation and Lamont-Doherty Earth Observatory's action area, combined with the relatively short duration of the seismic survey activities, it is more likely that there will be multiple takes of a smaller number of individuals that will occur within the action area.

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

The multi-beam echosounder, sub-bottom profiler, acoustic Doppler current profiler, and acoustic release transponder are the four additional active acoustic system that will operate during the proposed seismic survey on the R/V *Marcus G. Langseth*. The multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler have the potential to expose ESA-listed marine mammal species to sound levels above the 160 dB re: 1 µPa (rms) threshold. The multi-beam echosounder, sub-bottom profiler, acoustic Doppler current profiler and acoustic release transponder operate at generally higher frequencies than airgun array operations (10 to 13.5 [usually 12] kiloHertz for the multi-beam echosounder, 3.5 kiloHertz for

the sub-bottom profiler, 75 kiloHertz for the acoustic Doppler current profiler, and 8 to 13 kiloHertz for the acoustic release transponder). As such, the frequencies will attenuate more rapidly than those from airgun array sound sources. For these reasons, ESA-listed marine mammals will likely experience higher levels of sound from the airgun array well before the multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler sound of equal amplitude since these other sound sources will drop off faster than the airgun arrays.

While the airgun array is not operational, visual protected species observers will remain on duty to collect sighting data. If ESA-listed marine mammals or sea turtles closely approach the research vessel, the R/V *Marcus G. Langseth* will take evasive actions to avoid a vessel-strike and simultaneously avoid exposure to very high sound source levels. Vessel strike has already been ruled out as a discountable effect. We also rule out high-level ensonification of ESA-listed marine mammals (multi-beam echosounder sound source level equals 242 dB re: 1 µPa [rms], sub-bottom profiler sound source level equals 222 dB re: 1 µPa [rms], and acoustic Doppler current profiler sound source levels equals 224 dB re: 1 µPa [rms]), because it presents a low risk for auditory or other damage to occur. Boebel et al. (2006) and Lurton and DeRuiter (2011) concluded that multi-beam echosounders, sub-bottom profilers, and acoustic Doppler current profilers similar to those to be used during the proposed seismic survey activities presented a low risk for auditory damage or any other injury. To be susceptible to TTS, a marine mammal will have to pass at very close range and match the vessel's speed and direction; we expect a very small probability of this during the proposed seismic survey. An individual will have to be located well within 100 meters (328.1 feet) of the research vessel to experience a single multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler pulse that could result in TTS (LGL Ltd. 2008). It is possible, however, that some small number of ESA-listed marine mammals (fewer than those exposed to the airgun array) can experience low-level exposure to the multi-beam echosounder, sub-bottom profiler, acoustic Doppler current profiler, and acoustic release transponder. We are unable to quantify the level of exposure from the secondary sound sources, but do not expect any exposure at levels sufficient to cause more than behavioral responses (e.g., avoidance of the sound source) in some species capable of hearing frequencies produced by the multi-beam echosounder, sub-bottom profiler, acoustic Doppler current profiler, and acoustic release transponder. As discussed earlier, the sound levels produced by the airgun array are of primary concern in terms of exposure, due to their greater energy power, and the potential to cause injury or disrupt essential behavioral patterns.

11.3.1.4 Exposure Analysis for Endangered Species Act-Listed Sea Turtles in the Action Area

As discussed in the *Status of Species Likely to be Adversely Affected* section, there is one ESA-listed sea turtle species that is likely to be affected by the proposed action: leatherback turtles.

During the proposed action, ESA-listed sea turtles may be exposed to sound from five sound sources: the airgun array, multi-beam echosounder, sub-bottom profiler, acoustic Doppler current profiler, and acoustic release transponder. The National Science Foundation did not provide

estimates of the expected number of ESA-listed sea turtles exposed to received levels greater than or equal to 175 dB re: 1 µPa (rms) and 195 dB re: 1 µPa (rms). Our exposure estimates stem from the best available information on sea turtle densities and a predicted radius (rms) (Table 23) along seismic survey tracklines. Based upon information presented in the *Response Analysis*, we expect ESA-listed sea turtles exposed to these sound sources could be harmed, exhibit changes in behavior, and suffer stress.

11.3.1.5 Exposure of Endangered Species Act-Listed Sea Turtles to Airguns

The National Science Foundation and Lamont-Doherty Earth Observatory did not estimate the exposure of ESA-listed sea turtles to sounds from the airgun array associated with the proposed seismic survey activities. As such, we conducted our own exposure analysis. Below we detailed our exposure analysis for sea turtles, which follows a similar approach to that previously described for marine mammals. In this analysis, we rely on acoustic thresholds to determine sound levels at which sea turtles are expected to exhibit a response that may be considered take under the ESA, such as harm and harassment, then utilize these thresholds to calculate ensonified areas, and finally, either multiply these areas by data on sea turtle density, if available to estimate the number of sea turtles exposed to sound fields generated by the airgun array.

For our ESA section 7 consultation, we conducted our own independent review and conducted our own analysis, based on the best available information and methods to evaluate exposure to ESA-listed sea turtles. Below we describe the exposure analysis for ESA-listed sea turtles.

Acoustic Thresholds

In order to estimate exposure of ESA-listed sea turtles to sound fields generated by the airgun arrays that will be expected to result in a behavioral response that may be considered harassment under the ESA, we relied on the available scientific literature. Currently, the best available data come from studies by O'Hara and Wilcox (1990) and McCauley et al. (2000c), who experimentally examined behavioral responses of sea turtles in response to airgun arrays. O'Hara and Wilcox (1990) found that loggerhead turtles exhibited avoidance behavior at estimated sound levels of 175 to 176 dB re: 1 µPa (rms) (or slightly less) in a shallow canal. McCauley et al. (2000c) reported a noticeable increase in swimming behavior for both green and loggerhead turtles at received levels of 166 dB re: 1 µPa (rms). At 175 dB re: 1 µPa (rms), both green and loggerhead turtles displayed increased swimming speed and increasingly erratic behavior (McCauley et al. 2000c). Based on these data, we assume that sea turtles will exhibit a behavioral response in a manner that constitutes harassment under the ESA when exposed to received levels of 175 dB re: 1 µPa (rms) and higher, and so use this threshold to estimate the number of instances of exposure that will result in behavioral harassment, and 195 dB re: 1 µPa (rms) will serve as the exclusion radii for sea turtles and is protective. The predicted distances to which sound levels of 175 dB re: 1 µPa (rms) and 195 dB re: 1 µPa (rms) will be received from the single (40 cubic inch), 18, and 36 airgun arrays in water depths greater than 1,000 meters (3,280.8 feet) for sea turtles during the proposed seismic survey activities in the Northeast Pacific Ocean are in Table 7 above.

In order to estimate exposure of ESA-listed sea turtles to sound fields generated by airgun arrays that will be expected to result in sound-induced hearing loss (i.e., TTS or PTS), we relied on acoustic thresholds for PTS and TTS for impulsive sounds developed by the U.S. Navy for Phase III of their programmatic approach to evaluating the environmental effects of their military readiness activities (U.S. Navy 2017). At the time of our exposure analysis was conducted, we considered these to be the best available data since they rely on all available information on sea turtle hearing and employ the same statistical methodology to derive thresholds as in NMFS' recently issued technical guidance for auditory injury for marine mammals (NOAA 2018). Below we briefly detail these thresholds and their derivation. More information can be found in the U.S. Navy's technical report on the subject (U.S. Navy 2017).

To estimate received levels from airgun arrays and other impulsive sources expected to produce TTS in sea turtles, the U.S. Navy compiled all sea turtle audiograms available in the literature in an effort to create a composite audiogram for sea turtles as a hearing group. Since these data were insufficient to successfully model a composite audiogram via a fitted curve as was done for marine mammals, median audiogram values were used in forming the hearing group's composite audiogram. Based on this composite audiogram and data on the onset of TTS in fishes, an auditory weighting function was created to estimate susceptibility of sea turtles to TTS. Data from fishes were used since there are currently no data on TTS for sea turtles and fishes are considered to have hearing more similar to sea turtles than do marine mammals (Popper et al. 2014). Assuming a similar relationship between TTS onset and PTS onset as has been described for humans and the available data on marine mammals, an extrapolation to PTS susceptibility of sea turtles was made based on the methods proposed by Southall et al. (2007b). From on these data and analyses, dual metric thresholds were established similar to those described above for marine mammals; one threshold based on peak sound pressure level (0-to-peak SPL) that does not incorporate the auditory weighting function nor the duration of exposure, and another based on cumulative sound exposure level (SEL_{cum}) that incorporates both the auditory weighting function and the exposure duration (Table 22).

Table 22. Generalized hearing range and acoustic thresholds identifying the onset of permanent threshold shift and temporary threshold shift for sea turtles exposed to impulsive sounds (U.S. Navy 2017).

Hearing Group	Generalized Hearing Range	Permanent Threshold Shift Onset	Temporary Threshold Shift Onset
Sea Turtles	30 Hertz to 2 KiloHertz	204 dB re 1 μPa²·s SEL_{cum} 232 dB re: 1 μPa SPL (0-peak)	189 dB re 1 μPa²·s SEL_{cum} 226 dB re: 1 μPa SPL (0-peak)

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

Exposure Estimates

In this section, we first evaluate the likelihood that sea turtles will be exposed to sound fields from the seismic survey activities at or above the identified thresholds in Table 7 and Table 22. If we find that such exposure above any particular threshold is likely, we then estimate the number of instances in which we expect sea turtles to be exposed to these sound levels, based on the ensonified areas at or above these sound levels and information on sea turtle density.

We have determined that PTS for sea turtles is highly unlikely to occur. 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. Also, the overall density of sea turtles in the action area will be relatively low, further decreasing the changes of PTS occurring. We therefore conclude that the risk of PTS is highly unlikely such that it is discountable, and will not be considered further in this opinion. Also, 195 dB re: 1 µPa (rms) will serve as the exclusion radii for sea turtles and is protective from harm.

Based on information provided by the National Science Foundation and Lamont-Doherty Earth Observatory, we have determined that sea turtles are likely to be exposed to sound levels at or above the thresholds at which TTS and behavioral harassment will occur. From modeling by the Lamont-Doherty Earth Observatory, the National Science Foundation provided estimated distances for the 175 dB re: 1 µPa (rms) sound levels generated by the single, 18, and 36 airgun array configurations. The predicted radial distances for the behavioral harassment threshold for sea turtles for the R/V *Marcus G. Langseth*'s airgun arrays can be found in Table 23.

Table 23. Predicted radial distances from the R/V *Marcus G. Langseth*'s airgun array to isopleths corresponding to the behavioral harassment threshold and exclusion zone for sea turtles.

Source	Volume (in^3)	Water Depth (m)	Predicted Distance to Threshold (175 dB re: 1 µPa [rms]) (m)[1]	Predicted Distance to Exclusion Zone (195 dB re: 1 µPa [rms]) (m)[1]
1 Airgun	40	>1,000	77	8
18 Airguns	3,300	>1,000	814	76
36 Airguns	6,600	>1,000	1,864	181

[1]Distances for depths greater than 1,000 meters (3,281 feet) are based on Lamont-Doherty Earth Observatory's model results.

Using these radial distances from the airgun array to the 175 dB re: 1 µPa (rms) behavioral harassment threshold, which encompasses any exposure that will result in TTS, we estimated the ensonified area that may result from the proposed seismic survey activities. The ensonified area was then spatially intersected with density data for leatherback turtles provided by the U.S. Navy (https://www.nwtteis.com/portals/nwtteis/files/NWTT_Marine_Species_Density_Technical_Report_April_2019-web.pdf) and NMFS Southwest Fisheries Science Center (Curtis et al. 2015). While we recognize that these sea turtle density data are for the U.S. West Coast Exclusive Economic Zone off California, Oregon, and Washington, to our knowledge they represent the best available data within the action area and are being used by the U.S. Navy in consultation with NMFS on Phase III of the U.S. Navy's Northwest Training and Testing Study Area . The action area is located near the western boundary of the defined Northwest Training and Testing Offshore Study Area. Species-specific density estimates are available for leatherback turtles and have been adjusted to account for a six percent growth rate. Starting at 109 animals for 2014, a six percent growth rate for five years (2014 thorugh 2019) will yield 145.87 animals (and rounded up to 146 animals). The density estimate for leatherback turtles was then calculated by dividing 146 animals by 1,140,913 square kilometers (0.000128 animals per square kilometer).

Following this spatial intersection, we estimated the total number of sea turtles that will be exposed to sound fields that may cause behavioral harassment by multiplying the ensonified area covered by tracklines (radial distances from the airgun array to the predicted isopleths) by the sea turtle densities for the offshore area, where the seismic survey will occur. The area estimated to be ensonified in a single day of the seismic surey is then calculated, based on the areas predicted to be eonsified around the airgun array and representative trackline distances traveled per day. To account for possible delays during the seismic survey (e.g., weather, equipment malfunction) and additional seismic survey activities, a 25 percent contingency (associated with turns, airgun array testing, and repeat coverage for any areas where initial data quality is sub-standard) was added to the number of exposures using the quantitative method. Therefore, the product is multiplied by 1.25 to account for the 25 percent contingency. This results in an estimate to the total area expected to be ensonified to the behavioral harassment thresholds. Summing exposures along all of the tracklines yields the total exposures for leatherback turtles for the proposed action for the 18 airgun array (three-dimensional) and 36 airgun array (two-dimensional) configurations for the seismic survey activies. The final estimated exposure of sea turtles to sounds at or above 175 dB re: 1 µPa (rms) during the National Science Foundation and Lamont-Doherty Earth Observatory's seismic survey on the R/V *Marcus G. Langseth* in the Northeast Pacific Ocean can be found in Table 26..

Table 24. Density of ESA-listed sea turtles in the action area during the National Sciencd Foundation and Lamont-Doherty Earth Observatory's seismic survey in the Northeast Pacific Ocean

Species	Reported Density (number of animals per km^2)	Density Adjusted for Population Growth Rate (number of animals per km^2)
Leatherback Turtle	0.000114	0.000128

km^2=square kilometers

Table 25. Relevant isopleths, daily ensonified area, number of survey days, percent increase, and total ensonified areas during the National Science Foundation and Lamont-Doherty Earth Observatory's seismic survey in the Northeast Pacific Ocean.

Seismic Survey	Criteria	Relevant Isopleth (m)	Daily Ensonified Area (km^2)	Total Survey Days	25 Percent Increase	Total Ensonified Area (km^2)
Two-Dimensional Seismic Survey	175 dB	3,728	700.86	3	1.25	2,628.23
Three-Dimensional Seismic Survey	175 dB	1,628	325.19	16	1.25	6,503.8

m=meter
km^2=square kilometers

Table 26. Estimated exposure of Endangered Species Act-listed sea turtles during the National Science Foundation and Lamont-Doherty Earth Observatory's seismic survey in the Northeast Pacific Ocean.

Species	Density (number of animals per km^2)	Total Ensonified Area for 18 Airgun Array (km^2)	Total Ensonified Area for 36 Airgun Array (km^2)	Authorized Incidental Take by Harassment
Leatherback Turtle	0.000128	6,503.8	2,628.23	1 (0.83) + 1 (0.34) = 2

km^2=square kilometers

It is important to note that the number of exposures presented in Table 26 represent the estimated number 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 harassment threshold. They do not present information on the number of individuals that may experience TTS, nor do they represent the estimated duration of the exposure. Since the National Science Foundation and

Lamont-Doherty Earth Observatory did not provide distances to the TTS thresholds, nor information on the sound source level of their airgun array sound source, we were unable to quantitatively estimate the number of instances at or above the TTS thresholds. As such, we assume that some of the exposures identified in Table 26 will also involve TTS. While the exposures in Table 26 do not necessarily represent individual sea turtles, the overall exposure is relatively low compared to the abundance of each sea turtle population that may occur within the action area. Given this, we expect that most sea turtles will not be exposed more than once, meaning the numbers in Table 26 likely represent individual animals. As for the duration of each instances of exposure estimated in Table 26, 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 presented in Table 26 are expected to less than a single day due to the movement of the research vessel and animals..

Significant leatherback turtle nesting sites occur in the Western Pacific Ocean on beaches in Papua Barat Indonesia, Papua New Guinea, and the Solomon Islands, and in the Eastern Pacific Ocean on beaches in Mexico, Costa Rica, and elsewhere throughout Central America (NMFS 2016). Leatherback turtles in the Pacific Ocean nest from late fall through spring, with dates varying by region. Nesting typically occurs during November through March in Papua New Guinea (Benson 2007), and from October through January for leatherback turtle nesting in Mexico (Fritts 1982). Since there are no nesting sites in or near the action area, we do not expect nesting females or leatherback turtle hatchlings to be exposed to the seismic survey activities.

After nesting, adults undergo long-distance migrations to foraging grounds. Leatherback turtles tagged in Indonesia took ten to 12 months to travel across the Pacific Ocean to foraging areas about 50 to 100 kilometers (27 to 54 nautical miles) off the coasts of Oregon and Washington (Benson 2007; Benson 2011). During aerial surveys, leatherback turtles were sighted in the same area between June and September, mostly over slope waters (200 to 2,000 meters [656.2 to 6,561.7 feet] deep) and continental shelf waters (less than 200 meters [656.2 feet] deep) (Bowlby 1994). The fact that leatherback turtle prey, cndiarians (i.e., jellyfish), occurs in high densities in the region and supports leatherback turtle foraging was a primary reason for designating the area as critical habitat in 2012 (77 FR 41705). Based on this information, and the timing and location of the activities, we expect that foraging leatherback turtles will be present and may be exposed to the seismic survey activities.

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

The multi-beach echosounder, sub-bottom profiler, acoustic Doppler current profiler, and acoustic release transponder has the potential to expose ESA-listed sea turtle species to sound levels above the 175 dB re: 1 µPa (rms) threshold. As described previously, current data indicates sea turtles hear in the low frequency range. The multi-beam echosounder operates at frequencies of 10.5 to 13 (usually 12) kiloHertz, the sub-bottom profiler operates at frequencies

of 3.5 kiloHertz, the acoustic Doppler current profiler operates at frequencies of 75 kiloHertz, and the acoustic release transponder operates at frequencies of 8 to 13 kiloHertz, all which emit sounds outside the hearing frequency of sea turtles (typically 30 Hertz to 2 kiloHertz, with a range of maximum sensitivity between 100 to 800 Hertz). Sea turtles are not expected to detect and therefore not respond to sounds emitted by the multi-beam echosounder, sub-bottom profiler, acoustic Doppler current profiler, and acoustic release transponder.

11.3.2 Response Analysis

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

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

The *Response Analysis* also considers information on the potential for stranding and the potential effects on prey of ESA-listed marine mammals 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 or directly on ESA-listed species themselves. For the purposes of consultation, our assessments try to detect potential lethal, sub-lethal (or physiological), or behavioral responses that might result in reduced fitness of ESA-listed individuals. Ideally, response analyses will consider and weigh evidence of adverse consequences as well as evidence suggesting the absence of such consequences.

11.3.2.1 Potential Response of Marine Mammals to Acoustic Sources

Marine Mammals and Hearing Thresholds

Exposure of marine mammals to very strong impulsive sound sources from airgun arrays can result in auditory damage, such as changes to sensory hairs in the inner ear, which may temporarily or permanently impair hearing by decreasing the range of sound an animal can detect within its normal hearing ranges. Hearing threshold shifts depend upon the duration, frequency, sound pressure, and rise time of the sound. A TTS results in a temporary change to hearing sensitivity (Finneran 2013), and the impairment can last minutes to days, but full recovery of hearing sensitivity is expected. However, a study looking at the effects of sound on mice hearing, has shown that although full hearing can be regained from TTS (i.e., the sensory cells actually receiving sound are normal), damage can still occur to nerves of the cochlear nerve leading to delayed but permanent hearing damage (Kujawa and Liberman 2009). At higher received levels, particularly in frequency ranges where animals are more sensitive, permanent threshold shift can

occur, meaning lost auditory sensitivity is unrecoverable. Either of these conditions can result from exposure to a single pulse or from the accumulated effects of multiple pulses, in which case each pulse need not be as loud as a single pulse to have the same accumulated effect. A TTS and PTS are generally specific to the frequencies over which exposure occurs but can extend to a half-octave above or below the center frequency of the source in tonal exposures (less evident in broadband noise such as the sound sources associated with the proposed action (Kastak 2005; Ketten 2012; Schlundt 2000)).

Few data are available to precisely define each ESA-listed species hearing range, let alone its sensitivity and levels necessary to induce TTS or PTS. Baleen whales (e.g., blue, fin, humpback, and sei whales) have an estimated functional hearing frequency range of 7 Hertz to 35 kiloHertz and sperm whales have an estimated functional hearing frequency range of 150 Hertz to 160 kiloHertz (see Table 13) (Southall 2007). For pinnipeds in water, data are limited to measurements of TTS in harbor seals (*Phoca vitulina*), an elephant seal (*Mirounga angustirostris*), and California sea lions (*Zalophus californianus*) (Kastak et al. 1999; Kastelein et al. 2012). Otariid sea lions and fur seals, like Guadalupe fur seals, have an estimated functional hearing range of 60 Hertz to 39 kiloHertz.

Based upon captive studies of odontocetes, our understanding of terrestrial mammal hearing, and extensive modeling, the best available information supports the position that sound levels at a given frequency will need to be approximately 186 dB SEL or approximately 196 to 201 dB re: 1 µPa (rms) in order to produce a low-level TTS from a single pulse (Southall et al. 2007c). PTS is expected at levels approximately 6 dB greater than TTS levels on a peak-pressure basis, or 15 dB greater on an SEL basis than TTS (Southall et al. 2007c). In terms of exposure to the R/V *Marcus G. Langseth*'s airgun array, an individual will need to be within a few meters of the largest airgun to experience a single pulse greater than 230 dB re: 1 µPa (peak) (Caldwell and Dragoset 2000). If an individual experienced exposure to several airgun pulses of approximately 219 dB for low-frequency cetaceans, 230 dB for mid-frequency cetaceans, or 202 dB for high-frequency cetaceans, PTS could occur. Marine mammals (cetaceans and pinnipeds) will have to be within certain modeled radial distances specified in Table 15 and Table 16 from the R/V *Marcus G. Langseth*'s single airgun, 18 airgun array, and 36 airgun array to be within the ESA harm (MMPA Level A harassment) to be within the threshold isopleth and risk a PTS and within the ESA harassment (MMPA Level B harassment) to be within the threshold isopleth and risk behavioral responses.

Research and observations show that pinnipeds in the water are tolerant of anthropogenic noise and activity. If Guadalupe fur seals are exposed to active acoustic sources they may react in a number of ways depending on their experience with the sound source and what activity they are engaged in at the time of the acoustic exposure. Guadalupe fur seals may not react at all until the sound source is approaching within a few hundred meters and then may alert, approach, ignore the stimulus, change their behaviors, or avoid the immediate area by swimming away or diving (Finneran et al. 2003a; Götz and Janik 2011; Kvadsheim et al. 2010). Significant behavioral

reactions would not be expected in most cases, and long-term consequences for individuals or the population are unlikely.

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

Overall, we do not expect TTS to occur to any ESA-listed marine mammals as a result of exposure to the airgun array for several reasons, as the probability of occurrence is low. We expect that most individuals will move away from the airgun array as it approaches; however, a few individuals may be exposed to sound levels that may result in TTS or PTS, but we expect the probability to be low. As the seismic survey proceeds along each transect trackline and approaches ESA-listed individuals, the sound intensity increases, individuals will experience conditions (stress, loss of prey, discomfort, etc.) that prompt them to move away from the research vessel and sound source and thus avoid exposures that will induce TTS or PTS. Ramp-ups will also reduce the probability of TTS-inducing exposure at the start of seismic survey activities for the same reasons, as acoustic intensity increases, animals will move away and therefore unlikely to accumulate more injurious levels. Furthermore, mitigation measures will be in place to initiate a shut-down if individuals enter or are about to enter the 500 meter (1,640.4 feet) exclusion zone during full airgun array operations, which is beyond the distances believed to have the potential for PTS in any of the ESA-listed marine mammals as described above. As stated in the *Exposure Analysis*, each individual is expected to be potentially be exposed to 160 dB re: 1 µPa (rms) levels. We do not expect this to produce a cumulative TTS or other physical injury for several reasons. We expect that individuals will recover from TTS between each of these exposures, we expect monitoring to produce some degree of mitigation such that exposures will be reduced, and (as stated above), we expect individuals, to generally move away at least a short distance as received sound levels increase, reducing the likelihood of exposure that is biologically meaningful. In summary, we do not expect animals to be present for a sufficient duration to accumulate sound pressure levels that will lead to the onset of TTS or PTS.

Marine Mammals and Auditory Interference (Masking)

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

There is frequency overlap between airgun array sounds and vocalizations of ESA-listed marine mammals, particularly baleen whales and to some extent sperm whales. The proposed seismic

survey could mask whale calls at some of the lower frequencies for these species. This could affect communication between individuals, affect their ability to receive information from their environment, or affect sperm whale echolocation (Evans 1998; NMFS 2006h). Most of the energy of sperm whale clicks is concentrated at 2 to 4 kiloHertz and 10 to 16 kiloHertz , and though the findings by Madsen et al. (2006) suggest frequencies of pulses from airgun arrays can overlap this range, the strongest spectrum levels of airguns are below 200 Hertz (2 to 188 Hertz for the R/V *Marcus G. Langseth*'s airgun array). Any masking that might occur will likely to be temporary because acoustic sources from the seismic surveys are not continuous and the research vessel will continue to transit through the area. In addition, the proposed seismic survey activities on the R/V *Marcus G. Langseth* are planned to occur over the course of approximately 33 days (i.e., approximately 19 days of airgun array operations [approximately three days for the two-dimensional seismic survey and approximately 16 days for the three-dimensional seismic survey], approximately seven days of equipment deployment and retrieval, approximately five days of contingency time, two days of turns [with no airgun array firing], and approximately two days of transit) for seismic survey in the Northeast Pacific Ocean in July and August 2019.

Given the disparity between sperm whale echolocation and communication-related sounds with the dominant frequencies for seismic surveys, masking is not likely to be significant for sperm whales (NMFS 2006h). Overlap of the dominant low frequencies of airgun pulses with low-frequency baleen whale calls will be expected to pose a somewhat greater risk of masking. The R/V *Marcus G. Langseth*'s airguns will emit a 0.1 second pulse when fired approximately every 16 to 17 seconds. Therefore, pulses will not "cover up" the vocalizations of ESA-listed marine mammals to a significant extent (Madsen et al. 2002b). We address the response of ESA-listed marine mammals stopping vocalizations as a result of airgun sound in the *Marine Mammals and Behavioral Responses* section below.

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

The sound localization abilities of marine mammals suggest that, if signal and sound come from different directions, masking will not be as severe as the usual types of masking studies might suggest (Richardson 1995). The dominant background noise may be highly directional if it comes from a particular anthropogenic source such as a ship or industrial site. Directional hearing may significantly reduce the masking effects of these sounds by improving the effective signal-to-sound ratio. In the cases of higher frequency hearing by the bottlenose dolphin (*Tursiops truncatus*), beluga whale (*Delphinapterus leucas*), and killer whale, empirical evidence confirms that masking depends strongly on the relative directions of arrival of sound signals and

the masking sound (Bain 1993; Bain 1994; Dubrovskiy 2004). Toothed whales and probably other marine mammals as well, have additional capabilities besides directional hearing that can facilitate detection of sounds in the presence of background sound. There is evidence that some toothed whales can shift the dominant frequencies of their echolocation signals from a frequency range with a lot of ambient sound toward frequencies with less noise (Au 1975; Au 1974; Lesage 1999; Moore 1990; Romanenko 1992; Thomas 1990). A few marine mammal species increase the source levels or alter the frequency of their calls in the presence of elevated sound levels (Au 1993; Dahlheim 1987; Foote 2004; Holt 2009; Lesage 1999; Lesage 1993; Parks 2009a; Parks 2007; Terhune 1999).

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

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

Marine Mammals and Behavioral Responses

We expect the greatest response of marine mammals to airgun array sounds in terms of number of responses and overall impact to be in the form of changes in behavior. ESA-listed individuals may briefly respond to underwater sound by slightly changing their behavior or relocating a short distance, in which case some of the responses can equate to harassment of individuals but are unlikely to result in meaningful behavioral responses at the population level. Displacement from important feeding or breeding areas over a prolonged period would likely be more significant for individuals and could affect the population depending on the extent of the feeding area and duration of displacement. This has been suggested for humpback whales along the Brazilian coast as a result of increased seismic survey activity (Parente et al. 2007). Marine mammal responses to anthropogenic sound vary by species, state of maturity, prior exposure, current activity, reproductive state, time of day, and other factors (Ellison et al. 2012; Harris et al. 2018); this is reflected in a variety of aquatic, aerial, and terrestrial animal responses to anthropogenic

noise that may ultimately have fitness consequences (Costa et al. 2016; Fleishman et al. 2016; Francis and Barber 2013; New et al. 2014; NRC 2005). Although some studies are available which address responses of ESA-listed marine mammals considered in this opinion directly, additional studies to other related whales (such as bowhead and gray whales) are relevant in determining the responses expected by species under consideration. Therefore, studies from non-ESA-listed or species outside the action area are also considered here. Animals generally respond to anthropogenic perturbations as they will predators, increasing vigilance, and altering habitat selection (Reep et al. 2011). There is increasing support that this predator like response is true for animals' response to anthropogenic sound (Harris et al. 2018). Habitat abandonment due to anthropogenic noise exposure has been found in terrestrial species (Francis and Barber 2013). Because of the similarities in hearing anatomy of terrestrial and marine mammals, we expect it possible for ESA-listed marine mammals to behave in a similar manner as terrestrial mammals when they detect a sound stimulus. For additional information on the behavioral responses marine mammals exhibit in response to anthropogenic noise, including non-ESA-listed marine mammal species, see the *Federal Register* notice of the proposed IHA (84 FR 26940) as well as one of several reviews (e.g., Gomez et al. 2016; Southall et al. 2007b).

Several studies have aided in assessing the various levels at which whales may modify or stop their calls in response to sounds for airguns. Whales continue calling while seismic surveys are operating locally (Greene Jr et al. 1999; Jochens et al. 2006; Madsen et al. 2002b; McDonald et al. 1993; McDonald et al. 1995; Nieukirk et al. 2004; Richardson et al. 1986a; Smultea et al. 2004; Tyack et al. 2003). However, humpback whale males increasingly stopped vocal displays on Angolan breeding grounds as received seismic airgun levels increased (Cerchio 2014). Some blue, fin, and sperm whales stopped calling for short and long periods apparently in response to airguns (Bowles et al. 1994; Clark and Gagnon 2006; McDonald et al. 1995). Fin whales (presumably adult males) engaged in singing in the Mediterranean Sea moved out of the area of a seismic survey while airguns were operational as well as for at least a week thereafter (Castellote et al. 2012b). Dunn and Hernandez (2009) tracked blue whales during a seismic survey on the R/V *Maurice Ewing* in 2007 and did not observe changes in call rates and found no evidence of anomalous behavior that they could directly ascribe to the use of airguns at sound levels of approximately less than 145 dB re: 1 μPa (rms) (Wilcock et al. 2014). Blue whales may also attempt to compensate for elevated ambient sound by calling more frequently during seismic surveys (Iorio and Clark 2009). Bowhead whale calling rates were found to decrease during migration in the Beaufort Sea when seismic surveys were being conducted (Nations et al. 2009). Calling rates decreased when exposed to seismic airguns at estimated received levels of 116 to 129 dB re: 1 μPa (rms), but did not change at received levels of 99 to 108 dB re: 1 μPa (rms) (Blackwell et al. 2013). A more recent study examining cumulative sound exposure found that bowhead whales began to increase call rates as soon as airgun sounds were detectable, but this increase leveled off at approximate 94 dB re: 1 μPa^2-s over the course of ten minutes (Blackwell et al. 2015). Once sound levels exceeded approximately 127 dB re: 1 μPa^2-s over ten minutes, call rates began to decline and at approximately 160 dB re: 1 μPa^2-s over 10 minutes, bowhead

whales appeared ceased calling all together (Blackwell et al. 2015). While we are aware of no data documenting changes in North Atlantic right whale vocalization in association with seismic surveys, as mentioned previously they do shift calling frequencies and increase call amplitude over both long and short term periods due to chronic exposure to vessel sound (Parks and Clark 2007; Parks et al. 2007; Parks et al. 2011; Parks et al. 2012; Parks et al. 2009; Tennessen and Parks 2016). Sperm whales, at least under some conditions, may be particularly sensitive to airgun sounds, as they have been documented to cease calling in association with airguns being fired hundreds of kilometers away (Bowles et al. 1994). Other studies have found no response by sperm whales to received airgun sound levels up to 146 dB re: 1 µPa (peak-to-peak) (Madsen et al. 2002a; McCall Howard 1999). For the species considered in this consultation, some exposed individual ESA-listed marine mammals may cease calling or otherwise alter their vocal behavior in response to the R/V *Marcus G. 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 at a later time or location away from the R/V *Marcus G. Langseth*'s airgun array during the course of the proposed seismic survey once the acoustic stressor has diminished.

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

that will occur if a marine mammal were present in the exclusion zone will lower the likelihood that marine mammals will be exposed to sounds from the airgun array.

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

Humpback whales exhibit a pattern of lower threshold responses when not occupied with feeding. Migrating humpbacks altered their travel path (at least locally) along Western Australia at received levels as low as 140 dB re: 1 µPa (rms) when females with calves were present, or 7 to 12 kilometers (3.8 to 6.5 nautical miles) from the acoustic source (McCauley et al. 2000a; McCauley et al. 1998). A startle response occurred as low as 112 dB re: 1 µPa (rms). Closest approaches were generally limited to 3 to 4 kilometers (1.6 to 2.2 nautical miles), although some individuals (mainly males) approached to within 100 meters (328.1 feet) on occasion where sound levels were 179 dB re: 1 µPa (rms). Changes in course and speed generally occurred at estimated received levels of 157 to 164 dB re: 1 µPa (rms). Similarly, on the east coast of Australia, migrating humpback whales appear to avoid seismic airguns at distances of 3 kilometers (1.6 nautical miles) at levels of 140 dB re: 1 μPa^2-second. A recent study examining the response of migrating humpback whales to a full 51,291.5 cubic centimeters (3,130 cubic inch) airgun array found that humpback whales exhibited no abnormal behaviors in response to the active airgun array, and while there were detectible changes in respiration and diving, these were similar to those observed when baseline groups (i.e., not exposed to active sound sources) were joined by another humpback whale (Dunlop et al. 2017). While some humpback whales were also found to reduce their speed and change course along their migratory route, overall these results suggest that the behavioral responses exhibited by humpback whales are unlikely to have significant biological consequences for fitness (Dunlop et al. 2017). Feeding humpback whales appear to be somewhat more tolerant. Humpback whales off the coast of Alaska startled at 150 to 169 dB re: 1 µPa (rms) and no clear evidence of avoidance was apparent at received levels up to 172 dB re: 1 µPa (rms) (Malme et al. 1984a; Malme et al. 1985). Potter et al. (2007)

found that humpback whales on feeding grounds in the Atlantic Ocean did exhibit localized avoidance to airgun arrays. Among humpback whales on Angolan breeding grounds, no clear difference was observed in encounter rate or point of closest approach during seismic versus non-seismic periods (Weir 2008).

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

Sperm whale response to airguns has thus far included mild behavioral disturbance (temporarily disrupted foraging, avoidance, cessation of vocal behavior) or no reaction. Several studies have found sperm whales in the Atlantic Ocean to show little or no response (Davis et al. 2000; Madsen et al. 2006; Miller et al. 2009; Moulton and Miller 2005a; Stone 2003; Stone et al. 2017; Stone and Tasker 2006; Weir 2008). Detailed study of sperm whales in the Gulf of Mexico suggests some alteration in foraging from less than 130 to 162 dB re: 1 µPa peak-to-peak, although other behavioral reactions were not noted by several authors (Gordon et al. 2006; Gordon et al. 2004; Jochens et al. 2006; Madsen et al. 2006; Winsor and Mate 2006). This has been contradicted by other studies, which found avoidance reactions by sperm whales in the Gulf of Mexico in response to seismic ensonification (Jochens and Biggs 2004; Jochens 2003; Mate et al. 1994). Johnson and Miller (2002) noted possible avoidance at received sound levels of 137 dB re: 1 µPa. Other anthropogenic sounds, such as pingers and sonars, disrupt behavior and vocal patterns (Goold 1999; Watkins et al. 1985; Watkins and Schevill 1975a). Miller et al. (2009) found sperm whales to be generally unresponsive to airgun exposure in the Gulf of Mexico, although foraging behavior may have been affected based on changes in echolocation rate and slight changes in dive behavior. Displacement from the area was not observed. Winsor and Mate (2013) did not find a non-random distribution of satellite-tagged sperm whales at and beyond 5 kilometers (2.7 nautical miles) from airgun arrays, suggesting individuals were not displaced or move away from the airgun array at and beyond these distances in the Gulf of Mexico (Winsor and Mate 2013). However, no tagged whales within 5 kilometers (2.7 nautical miles) were available to assess potential displacement within 5 kilometers (2.7 nautical miles) (Winsor and Mate 2013). In a follow-up study using additional data, Winsor et al. (2017) found no evidence to suggest sperm whales avoid active airguns within distances of 50 kilometers (27 nautical miles). The lack of response by this species may in part be due to its higher range of hearing sensitivity and the low-frequency (generally less than 200 Hertz) pulses produced by seismic airguns (Richardson et al. 1995b). However, sperm whales are exposed to considerable energy above 500 Hertz during the course of seismic surveys (Goold and Fish 1998), so even

though this species generally hears at higher frequencies, this does not mean that it cannot hear airgun sounds. Breitzke et al. (2008) found that source levels were approximately 30 dB re: 1 µPa lower at 1 kiloHertz and 60 dB re: 1 µPa lower at 80 kiloHertz compared to dominant frequencies during a seismic source calibration. Another odontocete, bottlenose dolphins, progressively reduced their vocalizations as an airgun array came closer and got louder (Woude 2013). Reactions of sperm whales to impulse noise likely vary depending on the activity at 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).

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

Kvadsheim et al. (2010) found that captive hooded seal (*Cystophora cristata*) reacted to 1 to 7 kiloHertz sonar signals by moving to the areas of last sound pressure level, at levels between 160 and 170 dB re: 1 µPa. Finneran et al. (2003b) found that trained captive sea lions showed avoidance behavior in response to impulsive sounds at levels above 165 to 170 dB re: 1 µPa (rms). These studies are in contrast to the results of Costa (1993) which found that free ranging elephant seals showed no change in diving behavior when exposed to very low frequency sounds (55 to 95 Hertz) at levels up to 137 dB re: 1 µPa (though the received level in this study were much lower (Costa et al. 2003). Similar to behavioral responses of mysticetes and odontocetes, potential behavioral responses of pinnipeds to the proposed seismic survey activities are not expected to impact the fitness of any individual animals as the responses are not likely to adversely affect the ability of the animals to forage, detect predators, select a mate, or reproduce

successfully. As noted in (Southall et al. 2007a), substantive behavioral reactions to noise exposure (such as disruption of critical life functions, displacement, or avoidance of important habitat) are considered more likely to be significant if they last more than 24 hours, or recur on subsequent days. Behavioral reactions are not expected to last more than 24 hours or recur on subsequent days such that an animal's fitness could be impacted. That we do not expect fitness consequences is further supported by Navy monitoring of Navy-wide activities since 2006 which has documented hundreds of thousands of marine mammals on training and testing range complexes and there are only two instances of overt behavioral change that have been observed and there have been no demonstrable instances of injury to marine mammals as a result of non-impulsive acoustic sources such as low frequency active sonar. Because we do not expect any fitness consequences from any individual animals to result from instances of behavioral response, we do not expect any population level effects from these behavioral responses.

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

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

In summary, ESA-listed marine mammals are expected to exhibit a wide range of behavioral responses when exposed to sound fields from the airgun array. Baleen whales are expected to mostly exhibit avoidance behavior, and may also alter their vocalizations. Toothed whales (i.e., sperm whales) are expected to exhibit less overt behavioral changes, but may alter foraging behavior, including echolocation vocalizations. Pinnipeds (i.e., Guadalupe fur seals) are expect to exhibit avoidance and behavioral changes. These responses are expected to be temporary with behavior returning to a baseline state shortly after the sound source becomes inactive or leaves the area.

Marine Mammals and Physical or Physiological Effects

Individual whales exposed to airguns (as well as other sound sources) could experience effects not readily observable, such as stress (Romano et al. 2002), that may have adverse affects. Other possible responses to impulsive sound sources like airgun arrays include neurological effects, bubble formation, resonance effects, and other types of organ or tissue damage (Cox et al. 2006; Southall et al. 2007b; Tal et al. 2015; Zimmer and Tyack 2007), but similar to stress, these effects are not readily observable. Importantly, these more severe physical and physiological responses have been associated with explosives and/or mid-frequency tactical sonar, but not seismic airguns. We do not expect ESA-listed marine mammals to experience any of these more severe physical and physiological responses as a result of the proposed seismic survey activities.

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

adults and mammals with poor diets or undergoing dietary change tend to have higher fecal cortisol levels (Hunt et al. 2006; Keay et al. 2006).

Loud sounds generally increase stress indicators in mammals (Kight and Swaddle 2011). Romano et al. (2004) found beluga whales and bottlenose dolphins exposed to a seismic watergun (up to 228 dB re: 1 µPa m 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. 2012b). These levels returned to baseline after 24 hours of traffic resuming.

As whales use hearing for communication as a primary way to gather information about their environment, we assume that limiting these abilities, as is the case when masking occurs, will be stressful. We also assume that any individuals exposed to sound levels sufficient to trigger onset of PTS or TTS will also experience physiological stress response (NMFS 2006b; NRC 2003b). Finally, we assume that some individuals exposed at sound levels below those required to induce a TTS, but above the ESA harassment (MMPA Level B harassment) 160 dB re: 1 µPa (rms) threshold, will experience a stress response, which may also be associated with an overt behavioral response. However, since in all cases exposure to sounds from airgun arrays (or fisheries echosounder) are expected to be temporary, we expect any such stress responses to be short-term. Given the available data, animals will be expected to return to baseline state (e.g., baseline cortisol level) within hours to days, with the duration of the stress response depending on the severity of the exposure (i.e., we expect a TTS exposure will result in a longer duration before returning to a baseline state as compared to exposure to levels below the TTS threshold).

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

appears to result in beneficial effects in diverse taxa. Clearly, the impacts of even loud sound 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 reproductive and metabolic physiology of ESA-listed marine mammals.

It is possible that an animal's prior exposure to sounds from seismic surveys influence its future response. We have little information available to us as to what response individuals will have to future exposures to sources from seismic surveys compared to prior experience. If prior exposure produces a learned response, then this subsequent learned response will likely be similar to or less than prior responses to other stressors where the individual experienced a stress response associated with the novel stimuli and responded behaviorally as a consequence (such as moving away and reduced time budget for activities otherwise undertaken) (Andre 1997; André 1997; Gordon et al. 2006). We do not believe sensitization will occur based upon the lack of severe responses previously observed in marine mammals and sea turtles exposed to sounds from seismic surveys that will be expected to produce a more intense, frequent, and/or earlier response to subsequent exposures (see *Response Analysis*). The proposed action will take place over a little more than approximately 33 days; minimizing the likelihood that sensitization will occur. As stated before, we believe that exposed individuals will move away from the sound source, especially in the open ocean of the action area, where we expect species to be transiting through.

Marine Mammals and Strandings

There is some concern regarding the coincidence of marine mammal strandings and proximal seismic surveys. No conclusive evidence exists to causally link stranding events to seismic surveys. Suggestions that there was a link between seismic surveys and strandings of humpback whales in Brazil (Engel et al. 2004) were not well founded (Iagc 2004; IWC 2007a). In September 2002, two Cuvier's beaked whales (*Ziphius cavirostris*) stranded in the Gulf of California, Mexico. The R/V *Maurice Ewing* had been operating a 20 airgun array (139,126.2 cubic centimeters [8,490 cubic inch]) 22 kilometers (11.9 nautical miles) offshore the general area at the time that stranding occurred. The link between the stranding and the seismic surveys was inconclusive and not based on any physical evidence, as the individuals who happened upon the stranding were ill-equipped to perform an adequate necropsy (Taylor et al. 2004). Furthermore, the small numbers of animals involved and the lack of knowledge regarding the spatial and temporal correlation between the beaked whales and the sound source underlies the uncertainty regarding the linkage between sound sources from seismic surveys and beaked whale strandings (Cox et al. 2006). Numerous studies suggest that the physiology, behavior, habitat relationships, age, or condition of cetaceans may cause them to strand or might pre-dispose them to strand when exposed to another phenomenon. These suggestions are consistent with the conclusions of numerous other studies that have demonstrated that combinations of dissimilar stressors commonly combine to kill an animal or dramatically reduce its fitness, even though one exposure without the other does not produce the same result (Creel 2005; Fair and Becker 2000; Kerby et al. 2004; Moberg 2000; Romano et al. 2004). At present, the factors of airgun arrays

from seismic surveys that may contribute to marine mammal strandings are unknown and we have no evidence to lead us to believe that aspects of the airgun array proposed for use will cause marine mammal strandings. We do not expect ESA-listed marine mammals to strand as a result of the proposed seismic survey. The seismic survey will take place in the Northeast Pacific Ocean, and the closest approach to the United States coastline will be approximately 370.1 kilometers (230 miles) from land off Washington and Oregon. If exposed to seismic survey activities, we expect ESA-listed marine mammals will have sufficient space in the open ocean to move away from the sound source and will not be likely to strand.

Responses of Marine Mammal Prey

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

Some support has been found for fish or invertebrate mortality resulting from exposure to airguns, and this is limited to close-range exposure to high amplitudes (Bjarti 2002; D'Amelio 1999; Falk and Lawrence 1973; Hassel et al. 2003; Holliday et al. 1987; Kostyuchenko 1973; La Bella et al. 1996; McCauley et al. 2000a; McCauley et al. 2000b; McCauley et al. 2003; Popper et al. 2005). Lethal effects, if any, are expected within a few meters of the airgun array (Buchanan et al. 2004; Dalen and Knutsen 1986). We expect that if fish detect the sound and perceive it as a threat or some other signal that induces them to leave the area they are capable of moving away from the sound source (e.g., airgun array) if it causes them discomfort and will return to the area and available as prey for marine mammals.

There are reports showing sub-lethal effects to some fish species. Several species at various life stages have been exposed to high-intensity sound sources (220 to 242 dB re: 1 µPa) at close distances, with some cases of injury (Booman et al. 1996; McCauley et al. 2003). Effects from TTS were not found in whitefish at received levels of approximately 175 dB re: 1 $\mu Pa^2 s$, but pike did show 10 to 15 dB of hearing loss with recovery within one day (Popper et al. 2005). Caged pink snapper (*Pelates spp.*) have experienced PTS when exposed over 600 times to received sound levels of 165 to 209 dB re: 1 µPa peak-to-peak. Exposure to airguns at close range were found to produce balance issues in exposed fry (Dalen and Knutsen 1986). Exposure of monkfish (*Lophius* spp.) and capelin (*Mallotus villosus*) eggs at close range to airguns did not produce differences in mortality compared to control groups (Payne 2009). Salmonid swim bladders were reportedly damaged by received sound levels of approximately 230 dB re: 1 µPa (Falk and Lawrence 1973).

By far the most common response by fishes is a startle or distributional response, where fish react momentarily by changing orientation or swimming speed, or change their vertical

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

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

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

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

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

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

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

The overall response of fishes and squids is to exhibit startle responses and undergo vertical and horizontal movements away from the sound field. We are not aware of any specific studies regarding sound effects on and the detection ability of other invertebrates such as krill (*Euphausiacea* spp.), the primary prey of most ESA-listed baleen whales. However, we do not expect krill to experience effects from sounds of airguns. Although humpback whales consume fish regularly, we expect that any disruption to their prey will be temporary, if at all. Therefore,

we do not expect any adverse effects from lack of prey availability to baleen whales. Sperm whales regularly feed on squid and some fishes and we expect individuals to feed while in the action area during the proposed seismic survey activities. Based upon the best available information, fishes and squids located within the sound fields corresponding to the approximate 160 dB re: 1 µPa (rms) isopleths could vacate the area and/or dive to greater depths. We do not expect indirect effects from airgun array operations through reduced feeding opportunities for ESA-listed marine mammals to be sufficient to reach a significant level. Effects are likely to be temporary and, if displaced, both marine mammals and their prey will re-distribute back into the action area once seismic survey activities have passed or concluded.

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

We expect ESA-listed marine mammals to experience ensonification from not only the airgun array, but also from the multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler. The multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler used during the seismic survey operate at a frequency of 10.5 to 13 (usually 12) kilohertz, 3.5 kiloHertz, and 75 kiloHertz, respectively. These frequencies are within the functional hearing range of baleen whales (7 Hertz to 35 kiloHertz), such as blue, fin, humpback, and sei whales, as well as sperm whales (150 Hertz to 160 kiloHertz) (NOAA 2018). We expect that these mapping systems will produce harmonic components in a frequency range above and below the center frequency similar to other commercial sonars (Deng 2014). Although Todd et al. (1992) found that mysticetes reacted to sonar sounds at 3.5 kiloHertz within the 80 to 90 dB re: 1 µPa range, it is difficult to determine the significance of this because the sound source was a signal designed to be alarming and the sound level was well below typical ambient noise. Goldbogen et al. (2013) found blue whales to respond to 3.5 to 4 kiloHertz mid-frequency sonar at received levels below 90 dB re: 1 µPa. Responses included cessation of foraging, increased swimming speed, and directed travel away from the source (Goldbogen 2013). Hearing is poorly understood for ESA-listed baleen whales, but it is assumed that they are most sensitive to frequencies over which they vocalize, which are much lower than frequencies emitted by the multi-beam echosounder, sub-bottom profiler, acoustic Doppler current profiler, and acoustic release transponder (Ketten 1997; Richardson et al. 1995e).

Assumptions for humpback and sperm whale hearing are much different than for ESA-listed baleen whales. Humpback and sperm whales vocalize between 3.5 to 12.6 kiloHertz and an audiogram of a juvenile sperm whale provides direct support for hearing over this entire range (Au 2000; Au et al. 2006b; Carder and Ridgway 1990; Erbe 2002a; Frazer and Mercado 2000; Goold and Jones 1995; Levenson 1974; Payne and Payne 1985; Payne 1970; Richardson et al. 1995e; Silber 1986a; Thompson et al. 1986a; Tyack 1983a; Tyack and Whitehead 1983; Weilgart and Whitehead 1993; Weilgart and Whitehead 1997b; Weir et al. 2007; Winn et al. 1970a). The response of a blue whale to 3.5 kiloHertz sonar supports this species' ability to hear this signal as well (Goldbogen 2013). Maybaum (1990a; 1993) observed that Hawaiian

humpback whales moved away and/or increased swimming speed upon exposure to 3.1 to 3.6 kiloHertz sonar. Kremser et al. (2005) concluded the probability of a cetacean swimming through the area of exposure when such sources emit a pulse is small, as the animal will have to pass at close range and be swimming at speeds similar to the vessel. The animal will have to pass the transducer at close range and be swimming at speeds similar to the vessel in order to receive the multiple pulses that might result in sufficient exposure to cause TTS. Sperm whales have stopped vocalizing in response to 6 to 13 kiloHertz pingers, but did not respond to 12 kiloHertz echosounders (Backus and Schevill 1966; Watkins 1977; Watkins and Schevill 1975b). Sperm whales exhibited a startle response to 10 kiloHertz pulses upon exposure while resting and feeding, but not while traveling (Andre 1997; André 1997).

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

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

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

11.3.2.2 Potential Responses of Sea Turtles to Acoustic Sources

As with marine mammals, ESA-listed sea turtles may exhibit a variety of different responses to sound fields associated with seismic survey activities. Below we review what is known about the following responses that sea turtles may exhibit (reviewed in Nelms et al. 2016):

- Hearing threshold shifts;
- Behavioral responses; and
- Non-auditory physical or physiological effects.

To our knowledge, strandings of sea turtles in association with anthropogenic sound has not been documented, and so no such stranding response is expected. In addition, masking is not expected to affect sea turtles because they are not known to rely heavily on acoustics for life functions (Nelms et al. 2016; Popper et al. 2014).

Sea Turtles and Hearing Thresholds

Like marine mammals, if exposed to loud sounds sea turtles may experience TTS and/or PTS. Although all sea turtle species studies exhibit the ability to detect low frequency sound, the potential effects of exposure to loud sounds on sea turtle biology remain largely unknown (Nelms et al. 2016; Samuel et al. 2005). Few data are available to assess sea turtle hearing, let alone the effects sound sources from seismic surveys may have on their hearing potential. The only study which addressed 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 one 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 (McCauley et al. 2000a; McCauley et al. 2000b; Moein et al. 1994), 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 seismic airgun arrays (Smultea and Holst 2003). For this reason, mitigation measures will be implemented to limit sea turtle exposure at 100 meters (328.1 feet). In most cases, we expect most 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 and the effectiveness of mitigation 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 or PTS, but it could occur for a few individuals. Although the probability of this 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).

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 much information on how sea turtles specifically will respond, but we present the available information. Behavioral responses to human activity have been investigated for only a few species of sea turtles: green and loggerhead (McCauley et al. 2000c; O'hara and Wilcox 1990); and leatherback, loggerhead, olive ridley, and 160 unidentified turtles (hardshell species) (Weir 2007). The work by O'Hara and Wilcox (1990) and McCauley et al. (2000c) 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 since at and above this level loggerhead turtles were observed to exhibit avoidance behavior, increased swimming speed, and erratic behavior. Loggerhead turtles have also been observed to more towards the surface upon exposure to an airgun (Lenhardt 1994; Lenhardt et al. 1983). 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 specifically (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. 2006; Holst and Smultea 2008a; Holst et al. 2005a; NMFS 2006a; NMFS 2006h; Smultea et al. 2005).

Observational evidence suggests that sea turtles are not as sensitive to sound as are marine mammals and 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 to closer proximity, 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 while the R/V *Marcus G. Langseth* transits through.

Sea Turtles and Physical or Physiological Effects

Direct evidence of seismic sound causing stress is lacking in sea turtles. However, animals often respond to anthropogenic stressors in a manner that resembles a predator response (Beale and Monaghan 2004; Frid 2003; Frid and Dill 2002; Gill et al. 2001; Harrington and Veitch 1992; Harris et al. 2018; Lima 1998; Romero 2004). As predators generally induce a stress response in

their prey (Dwyer 2004; Lopez 2001; Mateo 2007), we assume that sea turtles experience a stress response if exposed to loud sounds from airgun arrays. We expect breeding adult females may experience a lower stress response, as female loggerhead, hawksbill, and green turtles appear to have a physiological mechanism to reduce or eliminate hormonal response 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 2001; Jessop et al. 2000; 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.

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

Sea turtles do not possess a hearing range that includes frequencies emitted by the multi-beam echosounder (10.5 to 13 [usually 12] kiloHertz), sub-bottom profiler (3.5 kiloHertz), acoustic Doppler current profiler (75 kiloHertz), and acoustic release transponder (8 to 13 kiloHertz). 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.

Marine Mammal and Sea Turtle Prey

Seismic surveys may also have indirect, adverse effects on ESA-listed marine mammals and sea turtles by affecting their prey (including larval stages) through lethal or sub-lethal damage, stress responses, or alterations in their behavior or distribution. Such prey include fishes (blue, fin, humpback, sei, and sperm whales and Guadalupe fur seals), zooplankton (blue, fin, humpback, and sei whales as well as sea turtles), cephalopods (sperm whales and Guadalupe fur seals), and other invertebrates such as crustaceans, molluscs, and jellyfish (blue whales and sea turtles). In a recent, fairly exhaustive review, Carroll et al. (2017) summarized the available information the available information on the impact seismic surveys have on fishes and invertebrates. In many cases, species-specific information on the prey of ESA-listed marine mammals and sea turtles is not available. Until more specific information becomes available, we expect that the prey of ESA-listed marine mammals and sea turtles will respond to sound associated with the proposed action in a similar manner to those fishes and invertebrates described below [information derived from Carroll et al. (2017) unless otherwise noted].

Like with marine mammals and sea turtles, it is possible that seismic surveys can cause physical and physiological responses, including direct mortality, in fishes and invertebrates. In fishes, such responses appear to be highly variable, and depend on the nature of the exposure to seismic survey activities, as well as the species in question. Current data indicate that possible physical and physiological responses include hearing threshold shifts, barotraumatic ruptures, stress responses, organ damage, and/or mortality. For invertebrates research is more limited, but the available data suggest that exposure to seismic survey activities can result in anatomical damage and mortality in some cases. In crustaceans and bivalves, there are mixed results with some

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

The prey of ESA-listed marine mammals 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 other noting startle or alarm responses and/or avoidance behavior. However, no effects to foraging or reproduction have been documented. Similarly, data on the behavioral response of invertebrates suggests that some species may exhibit a startle response, but most studies do not suggest strong behavioral responses. For example, a recent study by Charifi et al. (2017) found that oyster appear to close their valves in response to low frequency sinusoidal sounds. In addition, Day et al. (2017) recently found that when exposed to seismic airgun array sounds, scallops exhibit behavioral responses such as flinching, but none of the observed behavioral responses were considered to be energetically costly. As with marine mammals and sea turtles, behavioral responses by fishes and invertebrates may also be associated with a stress response.

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

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

11.4 Risk Analysis

In this section, we assess the consequences of the responses of the individuals that have been exposed, the populations those individuals represent, and the species those populations comprise. For designated critical habitat, we assess the consequences of these responses on the value of the critical habitat for the conservation of the species for which the habitat has been designated.

We measure risks to individuals of threatened or endangered species based upon effects on the individual's fitness, which may be indicated by changes to the individual's growth, survival, annual reproductive fitness, and lifetime reproductive success. We expect up to 19 blue, 74 fin, five Central DPS of humpback, 14 Mexico DPS of humpback, six sei, and 48 sperm whales, and 65 Guadalupe fur seals (see Table 20), to be exposed to the airgun array within 160 dB re: 1 µPa (rms) ensonified areas during the seismic survey activities. We expect up to two blue, seven fin, one Central America DPS of humpback, two Mexico DPS of humpback, two sei, and zero sperm whales, and zero Guadalupe fur seals (see Table 20), to be exposed the airgun array within PTS ensonified areas during the seismic survey activities. We expect up to two leatherback turtles to be exposed the airgun array within 175 dB re: 1 µPa (rms) ensonified areas during the seismic survey activities.

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

Because of the mitigation measures in the incidental harassment authorization, and the nature of the seismic survey activities, as described above, we do not expect any mortality to occur from the exposure to the acoustic sources that result from the proposed action. As described above, the proposed action will result in temporary harassment and potential harm to the exposed marine mammals and sea turtles. Harassment is not expected to have more than short-term effects on individual ESA-listed species (blue, fin, Central America DPS and Mexico DPS of humpback, sei, and sperm whales, Guadalupe fur seals, or leatherback turtles). While permitted, harm under the ESA is not expected to occur with high probability given the mitigation measures (e.g., shut-down procedures) in place for the proposed seismic survey activities to protect ESA-listed species. As such we do not expect ESA-listed marine mammals and sea turtles exposed to the action's effects to experience reductions in fitness, nor do we expect the action to have adverse consequences on the viability of the populations those individuals represent or the species those populations comprise. No designated critical habitat for these species will be adversely affected by the seismic survey activities associated with the proposed action.

12 INTEGRATION AND SYNTHESIS

The *Integration and Synthesis* section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the *Effects of the Action* (Section 11) to the *Environmental Baseline* (Section 10) and the *Cumulative Effects* (Section 13) to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) reduce appreciably the likelihood of both the survival and recovery of a ESA-listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) reduce the value of designated or proposed critical habitat for the conservation of the species. These assessments are made in full consideration of the *Species and Critical Habitat Not Likely to be Adversely Affected* (Section 7), *Species Likely to be Adversely Affected* (Section 8), and *Status of the Species Likely to be Adversely Affected* (Section 9).

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

12.1 Blue Whale

No reduction in the distribution of blue whales from the Pacific Ocean is expected because of the National Science Foundation and Lamont-Doherty Earth Observatory's seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization.

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

There are three stocks of blue whales designated under the MMPA in U.S. waters: the Eastern North Pacific Ocean (approximately 1,647 individuals [minimum number of individuals N_{min}=1,551]), the Central Pacific Ocean (approximately 133 individuals [N_{min}=63]), and Western North Atlantic Ocean (N_{min}=440). In the Southern Hemisphere, the latest abundance estimate for Antarctic blue whales is 2,280 individuals in 1997/1998 (95 percent confidence interval 1,160 to 4,500) (Branch 2007).

Current estimates indicate a growth rate of just under three percent per year for the Eastern North Pacific stock (Calambokidis et al. 2009). An overall population growth rate for the species or growth rates for the two other individual U.S. stocks are not available at this time. In the Southern Hemisphere, population growth estimates are available only for Antarctic blue whales, which estimate a population growth estimates are available only for Antarctic blue whales, which

estimate a population growth rate of 8.2 percent per year (95 percent confidence interval 1.6 to 14.8 percent) (Branch 2007). Because populations appear to be increasing in size, the species appears to be somewhat resilient to current threats; however, the species has not recovered to pre-exploitation levels.

No reduction in numbers is anticipated as part of the proposed actions. Therefore, no reduction in reproduction is expected as a result of the proposed actions. There are expected to be two individuals harmed and 19 individuals harassed as a result of the proposed seismic survey activities. Because we do not anticipate a reduction in numbers or reproduction of blue whales as a result of the proposed seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization, a reduction in the species' likelihood of survival is not expected.

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

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

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

12.2 Fin Whale

No reduction in the distribution of fin whales from the Pacific Ocean is expected because of the National Science Foundation and Lamont-Doherty Earth Observatory's seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization.

Of the three to seven stocks in the North Atlantic Ocean (approximately 50,000 individuals), one designated under the MMPA that occurs in U.S. waters, where the best estimate of abundance is 1,618 individuals (N_{min}=1,234); however, this may be an underrepresentation as the entire range of stock was not surveyed (Palka 2012). There are three stocks designated under the MMPA in U.S. Pacific Ocean waters: Northeast Pacific [minimum 1,368 individuals], Hawaii (approximately 58 individuals [N_{min}=27]) and California/Oregon/Washington (approximately 9,029 [N_{min}=8,127] individuals) (Nadeem et al. 2016). The International Whaling Commission also recognizes the China Sea stock of fin whales, found in the Northwest Pacific Ocean, which currently lacks an abundance estimate (Reilly et al. 2013). Abundance data for the Southern

Hemisphere stock are limited; however, there were assumed to be somewhat more than 15,000 in 1983 (Thomas et al. 2016).

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

No reduction in numbers is anticipated as part of the proposed actions. Therefore, no reduction in reproduction is expected as a result of the proposed actions. There are expected to be seven individuals harmed and 74 individuals harassed as a result of the proposed seismic survey activities. Because we do not anticipate a reduction in numbers or reproduction of fin whales as a result of the proposed seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization, a reduction in the species' likelihood of survival is not expected.

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

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

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

12.3 Humpback Whale – Central America Distinct Population Segment

No reduction in the distribution of Central America DPS of humpback whales from the Pacific Ocean is expected because of the National Science Foundation and Lamont-Doherty Earth Observatory's seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization.

The global, pre-exploitation estimate for humpback whales is 1,000,000 (Roman and Palumbi 2003). The current abundance of the Central America DPS is 411. A population growth rate is currently unavailable for the Central America DPS of humpback whales.

No reduction in numbers is anticipated as part of the proposed actions. Therefore, no reduction in reproduction is expected as a result of the proposed actions. There are expected to be one individuals harmed and five individuals harassed as a result of the proposed seismic surveys. Because we do not anticipate a reduction in numbers or reproduction of Central DPS of humpback whales as a result of the proposed seismic survey activities and the NMFS Permits

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

The 1991 Final Recovery Plan for the humpback whale lists recovery objectives for the species. The following recovery objectives are relevant to the impacts of the proposed actions:

- Maintain and enhance habitats used by humpback whales currently or historically.
- Identify and reduce direct human-related injury and morality.
- Measure and monitor key population parameters.
- Improve administration and coordination of recovery program for humpback whales.

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

12.4 Humpback Whale – Mexico Distinct Population Segment

No reduction in the distribution of Mexico DPS of humpback whales from the Pacific Ocean is expected because of the National Science Foundation and Lamont-Doherty Earth Observatory's research activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization.

The global, pre-exploitation estimate for humpback whales is 1,000,000 (Roman and Palumbi 2003). The current abundance of the Mexico DPS is unavailable. A population growth rate is currently unavailable for the Mexico DPS of humpback whales.

No reduction in numbers is anticipated as part of the proposed actions. Therefore, no reduction in reproduction is expected as a result of the proposed actions. There are expected to be two individuals harmed and 14 individuals harassed as a result of the proposed seismic survey activities. Because we do not anticipate a reduction in numbers or reproduction of Mexico DPS of humpback whales as a result of the proposed seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization, a reduction in the species' likelihood of survival is not expected.

The 1991 Final Recovery Plan for the humpback whale lists recovery objectives for the species. The following recovery objectives are relevant to the impacts of the proposed actions:

- Maintain and enhance habitats used by humpback whales currently or historically.
- Identify and reduce direct human-related injury and morality.
- Measure and monitor key population parameters.
- Improve administration and coordination of recovery program for humpback whales.

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

12.5 Sei Whale

No reduction in the distribution of sei whales from the Pacific Ocean is expected because of the National Science Foundation and Lamont-Doherty Earth Observatory's seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization.

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

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

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

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

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

12.6 Sperm Whale

No reduction in the distribution of sperm whales from the Pacific Ocean is expected because of the National Science Foundation and Lamont-Doherty Earth Observatory's seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization.

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

No reduction in numbers is anticipated as part of the proposed actions. There are expected to be zero individuals harmed and 48 individuals harassed as a result of the proposed seismic survey activities. Therefore, no reduction in reproduction is expected as a result of the proposed actions. Because we do not anticipate a reduction in numbers or reproduction of sperm whales as a result of the proposed seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization, a reduction in the species' likelihood of survival is not expected.

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

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

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

12.7 Guadalupe Fur Seal

No reduction in the distribution of Guadalupe fur seals from the Pacific Ocean is expected because of the National Science Foundation and Lamont-Doherty Earth Observatory's seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization.

All Guadalupe fur seals represent a single population, with two known breeding colonies in Mexico, and a purported breeding colony in the United States. When the more recent NMFS stock assessment report for Guadalupe fur seals was published in 2000, the breeding colonies in Mexico were increasing; more recent evidence indicates that this trend is continuing (Aurioles-Gamboa et al. 2010; Esperon-Rodriguez and Gallo-Reynoso 2012). After compiling data from counts over 30 years, Gallo calculated that the population of Guadalupe fur seals in Mexico was increasing, with an average annual growth rate of 13.3 percent on Guadalupe Island (Gallo-Reynoso 1994b). More recent estimates of the Guadalupe fur seal population of the San Benito Archipelago (from 1997 through 2007) indicates that it is increasing as well at an annual rate of 21.6 percent (Esperon-Rodriguez and Gallo-Reynoso 2012), and that this population is at a phase of exponential increase (Aurioles-Gamboa et al. 2010). The most recent NMFS stock assessment report states that Guadalupe fur seals are incrasing at an average rate of 10.3 percent. Direct counts of animals at Isla Guadalupe and Isla San Benito during 2010 resulted in a minimum of 13,327 animals and 2,503 animals respectively, for a minimum population size of 15,380 animals (Carretta et al. 2017b).

No reduction in numbers is anticipated as part of the proposed actions. There are expected to be zero individuals harmed and 65 individuals harassed as a result of the proposed seismic survey activities. Therefore, no reduction in reproduction is expected as a result of the proposed actions. Because we do not anticipate a reduction in numbers or reproduction of Guadalupe fur seals as a result of the proposed seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization, a reduction in the species' likelihood of survival is not expected.

There has been no Recovery Plan prepared for Guadalupe fur seals.

Because no mortalities or effects on the distribution of Guadalupe fur seals are expected as a result of the proposed actions, we do not anticipate the proposed seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization will impede the recovery objectives for Guadalupe fur seals. 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 Guadalupe fur seals in the wild.

12.8 Leatherback Turtle

No reduction in the distribution of leatherback turtles from the Pacific Ocean is expected because of the National Science Foundation and Lamont-Doherty Earth Observatory's seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization.

Leatherback turtle populations in the Pacific Ocean are low. Overall populations in the Pacific Ocean have declined from an estimated 81,000 individuals to less than 3,000 total adults and subadults (Spotila et al. 2000). Counts of leatherback turtles at nesting beaches in the western Pacific Ocean indicate that the subpopulation has been declining at a rate of almost six percent per year since 1984 (Tapilatu et al. 2013).

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

The Pacific Recovery Plan for the population of leatherback turtles lists recovery objectives for the species. The following recovery objective is relevant to the impacts of the proposed action:

- Monitoring and research.

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 NMFS Permits and Conservation 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 CUMULATIVE EFFECTS

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

We expect that those aspects described in the *Environmental Baseline* (Section 10) will continue to impact ESA-listed resources into the foreseeable future. We expect climate change, oceanic

temperature regimes, whaling and subsistence harvesting, sea turtle harvesting, vessel strikes, whale watching, fisheries (fisheries interactions and aquaculture), pollution (marine debris, pesticides and contaminants, and hydrocarbons), aquatic nuisance species, anthropogenic sound (vessel sound and commercial shipping, aircraft, seismic surveys, and marine construction), military activities, and scientific research activities to continue into the future for marine mammals and sea turtles. However, movement towards bycatch reduction and greater foreign protections of sea turtles are generally occurring throughout the Northeast Pacific Ocean, which may aid in abating the downward trajectory of sea turtle populations.

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

14 CONCLUSION

After reviewing the current status of the ESA-listed species, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent actions, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence or recovery of blue, fin, Central America DPS of humpback, Mexico DPS of humpback, sei, and sperm whales, Guadalupe fur seals, or leatherback turtles.

15 INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct (16 U.S.C. §1532(19)). "Harm" is further defined by regulation to include significant habitat modification or degradation that results in death or injury to ESA-listed species by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding, or sheltering (50 C.F.R. §222.102).

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

For purposes of this consultation, we relied on NMFS' interim definition of harassment to evaluate when the proposed activities are likely to harass ESA-listed marine mammal and sea turtle species.

ESA section 7(b)(4) states that take of ESA-listed marine mammals must be authorized under MMPA section 101(a)(5) before the Secretary can issue an incidental take statement for ESA-listed marine mammals. NMFS' implementing regulations for MMPA section 101(a)(5)(D) specify that an incidental harassment authorization is required to conduct activities pursuant to any incidental take authorization for a specific activity that will "take" marine mammals. Once NMFS has authorized the incidental take of marine mammals under an incidental harassment authorization for the tentative period of July 11, 2019, through July 10, 2020, under the MMPA, the incidental take of ESA-listed marine mammals is exempt from the ESA take prohibitions as stated in this incidental take statement pursuant to section 7(b)(4) and 7(o)(2).

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

15.1 Amount or Extent of Take

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

If the amount or location of tracklines during the seismic survey changes, or the number of seismic survey days is increased, then incidental take for marine mammals 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 percent contingency, greater estimates of sound propagation, and/or increases in airgun array source levels occur, reinitiation of consultation will be necessary.

15.1.1 Marine Mammals

NMFS ESA Interagency Cooperation Division and NMFS Permits and Conservation Division anticipates the proposed seismic survey in the Northeast Pacific Ocean is likely to result in the incidental take of ESA-listed marine mammals by harassment and harm (Table 27). Behavioral harassment (MMPA Level B harassment) is expected to occur at received levels at or above 160 dB re: 1 µPa (rms) for ESA-listed marine mammals. For all species of ESA-listed marine mammals, this incidental take will result from exposure to acoustic energy during airgun array operations and will be in the form of harassment (MMPA Level B harassment), and is not expected to result in the death or injury of any individuals that will be exposed. It is believed that

any harm or PTS (MMPA Level A harassment) incurred in these marine mammals as a result of the proposed seismic survey activities will be in the form of only a small degree of PTS, not total deafness, and will be unlikely to affect the fitness of any individuals, because of the constant movement of both the R/V *Marcus G. Langseth* and of the marine mammals in the action area, as well as the fact that the research vessel is not expected to remain in any one area in which individual marine mammals will be expected to concentrate for an extended period of time (i.e., since the duration of exposure to loud sounds will be relatively short). Also, as described above, we expect that marine mammals will be likely to move away from a sound source that represents an aversive stimulus, especially at levels that will be expected to result in PTS, given sufficient notice of the R/V *Marcus G. Langseth*'s approach due to the research vessel's relatively low speed when conducting seismic surveys.

Table 27. Estimated amount of incidental take of Endangered Species Act-listed marine mammals authorized in the Northeast Pacific 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)
Blue Whale	19	2
Fin Whale	74	7
Humpback Whale – Central America DPS	5	1
Humpback Whale – Mexico DPS	14	2
Sei Whale	6	2
Sperm Whale	48	0
Guadalupe Fur Seal	65	0

DPS=Distinct Population Segment

15.1.2 Sea Turtles

We also expect individual leatherback turtles can be exposed to sounds from the airgun arrays during the course of the proposed seismic survey that will elicit a behavioral response that will constitute harassment (Table 28). A behavioral response that will constitute ESA harassment is expected to occur at received levels at or above 175 dB re: 1 µPa (rms) for ESA-listed sea turtles. No death or injury is expected for any individual sea turtle exposed to seismic survey activities.

Table 28. Estimated amount of incidental take of Endangered Species Act-listed sea turtles authorized in the Northeast Pacific Ocean by the incidental take statement.

Species	Authorized Incidental Take by Harassment
Leatherback Turtle	2

15.2 Effects of the Take

In this opinion, NMFS determined that the amount or extent of anticipated take, coupled with other effects of the proposed action, is not likely to result in jeopardy to the species or destruction or adverse modification of critical habitat.

15.3 Reasonable and Prudent Measures

The measures described below are nondiscretionary, and must be undertaken by the National Science Foundation, Lamont-Doherty Earth Observatory, and the NMFS Permits and Conservation Division so that they become binding conditions for the exemption in section 7(o)(2) to apply. Section 7(b)(4) of the ESA requires that when a proposed agency action is found to be consistent with section 7(a)(2) of the ESA and the proposed action may incidentally take individuals of ESA-listed species, NMFS will issue a statement that specifies the impact of any incidental taking of 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 threatened and endangered species:

- The NMFS Permits and Conservation Division must ensure that the National Science Foundation and Lamont-Doherty Earth Observatory implements a program to mitigate and report the potential effects of seismic survey activities as well as the effectiveness of mitigation measures incorporated as part of the proposed incidental harassment authorization for the incidental taking of blue, fin, Central America DPS of humpback, Mexico DPS of humpback, sei, and sperm whales and Guadalupe fur seals pursuant to section 101(a)(5)(D) of the MMPA and as specified below for leatherback turtles. In addition, the NMFS Permits and Conservation Division must ensure that the provisions of the incidental harassment authorization are carried out, and to inform the NMFS ESA Interagency Cooperation Division if take is exceeded.

- The NMFS Permits and Conservation Division must ensure that the National Science Foundation and Lamont-Doherty Earth Observatory implement a program to monitor and report any potential interactions between seismic survey activities and threatened and endangered species of marine mammals and sea turtles.

15.4 Terms and Conditions

To be exempt from the prohibitions of section 9 of the ESA and regulations issued pursuant to section 4(d), the National Science Foundation, Lamont-Doherty Earth Observatory, and NMFS Permits and Conservation Division must comply with the following terms and conditions, which implement the *Reasonable and Prudent Measures* described above. These include the take minimization, monitoring and reporting measures required by the section 7 regulations (50 C.F.R. §402.14(i)). These terms and conditions are non-discretionary. If the National Science Foundation, Lamont-Doherty Earth Observatory, and NMFS Permits and Conservation Division fail to ensure compliance with these terms and conditions and their implementing reasonable and prudent measures, the protective coverage of section 7(o)(2) may lapse.

To implement the reasonable and prudent measures, the National Science Foundation, Lamont-Doherty Earth Observatory, and the NMFS Permits and Conservation Division shall implement the following terms and conditions:

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

16 CONSERVATION RECOMMENDATIONS

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

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

1. We recommend that the National Science Foundation promote and fund research examining the potential effects of seismic surveys on ESA-listed sea turtle and fish species.

2. We recommend that the National Science Foundation develop a more robust propagation model that incorporates environmental variables into estimates of how far sound levels reach from airgun arrays.
3. We recommend that the National Science Foundation 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 NMFS Permits and Conservation Division develop a flow chart with decision points for mitigation and monitoring measures to be included in future MMPA incidental take authorizations for seismic surveys.
5. We recommend the National Science Foundation use (and NMFS Permits and Conservation Division require in MMPA incidental take authorizations) thermal imaging cameras, in addition to binoculars (Big-Eye and handheld) and the naked eye, for use during daytime and nighttime visual observations and test their effectiveness at detecting ESA-listed species.
6. We recommend the National Science Foundation use the Marine Mammal Commission's recommended method for estimating the number of cetaceans in the vicinity of seismic surveys based on the number of groups detected for post-seismic survey activities take analysis and use in monitoring reports.
7. We recommend the National Science Foundation and NMFS Permits and Conservation Division work to make the data collected as part of the required monitoring and reporting available to the public and scientific community in an easily accessible online database that can be queried to aggregate data across protected species observer reports. Access to such data, which may include sightings as well as responses to seismic survey activities, will not only help us understand the biology of ESA-listed species (e.g., their range), it will inform future consultations and incidental take authorizations/permits by providing information on the effectiveness of the conservation measures and the impact of seismic survey activities on ESA-listed species.
8. We recommend the National Science Foundation and NMFS Permits and Conservation Division consider using the potential standards for towed array passive acoustic monitoring 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 National Science Foundation utilize real-time cetacean sighting services such as the WhaleAlert application (http://www.whalealert.org/). We recognize that the research vessel may not have reliable internet access during operations far offshore, but nearshore, where many of the cetaceans considered in this opinion are likely found in greater numbers, we anticipate internet access may be better. Monitoring such systems will help plan seismic survey activities and transits to avoid locations with recent

ESA-listed cetacean sightings, and may also be valuable during other activities to alert others of ESA-listed cetaceans within the area, which they can then avoid.

10. We recommend the National Science Foundation submit their monitoring data (i.e., visual sightings) by Protected Species Observers to the Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations online database so that it can be added to the aggregate marine mammal, seabird, sea turtle, and fish observation data from around the world.
11. We recommend the vessel operator and other relevant vessel personnel (e.g., crew members) on the R/V *Marcus G. 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 protected species observers.
12. We recommend the National Science Foundation's seismic survey activities actively avoid designated critical habitat for the leatherback turtle and Southern DPS of green sturgeon.

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

17 REINITIATION NOTICE

This concludes formal consultation for the National Science Foundation and Lamont-Doherty Earth Observatory's proposed high-energy marine seismic survey by the R/V *Marcus G. Langseth* in the Northeast Pacific Ocean and NMFS Permits and Conservation 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. As 50 C.F.R. §402.16 states, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if:

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

If the amount of tracklines, location of tracklines, acoustic characteristics of the airgun arrays, or any other aspect of the proposed action changes in such a way that the incidental take of ESA-

listed species can be greater than estimated in the incidental take statement of this opinion, then (3) above may be met and reinitiation of consultation may be necessary.

18 REFERENCES

Aburto, A., D. J. Rountry, and J. L. Danzer. 1997. Behavioral responses of blue whales to active signals. Naval Command, Control and Ocean Surveillance Center, RDT&E Division, Technical Report 1746, San Diego, CA.

Ackerman, R. A. 1997. The nest environment and the embryonic development of sea turtles. Pages 83-106 *in* M. J. Kennish, and P. L. Lutz, editors. The Biology of Sea Turtles. CRC Press, Boca Raton.

Adams, Josh, Jonathan J. Felis, John W. Mason, and John Y. Takekawa. 2014. Pacific Continental Shelf Environmental Assessment (PaCSEA): Aerial seabird and marine mammal surveys off northern California, Oregon, and Washington, 2011-2012. Bureau of Ocean Energy Management (BOEM), Pacific OCS Region, Camarillo, California.

Addison, R. F., and P. F. Brodie. 1987. Transfer of organochlorine residues from blubber through the circulatory system to milk in the lactating grey seal Halichoerus grypus. Canadian Journal of Fisheries and Aquatic Sciences 44:782-786.

Al-Bahry, S. N., and coauthors. 2009. Ultrastructural features and elemental distribution in eggshell during pre and post hatching periods in the green turtle, Chelonia mydas at Ras Al-Hadd, Oman. Tissue and Cell 41(3):214-221.

Allen, M.R., and coauthors. 2018. Technical Summary. In: *Global warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty* [V. Masson-Delmotte, P. Zhai, H. O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J. B. R. Matthews, Y. Chen, X. Zhou, M. I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, T. Waterfield (eds.)].

Amaral, Kimberly, and Carole Carlson. 2005. Summary of non-lethal research techniques for the study of cetaceans. United Nations Environment Programme UNEP(DEC)/CAR WG.27/REF.5. 3p. Regional Workshop of Experts on the Development of the Marine Mammal Action Plan for the Wider Caribbean Region. Bridgetown, Barbados, 18-21 July.

Anan, Y. , T. Kunito, I. Watanabe, H. Sakai, and S. Tanabe. 2001. Trace element accumulation in hawksbill turtles (Eretmochelys imbricata) and green turtles (Chelonia mydas) from Yaeyama Islands, Japan. Environmental Toxicology and Chemistry 20(12):2802-2814.

Anderwald, P., P. G. H. Evans, and A. R. Hoelzel. 2006. Interannual differences in minke whale foraging behaviour around the small isles, West Scotland. Pages 147 *in* Twentieth Annual Conference of the European Cetacean Society, Gdynia, Poland.

André, M., M. Terada, and Y. Watanabe. 1997. Sperm whale (*Physeter macrocephalus*) behavioural responses after the playback of artificial sounds. Report of the International Whaling Commission 47:499-504.

Andre, M.; L. F. Lopez Jurado. 1997. Sperm whale (*Physeter macrocephalus*) behavioural response after the playback of artificial sounds. Pages 92 *in* Tenth Annual Conference of the European Cetacean Society, Lisbon, Portugal.

André, M.; Terada, M.; Watanabe, Y. 1997. Sperm whale (*Physeter macrocephalus*) behavioural responses after the playback of artificial sounds. Report of the International Whaling Commission 47:499-504.

Antonelis, G.A., J. D. Baker, T. C. Johanos, Robert C. Braun, and A. L. Harting. 2006. Hawaiian monk seal (Monachus schauinslandi): status and conservation issues. Atoll Research Bulletin 543:75-101.

Archer, F. I., and coauthors. 2013. Mitogenomic phylogenetics of fin whales (Balaenoptera physalus spp.): genetic evidence for revision of subspecies. PLoS One 8(5):e63396.

Attard, Catherine R. M., and coauthors. 2010. Genetic diversity and structure of blue whales (*Balaenoptera musculus*) in Australian feeding aggregations. Conservation Genetics 11(6):2437–2441.

Au, W. W. L. 1993. The Sonar of Dolphins. Springer-Verlag, New York, New York.

Au, W. W. L. 2000. Hearing in whales and dolphins: an overview. Pages 1-42 *in* W. W. L. Au, A. N. Popper, and R. R. Fay, editors. Hearing by Whales and Dolphins. Springer-Verlag, New York.

Au, W. W. L., and M. Green. 2000. Acoustic interaction of humpback whales and whale-watching boats. Marine Environmental Research 49(5):469-481.

Au, Whitlow, James Darling, and Kimberly Andrews. 2001. High-frequency harmonics and source level of humpback whale songs. Journal of the Acoustical Society of America 110(5 Part 2):2770.

Au, Whitlow W. L. 1975. Propagation of dolphin echolocation signals. Pages 23 *in* Conference on the Biology and Conservation of Marine Mammals, University of California, Santa Cruz.

Au, Whitlow W. L., D. A. Carder, R. H. Penner, and B. L. Scronce. 1985. Demonstration of adaptation in beluga whale echolocation signals. Journal of the Acoustical Society of America 77(2):726-730.

Au, Whitlow W. L., and coauthors. 2006a. Acoustic properties of humpback whale songs. Journal of Acoustical Society of America 120(August 2006):1103-1110.

Au, Whitlow W. L., and coauthors. 2006b. Acoustic properties of humpback whale songs. Journal of the Acoustical Society of America 120(2):1103-1110.

Au, Whitlow W. L.; Robert W. Floyd; Ralph H. Penner; A. Earl Murchison. 1974. Measurement of echolocation signals of the Atlantic bottlenose dolphin, *Tursiops truncatus* Montagu in open waters. Journal of the Acoustical Society of America 56(4):1280-1290.

Au, Whitlow W.L, A.N. Popper, and R.R. Fay. 2000. Hearing by whales and dolphins. Springer-Verlag, New York.

Aurioles-Gamboa, D., C. J. Hernandez-Camacho, and E. Rodriguez-Krebs. 1999. Notes on the southernmost records of the Guadalupe fur seal, *Arctocephalus townsendi*, in Mexico. Marine Mammal Science 15(2):581-583.

Aurioles-Gamboa, David, Fernando Elorriaga-Verplancken, and Claudia J. Hernandez-Camacho. 2010. The current population status of Guadalupe fur seal (*Arctocephalus townsendi*) on the San Benito Islands, Mexico. Marine Mammal Science 26(2):402-408.

Avens, L., J. C. Taylor, L. R. Goshe, T. T. Jones, and M. Hastings. 2009. Use of skeletochronological analysis to estimate the age of leatherback sea turtles *Dermochelys coriacea* in the western North Atlantic. Endangered Species Research 8(3):165-177.

Backus, R.H. , and W.E. Schevill. 1966. Physeter clicks. Pages 510-528 *in* K. S. Norris, editor. Whales, dolphins, and porpoises. University of California Press, Berkeley, California.

Bailey, Helen, and Paul M. Thompson. 2009. Using marine mammal habitat modelling to identify priority conservation zones within a marine protected area. Marine Ecology Progress Series 378:279-287.

Bain, D. E., D. Lusseau, R. Williams, and J.C. Smith. 2006. Vessel traffic disrupts the foraging behavior of southern resident killer whales (*Orcinus* spp.). International Whaling Commission.

Bain, D. E., and R. Williams. 2006. Long-range effects of airgun noise on marine mammals: responses as a function of received sound level and distance. International Whaling Commission Working Paper SC/58/E35.

Bain, David E.; Birgit Kriete; Marilyn E. Dahlheim. 1993. Hearing abilities of killer whales (*Orcinus orca*). Journal of the Acoustical Society of America 94(3 part 2):1829.

Bain, David E.; Marilyn E. Dahlheim. 1994. Effects of masking noise on detection thresholds of killer whales. Pages 243-256 *in* T. R. Loughlin, editor. Marine Mammals and the Exxon Valdez. Academic Press, San Diego.

Baird, Robin W., and coauthors. 2015. False killer whales and fisheries interactions in Hawaiian waters: Evidence for sex bias and variation among populations and social groups. Marine Mammal Science 31(2):579-590.

Baker, C. Scott, and Phillip J. Clapham. 2004. Modelling the past and future of whales and whaling. Trends in Ecology and Evolution 19(7):365-371.

Baker, Jason D., Charles L. Littnan, and David W. Johnston. 2006. Potential effects of sea level rise on the terrestrial habitats of endangered and endemic megafauna in the Northwestern Hawaiian Islands. Endangered Species Research 2:21-30.

Barber, J. R., K. R. Crooks, and K. M. Fristrup. 2010. The costs of chronic noise exposure for terrestrial organisms. Trends in Ecology and Evolution 25(3):180–189.

Barbieri, E. 2009. Concentration of heavy metals in tissues of green turtles (Chelonia mydas) sampled in the Cananeia Estuary, Brazil. Brazilian Journal of Oceanography 57(3):243-248.

Barkaszi, M. J., M. Butler, R. Compton, A. Unietis, and B. Bennet. 2012a. Seismic survey mitigation measures and marine mammal observer reports. Bureau of Ocean Energy Management, OCS Study BOEM 2012-015.

Barkaszi, M.J., M. Butler, R. Compton, A. Unietis, and B. Bennet. 2012b. Seismic Survey Mitigation Measures and Marine Mammal Observer Reports. U.S. Department of the Interior, Bureau of Ocean Energy Management, Gulf of Mexico OCS Region, OCS Study BOEM 2012-015, New Orleans, LA.

Barlow, J. 2003. Preliminary estimates of the abundance of cetaceans along the U.S. West Coast: 1991-2001. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center, LJ-03-03.

Barlow, J. 2010a. Cetacean abundance in the California Current estimated from a 2008 ship-based line-transect survey. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center.

Barlow, J. 2016. Cetacean abundance in the California Current estimated from ship-based line-transect surveys in 1991-2014. National Marine Fisheries Service Southwester Fisheries Science Center, Administrative Report LJ-16-01.

Barlow, Jay. 2010b. Cetacean abundance in the California Current estimated from a 2008 ship-based line transect survey. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center.

Barlow, Jay, and Karin A. Forney. 2007. Abundance and population density of cetaceans in the California Current ecosystem. Fishery Bulletin 105(4):509-526.

Bartholomew Jr., George A. 1950. A male Guadalupe fur seal on San Nicholas Island, California. Journal of Mammalogy 31(2):175-180.

Bartol, Soraya Moein, J. A. Musick, and M. Lenhardt. 1999. Evoked potentials of the loggerhead sea turtle (Caretta caretta). Copeia 1999(3):836-840.

Bauer, Gordon B. 1986. The behavior of humpback whales in Hawaii and modifications of behavior induced by human interventions. (Megaptera novaeangliae). University of Hawaii. 314p.

Baulch, S., and C. Perry. 2014a. Evaluating the impacts of marine debris on cetaceans. Mar Pollut Bull 80(1-2):210-21.

Baulch, Sarah, and Clare Perry. 2014b. Evaluating the impacts of marine debris on cetaceans. Marine Pollution Bulletin 80(1-2):210-221.

Beale, C.M., and P. Monaghan. 2004. Human disturbance: people as predation-free predators? Journal of Applied Ecology 41:335-343.

Beamish, R. J. 1993. Climate and exceptional fish production off the west coast of North American. Canadian Journal of Fisheries and Aquatic Sciences 50(10):2270-2291.

Becker, E. A., and coauthors. 2010. Comparing California Current cetacean-habitat models developed using in situ and remotely sensed sea surface temperature data. Marine Ecology Progress Series 413:163-183.

Becker, Elizabeth A., Karin A. Forney, Megan C. Ferguson, Jay Barlow, and Jessica V. Redfern. 2012. Predictive modeling of cetacean densities in the California current ecosystem based on summer/fall ship surveys in 1991-2008. NOAA, National Marine Fisheries Service, Southwest Fisheries Science Center.

Becker, Elizabeth A., and coauthors. 2014. Predicting seasonal density patterns of California cetaceans based on habitat models. Endangered Species Research 23(1):22-Jan.

Bejder, L., S. M. Dawson, and J. A. Harraway. 1999. Responses by Hector's dolphins to boats and swimmers in Porpoise Bay, New Zealand. Marine Mammal Science 15(3):738-750.

Bejder, L., A. Samuels, H. Whitehead, H. Finn, and S. Allen. 2009. Impact assessment research: Use and misuse of habituation, sensitisation and tolerance to describe wildlife responses to anthropogenic stimuli. Marine Ecology Progress Series 395:177-185.

Bejder, Lars, and David Lusseau. 2008. Valuable lessons from studies evaluating impacts of cetacean-watch tourism. Bioacoustics 17-Jan(3-Jan):158-161. Special Issue on the International Conference on the Effects of Noise on Aquatic Life. Edited By A. Hawkins, A. N. Popper & M. Wahlberg.

Belcher, R. L., and T.E. Lee, Jr. 2002. Arctocephalus townsendi. Mammalian Species 700(1):1-5.

Benson, Ashleen, and Andrew W. Trites. 2002. Ecological effects of regime shifts in the Bering Sea and eastern North Pacific Ocean. Fish and Fisheries 3(2):95-113.

Benson, S. R.; Dutton, P. H.; Hitipeuw, C.; Thebu, Y.; Bakarbessy, Y.; Sorondanya, C.; Tangkepayung, N.; Parker, D. 2007. Post-nesting movements of leatherbacks from Jamursba Medi, Papua, Indonesia: Linking local conservation with international threats. Pages 14 *in* Twenty-Fourth Annual Symposium on Sea Turtle Biology and Conservation.

Benson, Scott R., and coauthors. 2007. Post-nesting migrations of leatherback turtles (*Dermochelys coriacea*) from Jamursba-Medi, Bird's Head Peninsula, Indonesia. Chelonian Conservation and Biology 6(1):150-154.

Benson, Scott R., and coauthors. 2011a. Large-scale movements and high-use areas of western Pacific leatherback turtles, *Dermochelys coriacea*. Ecosphere 2(7):art84.

Benson, Scott R., and coauthors. 2011b. Large-scale movements and high-use areas of western Pacific leatherback turtles,Dermochelys coriacea. Ecosphere 2(7):art84.

Benson, Scott R.; Eguchi, Tomoharu; Foley, Dave G.; Forney, Karin A.; Bailey, Helen; Hitipeuw, Creusa; Samber, Betuel P.; Tapilatu, Ricardo F.; Rei, Vagi; Ramohia, Peter; Pita, John; Dutton, Peter H. 2011. Large-scale movements and high-use areas of western Pacific leatherback turtles, *Dermochelys coriacea*. Ecosphere 2(7):1-27.

Berchok, Catherine L., David L. Bradley, and Thomas B. Gabrielson. 2006. St. Lawrence blue whale vocalizations revisited: Characterization of calls detected from 1998 to 2001. Journal of the Acoustical Society of America 120(4):2340–2354.

Bernardi, G., S. R. Fain, J. P. Gallo-Reynoso, A. L. Figueroa-Carranza, and B. J. Le Boeuf. 1998. Genetic variability in Guadalupe fur seals. Journal of Heredity 89(4):301-305.

Bettridge, Shannon, and coauthors. 2015. Status review of the humpback whale (Megaptera novaeangliae) under the Endangered Species Act. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center.

Bjarti, T. 2002. An experiment on how seismic shooting affects caged fish. University of Aberdeen.

Blackwell, S. B., and coauthors. 2015. Effects of airgun sounds on bowhead whale calling rates: evidence for two behavioral thresholds. PLoS One 10(6):e0125720.

Blackwell, Susanna B., and coauthors. 2013. Effects of airgun sounds on bowhead whale calling rates in the Alaskan Beaufort Sea. Marine Mammal Science 29(4):E342-E365.

Blair, H. B., N. D. Merchant, A. S. Friedlaender, D. N. Wiley, and S. E. Parks. 2016. Evidence for ship noise impacts on humpback whale foraging behaviour. Biol Lett 12(8).

Blane, Jean M., and Reiner Jaakson. 1994a. The impact of ecotourism boats on the St. Lawrence beluga whales. Environmental Conservation 21(3):267–269.

Blane, Jean M., and Reiner Jaakson. 1994b. The impact of ecotourism boats on the St. Lawrence beluga whales (*Delphinapterus leucas*). Environmental Conservation 21(3):267-269.

Blunden, J., and D. S. Arndt. 2016. State of the Climate in 2015. Bulletin of the American Meteorological Society 97(8).

Boebel, O., E. Burkhardt, and H. Bornemann. 2006. Risk assessment of Atlas hydrosweep and Parasound scientific echosounders. EOS, Transactions, American Geophysical Union 87(36).

Booman, C., and coauthors. 1996. Effecter av luftkanonskyting på egg, larver og yngel. Fisken Og Havet 1996(3):1-83.

Boren, Laura J., Neil J. Gemmell, and Kerry J. Barton. 2001. Controlled approaches as an indicator of tourist disturbance on New Zealand fur seals (Arctocephalus forsteri). Fourteen Biennial Conference on the Biology of Marine Mammals, 28 November-3 December Vancouver Canada. p.30.

Borrell, Assumpcio, Dorete Bloch, and Genevieve Desportes. 1995. Age trends and reproductive transfer of organochlorine compounds in long-finned pilot whales from the Faroe Islands. Environmental Pollution 88(3):283-292.

Bowlby, C. Edward; Green, Gregory A.; Bonnell, Michael L. 1994. Observations of leatherback turtles offshore of Washington and Oregon. Northwestern Naturalist 75(1):33-35.

Bowles, A.E., M. Smultea, B. Würsig, D.P. DeMaster, and D. Palka. 1994. Relative abundance and behavior of marine mammals exposed to transmissions from the Heard Island Feasibility Test. Journal of the Acoustic Society of America 96(4):2469–2484.

Branch, Trevor A. 2007. Abundance of Antarctic blue whales south of 60 S from three complete circumpolar sets of surveys.

Breitzke, M.; Boebel, O.; El Naggar, S.; Jokat, W.; Werner, B. 2008. Broad-band calibration of marine seismic sources used by R/V *Polarstern* for academic research in polar regions. Geophysical Journal International 174:505-524.

Brown, J. Jed, and Gregory W. Murphy. 2010. Atlantic sturgeon vessel-strike mortalities in the Delaware Estuary. Fisheries 35(2):72-83.

Brownell Jr., Robert L., Phillip J. Clapham, Tomio Miyashita, and Toshio Kasuya. 2001. Conservation status of North Pacific right whales. Journal of Cetacean Research and Management (Special Issue 2):269-286.

Brownell, R. L., Jr., P. J. Clapham, T. Miyashita, and T. Kasuya. 2001. Conservation status of North Pacific right whales. Journal of Cetacean Research and Management Special Issue 2:269–286.

Bryant, P. J., C. M. Lafferty, and S. K. Lafferty. 1984. Reoccupation of Laguna Guerrero Negro, Baja California, Mexico, by gray whales. (*Eschrichtius robustus*). M. L. Jones, S. L. Swartz, and S. Leatherwood, editors. The Gray Whale, *Eschrichtius robustus*. Academic Press, New York.

Buchanan, R.A., J.R. Christian, S. Dufault, and V.D. Moulton. 2004. Impacts of underwater noise on threatened or endangered species in United States waters. American Petroleum Institute, LGL Report SA791, Washington, D.C.

Bugoni, L., L. Krause, and M. Virginia Petry. 2001. Marine debris and human impacts on sea turtles in southern Brazil. Marine Pollution Bulletin 42(12):pp. 1330-1334.

Burdin, A. M., A. L. Bradford, G. A. Tsidulko, and M. Sidorenko. 2011. Status of western gray whales off northeastern Sakhalin Island and eastern Kamchatka, Russia in 2010. International Whaling Commission-Scientific Committee, Tromso, Norway.

Burtenshaw, Jessica C., and coauthors. 2004. Acoustic and satellite remote sensing of blue whale seasonality and habitat in the Northeast Pacific. Deep-Sea Research II 51:967-986.

Busch, D. Shallin, and Lisa S. Hayward. 2009. Stress in a conservation context: A discussion of glucocorticoid actions and how levels change with conservation-relevant variables. Biological Conservation 142(12):2844-2853.

Calambokidis, J., E. Falcone, A. Douglas, L. Schlender, and J. Jessie Huggins. 2009. Photographic identification of humpback and blue whales off the US West Coast: Results and updated abundance estimates from 2008 field season. Cascadia Research, Olympia, Washington.

Calambokidis, J.; Falcone, E.; Douglas, A.; Schlender, L.; Jessie Huggins, J. 2009. Photographic identification of humpback and blue whales off the US West Coast: Results and updated abundance estimates from 2008 field season. Cascadia Research, Olympia, Washington.

Caldwell, Jack, and William Dragoset. 2000. A brief overview of seismic air-gun arrays. The Leading Edge 19(8):898-902.

Carder, D.A., and S. Ridgway. 1990. Auditory brainstem response in a neonatal sperm whale. Journal of the Acoustic Society of America 88(Supplement 1):S4.

Carretta, J. V., M. S. Lynn, and C. A. LeDuc. 1994. Right whale (*Eubalaena Glacialis*) sighting off San Clemente Island, California. Marine Mammal Science 10(1):101–105.

Carretta, J.V., and coauthors. 2016a. U.S. Pacific marine mammal stock assessments: 2015.

Carretta, James V., and Karin A. Forney. 1993. Report of the two aerial surveys for marine mammals in California coastal waters utilizing a NOAA DeHavilland Twin Otter aircraft,

March 9-April 7, 1991 and February 8-April 6, 1992. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center.

Carretta, James V., and coauthors. 2017a. U.S. Pacific Marine Mammal Stock Assessments: 2016. Southwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, NOAA-TM-NMFS-SWFSC-577, La Jolla, California.

Carretta, James V., and coauthors. 2018. U.S. Pacific Marine Mammal Stock Assessments: 2017. Southwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, NOAA-TM-NMFS-SWFSC-602, La Jolla, California.

Carretta, James V., and coauthors. 2017b. U.S. Pacific marine mammal stock assessments: 2016, NOAA-TM-NMFS-SWFSC-577.

Carretta, James V., and coauthors. 2019. U.S. Pacific marine mammal stock assessments: 2019. National Marine Fisheries Service.

Carretta, James V., and coauthors. 2016b. Sources of human-related injury and mortality for U.S. Pacific west coast marine mammal stock assessments, 2010-2014. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center, NOAA-TM-NMFS-SWFSC-554, La Jolla, California.

Carroll, A. G., R. Przeslawski, A. Duncan, M. Gunning, and B. Bruce. 2017. A critical review of the potential impacts of marine seismic surveys on fish & invertebrates. Marine Pollution Bulletin 114(1):24-Sep.

Casper, B. M., A. N. Popper, F. Matthews, T. J. Carlson, and M. B. Halvorsen. 2012. Recovery of barotrauma injuries in Chinook salmon, Oncorhynchus tshawytscha from exposure to pile driving sound. PLoS One 7(6):e39593.

Cassoff, Rachel M.; Kathleen M. Moore; William A. McLellan; Susan G. Barco; David S. Rotstein; Michael J. Moore. 2011. Lethal entanglement in baleen whales. Diseases of Aquatic Organisms 96(3):175-185.

Castellote, Manuel, Christopher W. Clark, and Marc O. Lammers. 2012a. Acoustic and behavioural changes by fin whales (*Balaenoptera physalus*) in response to shipping and airgun noise. Biological Conservation 147(1):115-122.

Castellote, Manuel, Christopher W. Clark, and Marc O. Lammers. 2012b. Acoustic and behavioural changes by fin whales (Balaenoptera physalus) in response to shipping and airgun noise. Biological Conservation.

Cattet, M. R. L., K. Christison, N. A. Caulkett, and G. B. Stenhouse. 2003. Physiologic responses of grizzly bears to different methods of capture. Journal of Wildlife Diseases 39(3):649-654.

Caurant, F. , P. Bustamante, M. Bordes, and P. Miramand. 1999. Bioaccumulation of cadmium, copper and zinc in some tissues of three species of marine turtles stranded along the French Atlantic coasts. Marine Pollution Bulletin 38(12):1085-1091.

Cerchio, Salvatore; Samantha Strindberg; Tim Collins; Chanda Bennett; Howard Rosenbaum. 2014. Seismic surveys negatively affect humpback whale singing activity off northern Angola. PLoS ONE 9(3):e86464.

Chance, Rosie, Timothy D. Jickells, and Alex R. Baker. 2015. Atmospheric trace metal concentrations, solubility and deposition fluxes in remote marine air over the south-east Atlantic. Marine Chemistry 177:45-56.

Chapman, C. J., and A. D. Hawkins. 1973. Field study of hearing in cod, *Gadus morhua*-l. Journal of Comparative Physiology 85(2):147–167.

Chapman, C.J., and A.D. Hawkins. 1969. The importance of sound in fish behaviour in relation to capture by trawls. FAO Fisheries Report 62(3):717-729.

Chapman, N. Ross, and Andrea Price. 2011. Low frequency deep ocean ambient noise trend in the Northeast Pacific Ocean. Journal of the Acoustical Society of America 129(5):EL161-EL165.

Charif, R. A., D. K. Mellinger, K. J. Dunsmore, K. M. Fristrup, and C. W. Clark. 2002. Estimated source levels of fin whale (Balaenoptera physalus) vocalizations: Adjustments for surface interference. Marine Mammal Science 18(1):81-98.

Charifi, M., M. Sow, P. Ciret, S. Benomar, and J. C. Massabuau. 2017. The sense of hearing in the Pacific oyster, Magallana gigas. PLoS One 12(10):e0185353.

Cheng, Lijing, and coauthors. 2017. Improved estimates of ocean heat content from 1960 to 2015. Science Advances 3(3):e1601545.

Childers, A.R., T.E. Whitledge, and D.A. Stockwell. 2005. Seasonal and interannual variability in the distribution of nutrients and chlorophyll a across the Gulf of Alaska shelf: 1998-2000. Deep-Sea Research II 52:193-216.

Christian, Jerry F. Payne; Catherine D. Andrews; Linda L. Fancey; Jacqueline Guiney; Andrew Cook; John R. 2013. Are seismic surveys an important risk factor for fish and shellfish? Bioacoustics 17:262-265.

Christiansen, Fredrik, Marianne H. Rasmussen, and David Lusseau. 2014. Inferring energy expenditure from respiration rates in minke whales to measure the effects of whale watching boat interactions. Journal of Experimental Marine Biology and Ecology 459:96-104.

Clapham, Phillip J., and coauthors. 2004a. Distribution of North Pacific right whales (*Eubalaena japonica*) as shown by 19th and 20th century whaling catch and sighting records. Journal of Cetacean Research and Management 6(1):1-6.

Clapham, Phillip J., and coauthors. 2004b. Distribution of North Pacific right whales (Eubalaena japonica) as shown by 19th and 20th century whaling catch and sighting records. Journal of Cetacean Research and Management 6(1):1-6.

Clapham, Phillip J., Sharon B. Young, and Robert L. Brownell Jr. 1999. Baleen whales: Conservation issues and the status of the most endangered populations. Mammal Review 29(1):35-60.

Clark, C. W., J. F. Borsani, and G. Notarbartolo-Di-Sciara. 2002. Vocal activity of fin whales, Balaenoptera physalus, in the Ligurian Sea. Marine Mammal Science 18(1):286-295.

Clark, C. W., and coauthors. 2009. Acoustic masking in marine ecosystems: Intuitions, analysis, and implication. Marine Ecology Progress Series 395:201-222.

Clark, C. W., and G. J. Gagnon. 2004. Low-frequency vocal behaviors of baleen whales in the North Atlantic: Insights from Integrated Undersea Surveillance System detections, locations, and tracking from 1992 to 1996. Journal of Underwater Acoustics (USN) 52(3):48.

Clark, C.W. , and G.C. Gagnon. 2006. Considering the temporal and spatial scales of noise exposures from seismic surveys on baleen whales.

Clark, C.W., and R.A. Charif. 1998. Acoustic monitoring of large whales to the west of Britain and Ireland using bottom mounted hydrophone arrays, October 1996-September 1997. JNCC Report No. 281.

Clark, Christopher W., and Phillip J. Clapham. 2004. Acoustic monitoring on a humpback whale (Megaptera novaeangliae) feeding ground shows continual singing into late spring. Proceedings of the Royal Society of London Series B Biological Sciences 271(1543):1051-1057.

Clarke, Janet T., and Sue E. Moore. 2002. A note on observations of gray whales in the southern Chukchi and northern Bering Seas, August-November, 1980-89. Journal of Cetacean Research and Management 4(3):283-288.

Clement, D. 2013. Effects on Marine Mammals. Ministry for Primary Industries. Literature review of ecological effects of aquaculture. Report prepared by Cawthron Institute, Nelson, New Zealand.

Cohen, Andrew N.; Foster, Brent. 2000. The regulation of biological pollution: Preventing exotic species invasions from ballast water discharged into California coastal waters. Golden Gate University Law Review 30(4):787-773.

Conn, P. B., and G. K. Silber. 2013a. Vessel speed restrictions reduce risk of collision-related mortality for North Atlantic right whales. Ecosphere 4(4):art43.

Conn, P. B., and G. K. Silber. 2013b. Vessel speed restrictions reduce risk of collision-related mortality for North Atlantic right whales. Ecosphere 4(4):43.

Constantine, R. 2001. Increased avoidance of swimmers by wild bottlenose dolphins (Tursiops truncatus) due to long-term exposure to swim-with-dolphin tourism. Marine Mammal Science 17(4):689-702.

Conversi, Alessandra, Sergey Piontkovski, and Sultan Hameed. 2001. Seasonal and interannual dynamics of Calanus finmarchicus in the Gulf of Maine (Northeastern US shelf) with reference to the North Atlantic Oscillation. Deep Sea Research Part Ii: Topical studies in Oceanography 48(1-3)519-530.

Corkeron, Peter J. 1995. Humpback whales (Megaptera novaeangliae) in Hervey Bay, Queensland: Behaviour and responses to whale-watching vessels. Canadian Journal of Zoology 73(7):1290-1299.

COSEWIC. 2002. COSEWIC assessment and update status report on the blue whale Balaenoptera musculus (Atlantic population, Pacific population) in Canada.vi + 32.

Costa, Daniel P, and coauthors. 2016. A bioenergetics approach to understanding the population consequences of disturbance: Elephant seals as a model system. Pages 161-169 *in* A. N. Popper, and A. Hawkins, editors. The Effects of Noise on Aquatic Life II. Springer.

Costa, Daniel P. 1993. The relationship between reproductive and foraging energetics and the evolution of the Pinnipedia. Pages 293-314 *in* I. L. Boyd, editor. Marine Mammals - Advances in Behavioural and Population Biology. Oxford University Press, New York.

Costa, Daniel P., and coauthors. 2003. The effect of a low-frequency sound source (acoustic thermometry of the ocean climate) on the diving behavior of juvenile northern elephant seals, *Mirounga angustirostris*. Journal of the Acoustical Society of America 113(2):1155-1165.

Costantini, D., V. Marasco, and A. P. Moller. 2011. A meta-analysis of glucocorticoids as modulators of oxidative stress in vertebrates. Journal of Comparative Physiology B 181(4):447-56.

Cowan, D. E., and B. E. Curry. 1998. Investigation of the potential influence of fishery-induced stress on dolphins in the eastern tropical pacific ocean: Research planning. National Marine Fisheries Service, Southwest Fisheries Science Center, NOAA-TM-NMFS-SWFSC-254.

Cowan, D. E., and B. E. Curry. 2002. Histopathological assessment of dolphins necropsied onboard vessels in the eastern tropical pacific tuna fishery. National Marine Fisheries Service, Southwest Fisheries Science Center, NMFS SWFSC administrative report LJ-02-24C.

Cowan, D. E.; Curry, B. E. 2008. Histopathology of the alarm reaction in small odontocetes. Journal of Comparative Pathology 139(1):24-33.

Cox, T. M., and coauthors. 2006. Understanding the impacts of anthropogenic sound on beaked whales. Journal of Cetacean Research and Management 7(3):177-187.

Cranford, Ted W., and Petr Krysl. 2015. Fin whale sound reception mechanisms: Skull vibration enables low-frequency hearing. PLoS One 10(1):e116222.

Creel, S. 2005. Dominance, aggression, and glucocorticoid levels in social carnivores. Journal of Mammalogy 86(2):255-246.

Croll, D. A., C. W. Clark, J. Calambokidis, W. T. Ellison, and B. R. Tershy. 2001. Effect of anthropogenic low-frequency noise on the foraging ecology of *Balaenoptera* whales. Animal Conservation 4(1):13-27.

Croll, D.A., Bernie R. Tershy, A. Acevedo, and P. Levin. 1999. Marine vertebrates and low frequency sound. Technical report for LFA EIS, 28 February 1999. Marine Mammal and Seabird Ecology Group, Institute of Marine Sciences, University of California Santa Cruz. 437p.

Croll, Donald A., and coauthors. 2002. Only male fin whales sing loud songs. Nature 417:809.

Cummings, W.C., and P.O. Thompson. 1994. Characteristics and seasons of blue and finback whale sounds along the U.S. west coast as recorded at SOSUS stations. Journal of the Acoustical Society of America 95:2853.

Cummings, William C., and Paul O. Thompson. 1971. Underwater sounds from the blue whale, *Balaenoptera musculus*. Journal of the Acoustical Society of America 50(4B):1193-1198.

Curry, R. G., and M. S. McCartney. 2001. Ocean gyre circulation changes associated with the North Atlantic Oscillation. Journal of Physical Oceanography 31(12):3374-3400.

Curtis, K. A., J. E. Moore, and S. R. Benson. 2015. Estimating limit reference points for western Pacific leatherback turtles (Dermochelys coriacea) in the U.S. West Coast EEZ. PLoS One 10(9):e0136452.

Czech, Brian, and Paul R. Krausman. 1997. Distribution and causation of species endangerment in the United States. Science 277(5329):1116-1117.

D'Amelio, A. Santulli; A. Modica; C. Messina; L. Ceffa; A. Curatolo; G. Rivas; G. Fabi; V. 1999. Biochemical responses of European sea bass (*Dicentrarchus labrax* L.) to the stress induced by offshore experimental seismic prospecting. Marine Pollution Bulletin 38(12):1105-1114.

D'Vincent, Cynthia G., Russell M. Nilson, and Richard E. Hanna. 1985. Vocalization and coordinated feeding behavior of the humpback whale in southeastern Alaska. Scientific Reports of the Whales Research Institute 36:41-47.

Dahlheim, Marilyn E. 1987. Bio-acoustics of the gray whale (Eschrichtius robustus). University of British Columbia.

Dalen, J., and G.M. Knutsen. 1986. Scaring effects in fish and harmful effects on eggs, larvae and fry by offshore seismic explorations. Pp.93-102 In: H.M. Merklinger (Ed), Progress in Underwater Acoustics. Plenum, New York. 839p.

Dalton, Tracey, and Di Jin. 2010. Extent and frequency of vessel oil spills in US marine protected areas. Marine Pollution Bulletin 60(11):1939-1945.

Danielsdottir, A. K., E. J. Duke, P. Joyce, and A. Arnason. 1991. Preliminary studies on genetic variation at enzyme loci in fin whales (Balaenoptera physalus) and sei whales (Balaenoptera borealis) form the North Atlantic. Report of the International Whaling Commission Special Issue 13:115-124.

Davenport, J. ; J. Wrench ; J. McEvoy; V. Carnacho-Ibar. 1990. Metal and PCB concentrations in the "Harlech" leatherback. Marine Turtle Newsletter 48:1-6.

Davis, R.W., W.E. Evans, and B. Würsig. 2000. Cetaceans, sea turtles, and seabirds in the northern Gulf of Mexico: Distribution, abundance, and habitat associations. Volume II: Technical Report. Prepared by the GulfCet Program, Texas A&M University, for the U.S. Geological Survey, Biological Resources Division. Contract Nos. 1445-CT09-96-0004 and 1445-IA09-96-0009. OCS Study MMS 2000-03. 364p.

Day, R. D., R. D. McCauley, Q. P. Fitzgibbon, K. Hartmann, and J. M. Semmens. 2017. Exposure to seismic air gun signals causes physiological harm and alters behavior in the scallop Pecten fumatus. Proceedings of the National Academies of Science 114(40):E8537-E8546.

Deakos, Allan D. Ligon, and Mark H. 2011. Small-boat cetacean surveys off Guam and Saipan, Mariana Islands, February – March 2010. P. I. F. S. Center, editor. 2010 Cetacean Survey off Guam & Saipan.

Deakos, M. H., J. D. Baker, and L. Bejder. 2011. Characteristics of a manta ray *Manta alfredi* population off Maui, Hawaii, and implications for management. Marine Ecology Progress Series 429:245–260.

Deepwater Horizon NRDA Trustees. 2016. Deepwater Horizon Oil Spill: Final Programmatic Damage Assessment and Restoration Plan (PDARP) and Final Programmatic Environmental Impact Statement. NOAA.

Deepwater Horizon Trustees. 2016. *Deepwater Horizon* Oil Spill: Final Programmatic Damage Assessment and Restoration Plan and Final Programmatic Environmental Impact Statement. Deepwater Horizon Natural Resource Damage Assessment Trustees.

Deng, Z. Daniel; Brandon L. Southall; Thomas J. Carlson; Jinshan Xu; Jayson J. Martinez; Mark A. Weiland; John M. Ingraham. 2014. 200 kHz commercial sonar systems generate lower frequency side lobes audible to some marine mammals. PLoS ONE 9(4):e95315.

Derraik, J. G. B. 2002. The pollution of the marine environment by plastic debris: a review. Marine Pollution Bulletin 44(9):842-852.

Deruiter, S. L., and K. Larbi Doukara. 2012. Loggerhead turtles dive in response to airgun sound exposure. Endangered Species Research 16(1):55-63.

DeRuiter, Xavier Lurton; Stacy. 2011. Sound radiation of seafloor-mapping echosounders in the water column, in relation to the risks posed to marine mammals. International Hydrographic Review November:7-17.

Dickens, M. J., D. J. Delehanty, and L. M. Romero. 2010. Stress: An inevitable component of animal translocation. Biological Conservation 143(6):1329-1341.

Diebold, John B., and coauthors. 2010. *R/V Marcus G. Langseth* seismic source: Modeling and calibration. Geochemistry Geophysics Geosystems 10(12):Q12012.

Dierauf, Leslie A., and Frances M. D. Gulland. 2001. CRC Handbook of Marine Mammal Medicine, Second Edition edition. CRC Press, Boca Raton, Florida.

Dietrich, Kimberly S., Victoria R. Cornish, Kim S. Rivera, and Therese A. Conant. 2007. Best practices for the collection of longline data to facilitate research and analysis to reduce bycatch of protected species. NOAA Technical Memorandum NMFS-OPR-35. 101p.

Report of a workshop held at the International Fisheries Observer Conference Sydney, Australia, November 8,.

Doney, Scott C., and coauthors. 2012. Climate change impacts on marine ecosystems. Marine Science 4.

Drake, Jonathan Scott, and coauthors. 2010. Status review of five rockfish species in Puget Sound, Washington : bocaccio (Sebastes paucispinis), canary rockfish (S. pinniger), yelloweye rockfish (S. ruberrimus), greenstriped rockfish (S. elongatus), and redstripe rockfish (S. proriger).

Drinkwater, K. F., and coauthors. 2003. The response of marine ecosystems to climate variability associated with the North Atlantic oscillation. Geophysical Monograph 134:211-234.

Dubrovskiy, Nikolai A.; Ludmila R. Giro. 2004. Modeling of the click-production mechanism in the dolphin. Pages 59-64 *in* J. A. T. C. F. M. M. Vater, editor. Echolocation in Bats and Dolphins. University of Chicago Press.

Duce, R. A., and coauthors. 1991. The atmospheric input of trace species to the world ocean. Global Biogeochemical Cycles 5(3):193-259.

Duncan, E. M., and coauthors. 2017. A global review of marine turtle entanglement in anthropogenic debris: A baseline for further action. Endangered Species Research 34:431-448.

Dunlop, R. A., D. H. Cato, and M. J. Noad. 2008. Non-song acoustic communication in migrating humpback whales (*Megaptera novaeangliae*). Marine Mammal Science 24(3):613-629.

Dunlop, R. A., and coauthors. 2017. The behavioural response of migrating humpback whales to a full seismic airgun array. Proceedings of the Royal Society B-Biological Sciences 284(1869).

Dutton, P. H., B. W. Bowen, D. W. Owens, A. Barragan, and S. K. Davis. 1999. Global phylogeography of the leatherback turtle (*Dermochelys coriacea*). Journal of Zoology 248:397-409.

Dwyer, C. M. 2004. How has the risk of predation shaped the behavioural responses of sheep to fear and distress? Animal Welfare 13(3):269-281.

Eckert, KL, BP Wallace, JG Frazier, SA Eckert, and PCH Pritchard. 2012. Synopsis of the biological data on the leatherback sea turtle (Dermochelys coriacea). .172.

Edds-Walton, P.L. 1997. Acoustic communication signals of mysticete whales. Bioacoustics-the International Journal of Animal Sound and Its Recording 8:47–60.

Edds, P.L. 1988. Characteristics of finback *Balaenoptera physalus* vocalizations in the St. Lawrence estuary. Bioacoustics 1:131–149.

Edwards, Elizabeth F., Candice Hall, Thomas J. Moore, Corey Sheredy, and Jessica V. Redfern. 2015. Global distribution of fin whales Balaenoptera physalus in the post-whaling era (1980-2012). Mammal Review 45(4):197-214.

Ehrhart, L.M., and B.E. Witherington. 1987. Human and natural causes of marine turtle nest and hatchling mortality and their relationship to hatchling production on an important Florida nesting beach. Final Report, Project Number GFC-84-018. Florida Game and Fresh Water Fish Commission, Nongame Wildlife Program, Technical Report No. 1. Tallahassee, Florida. 141 pages. .

Elftman, M. D., C. C. Norbury, R. H. Bonneau, and M. E. Truckenmiller. 2007. Corticosterone impairs dendritic cell maturation and function. Immunology 122(2):279-290.

Ellison, W. T., B. L. Southall, C. W. Clark, and A. S. Frankel. 2012. A new context-based approach to assess marine mammal behavioral responses to anthropogenic sounds. Conservation Biology 26(1):21–28.

Engås, A., S. Løkkeborg, E. Ona, and A. Vold Soldal. 1996. Effects of seismic shooting on local abundance and catch rates of cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*). Canadian Journal of Fisheries and Aquatic Sciences 53:2238-2249.

Engås, A., S. Løkkeborg, A.V. Soldal, and E. Ona. 1993. Comparative trials for cod and haddock using commercial trawl and longline at two different stock levels. Journal of Northwest Atlantic Fisheries Science 19:83-90.

Engel, Márcia H., and coauthors. 2004. Are seismic surveys responsible for cetacean strandings? An unusual mortality of adult humpback whales in Abrolhos Bank, northeastern coast of Brazil. International Whaling Commission.

Engelhaupt, D., and coauthors. 2009. Female philopatry in coastal basins and male dispersion across the North Atlantic in a highly mobile marine species, the sperm whale (*Physeter macrocephalus*). Mol Ecol 18(20):4193-205.

Erbe, C. 2002a. Hearing abilities of baleen whales. Contractor Report DRDC Atlantic CR 2002-065. Defence R&D Canada, Queensland, Australia. 40p.

Erbe, C. 2002b. Underwater noise of whale-watching boats and potential effects on killer whales (Orcinus orca), based on an acoustic impact model. Marine Mammal Science 18(2):394-418.

Erbe, C., C. Reichmuth, K. Cunningham, K. Lucke, and R. Dooling. 2016. Communication masking in marine mammals: A review and research strategy. Marine Pollution Bulletin 103(1-2):15-38.

Erbe, Christine. 2002c. Hearing abilities of baleen whales. Defence R&D Canada – Atlantic report CR 2002-065. Contract Number: W7707-01-0828. 40pp.

Escorza-Trevino, Sergio. 2009. North Pacific marine mammals. Pages 781-788 *in* W. F. P. B. W. J. G. M. Thewissen, editor. Encyclopedia of Marine Mammals, Second edition. Academic Press, San Diego.

Esperon-Rodriguez, Manuel, and Juan Pablo Gallo-Reynoso. 2012. The re-colonization of the Archipelago of San Benito, Baja California, by the Guadalupe fur seal. Revista Mexicana de Biodiversidad 83(1):170-176.

Esperon-Rodriguez, Manuel, and Juan Pablo Gallo-Reynoso. 2013. Juvenile and subadult feeding preferences of the Guadalupe fur seal (*Arctocephalus townsendi*) at San Benito Archipelago, Mexico. Aquatic Mammals 39(2):125-131.

Evans, P. G. H. 1998. Biology of cetaceans of the North-east Atlantic (in relation to seismic energy).Chapter 5 *In:* Tasker, M.L. and C. Weir (eds), Proceedings of the Seismic and Marine Mammals Workshop, London 23-25 June 1998. Sponsored by the Atlantic Margin Joint Industry Group (AMJIG) and endorsed by the UK Department of Trade and Industry and the UK's Joint Nature Conservation Committee (JNCC).

Evans, Peter G. H., and Arne Bjørge. 2013. Impacts of climate change on marine mammals. Marine Climate Change Impacts Parternship: Science Review:134-148.

Evans, Peter G. H., Peter J. Canwell, and Emily Lewis. 1992. An experimental study of the effects of pleasure craft noise upon bottle-nosed dolphins in Cardigan Bay, West Wales. European Research on Cetaceans 6:43–46.

Evans, Peter G. H., and coauthors. 1994. A study of the reactions of harbour porpoises to various boats in the coastal waters of southeast Shetland. European Research on Cetaceans 8:60–64.

Fair, Patricia A., and Paul R. Becker. 2000. Review of stress in marine mammals. Journal of Aquatic Ecosystem Stress and Recovery 7(4):335-354.

Falk, M.R. , and M.J. Lawrence. 1973. Seismic exploration: Its nature and effects on fish. Department of the Environment, Fisheries and Marine Service, Resource Management Branch, Fisheries Operations Directorate, Central Region (Environment), Winnipeg, Canada.

Felix, Fernando. 2001. Observed changes of behavior in humphack whales during whalewatching encounters off Ecuador. Pages 69 *in* 14th Biennial Conference on the Biology of Marine Mammals, Vancouver, Canada.

Félix, Fernando. 2001. Observed changes of behavior in humpback whales during whalewatching encounters off Ecuador. 14th Biennial Conference on the Biology of Marine Mammals, Vancouver, Canada.

Ferguson, Megan C., Jay Barlow, Paul Fiedler, Stephen B. Reilly, and Tim Gerrodette. 2006. Spatial models of delphinid (family Delphinidae) encounter rate and group size in the eastern tropical Pacific Ocean. Ecological Modelling 193(4-Mar):645-662.

Ferrero, Richard C., Roderick C. Hobbs, and Glenn R. Vanblaricom. 2002. Indications of habitat use patterns among small cetaceans in the central North Pacific based on fisheries observer data. Journal of Cetacean Research and Management 4(3):311-321.

Fewtrell, J. L., and R. D. McCauley. 2012. Impact of air gun noise on the behaviour of marine fish and squid. Marine Pollution Bulletin 64(5):984-993.

Fewtrell, R. D. McCauley; J. 2013a. Experiments and observations of fish exposed to seismic survey pulses. Bioacoustics 17:205-207.

Fewtrell, R. D. McCauley; J. 2013b. Marine invertebrates, intense anthropogenic noise, and squid response to seismic survey pulses. Bioacoustics 17:315-318.

FHWG. 2008. Memorandum of agreement in principle for interim criteria for injury to fish from pile driving. California Department of Transportation and Federal Highway Administration, Fisheries Hydroacoustic Working Group.

Figureroa-Carranza, Ana Luisa. 1994. Early lactation and attendance behavior of the Guadalupe fur seal females (*Arctocephalus townsendi*). University of California, Santa Cruz, California.

Finneran, James J., Randall Dear, Donald A. Carder, and Sam H. Ridgway. 2003a. Auditory and behavioral responses of California sea lions (Zalophus californianus) to single underwater impulses from an arc-gap transducer. Journal of the Acoustical Society of America 114(3):1667-1677.

Finneran, James J., Randall Dear, Donald A. Carder, and Sam H. Ridgway. 2003b. Auditory and Behavioral Responses of California Sea Lions (*Zalophus californianus*) to Single Underwater Impulses From an Arc-Gap Transducer. Journal of the Acoustical Society of America 114(3):1667-1677.

Finneran, James J.; Carolyn E. Schlundt. 2013. Effects of fatiguing tone frequency on temporary threshold shift in bottlenose dolphins (*Tursiops truncatus*). Journal of the Acoustical Society of America 133(3):1819-1826.

Fitzgibbon, Q. P., R. D. Day, R. D. McCauley, C. J. Simon, and J. M. Semmens. 2017. The impact of seismic air gun exposure on the haemolymph physiology and nutritional condition of spiny lobster, Jasus edwardsii. Marine Pollution Bulletin 125(1-2):146-156.

Fleischer, Luis Armando. 1978. The distribution, abundance, and population characteristics of the Guadalupe fur seal, *Arctocephalus townsendi* (Merriam 1897). University of Washington, Seattle, Washington.

Fleishman, Erica, and coauthors. 2016. Monitoring population-level responses of marine mammals to human activities. Marine Mammal Science 32(3):1004-1021.

Fonfara, S., U. Siebert, A. Prange, and F. Colijn. 2007. The impact of stress on cytokine and haptoglobin mRNA expression in blood samples from harbour porpoises (*Phocoena phocoena*). Journal of the Marine Biological Association of the United Kingdom 87(1):305-311.

Foote, Andrew D.; Osborne, Richard W.; Hoelzel, A. Rus. 2004. Whale-call response to masking boat noise. Nature 428:910.

Forney, K. A., and J. Barlow. 1998. Seasonal patterns in the abundance and distribution of California cetaceans, 1991-1992. Marine Mammal Science 14(3):460-489.

Forney, Karin A. 2007. Preliminary cestimates of cetacean abundance along the U.S. West Coast and within four national marine sanctuaries during 2005. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center, Santa Cruz, California.

Forney, Karin A., and coauthors. 2012. Habitat-based spatial models of cetacean density in the eastern Pacific Ocean. Endangered Species Research 16(2):113-133.

Fossi, Maria Cristina, and coauthors. 2016. Fin whales and microplastics: The Mediterranean Sea and the Sea of Cortez scenarios. Environmental Pollution 209:68-78.

Francis, Clinton D., and Jesse R. Barber. 2013. A framework for understanding noise impacts on wildlife: An urgent conservation priority. Frontiers in Ecology and the Environment 11(6):305-313.

Francis, Clinton D.; Jesse R. Barber. 2013. A framework for understanding noise impacts on wildlife: An urgent conservation priority. Frontiers in Ecology and the Environment 11(6):305-313.

Frantzis, Alexandros, and Paraskevi Alexiadou. 2008. Male sperm whale (Physeter macrocephalus) coda production and coda-type usage depend on the presence of conspecifics and the behavioural context. Canadian Journal of Zoology 86(1):62-75.

Frazer, L. N., and E. Mercado, III. 2000. A sonar model for humpback whales. IEEE Journal of Oceanic Engineering 25(1):160-182.

Frazer, L. Neil, and Eduardo Mercado Iii. 2000. A sonar model for humpback whale song. IEEE Journal of Oceanic Engineering 25(1):160-182.

Frid, A, and L Dill. 2002. Human-caused disturbance stimuli as a form of predation risk. Conservation Ecology 6(1):11.

Frid, A. 2003. Dall's sheep responses to overflights by helicopter and fixed-wing aircraft. Biological Conservation 110(3):387-399.

Fritts, T. H., and M. A. McGehee. 1981. Effects of petroleum on the development and survival of marine turtles embryos. U.S. Fish and Wildlife Service, Contract No. 14-16-00009-80-946, FWSIOBS-81-3, Washington, D.C.

Fritts, T. H.; Stinson, M. L.; Màrquez, R. 1982. Status of sea turtle nesting in Southern Baja California, Mexico. Bulletin of the Southern California Academy of Sciences 81(2):51-60.

Fromentin, Jean-Marc, and Benjamin Planque. 1996. *Calanus* and environment in the eastern North Atlantic. II. Influence of the North Atlantic Oscillation on *C. finmarchicus* and *C. helgolandicus*. Marine Ecology Progress Series 134:111-118.

Fujihara, J. , T. Kunito, R. Kubota, and S. Tanabe. 2003. Arsenic accumulation in livers of pinnipeds, seabirds and sea turtles: Subcellular distribution and interaction between arsenobetaine and glycine betaine. Comparative Biochemistry and Physiology C-Toxicology & Pharmacology 136(4):287-296.

Gabriele, C. M., and A. S. Frankel. 2002. Surprising humpback whale songs in Glacier Bay National Park. Alaska Park Science: Connections to Natural and Cultural Resource Studies in Alaska's National Parks. p.17-21.

Gabriele, Christine, Blair Kipple, and Christine Erbe. 2003. Underwater acoustic monitoring and estimated effects of vessel noise on humpback whales in Glacier Bay, Alaska. Pages 56-57 *in* Fifteenth Biennial Conference on the Biology of Marine Mammals, Greensboro, North Carolina.

Gailey, Glenn, and coauthors. 2016. Behavioural responses of western gray whales to a 4-D seismic survey off northeastern Sakhalin Island, Russia. Endangered Species Research 30:53-71.

Gailey, Glenn, Bernd Wursig, and Trent L. Mcdonald. 2007. Abundance, behavior, and movement patterns of western gray whales in relation to a 3-D seismic survey, northeast Sakhalin Island, Russia. Environmental Monitoring and Assessment 134(3-Jan):75-91.

Gall, S. C., and R. C. Thompson. 2015. The impact of debris on marine life. Marine Pollution Bulletin 92(1-2):170–179.

Gallo-Reynoso, J. P. 1994a. Factors affecting the population status of Guadalupe fur seal, Arctocephalus townsendii (Merriam, 1897), at Isla de Guadalupe, Baja California, Mexico. Doctoral dissertation. University of California, Santa Cruz.

Gallo-Reynoso, J. P., B. J. Le Boeuf, and A. L. Figueroa. 1995. Track, location, duration and diving behavior during foraging trips of Guadalupe fur seal females. Pages 41 *in* Eleventh Biennial Conference on the Biology of Marine Mammals, Orlando, Florida.

Gallo-Reynoso, Juan Pablo. 1994b. Factors affecting the population status of Guadalupe fur seals, *Arctocephalus townsendi* (Merriam 1897), at Isla de Guadalupe, Baja California, Mexico. University of California, Santa Cruz.

Gallo, Frederic, and coauthors. 2018. Marine litter plastics and microplastics and their toxic chemicals components: the need for urgent preventive measures. Environmental Sciences Europe 30(1).

Gambell, Ray. 1999. The International Whaling Commission and the contemporary whaling debate. Pages 179-198 *in* J. R. T. Jr., editor. Conservation and Management of Marine Mammals. Smithsonian Institution Press, Washington.

Garcia-Fernandez, A. J., and coauthors. 2009. Heavy metals in tissues from loggerhead turtles (Caretta caretta) from the southwestern Mediterranean (Spain). Ecotoxicology and Environmental Safety 72(2):557-563.

Gardiner, Karen J., and Alisa J. Hall. 1997. Diel and annual variation in plasma cortisol concentrations among wild and captive harbor seals (*Phoca vitulina*). Canadian Journal of Zoology 75(11):1773-1780.

Gardner, S. C. , S. L. Fitzgerald, B. A. Vargas, and L. M. Rodriguez. 2006. Heavy metal accumulation in four species of sea turtles from the Baja California peninsula, Mexico. Biometals 19:91-99.

Gardner, S. C., and S. Chavez-Rosales. 2000. Changes in the relative abundance and distribution of gray whales (Eschrichtius robustus) in Magdalena Bay, Mexico during an El Nino event. Marine Mammal Science 16(4):728-738.

Garrett, C. 2004. Priority Substances of Interest in the Georgia Basin - Profiles and background information on current toxics issues. Canadian Toxics Work Group Puget Sound/Georgia Basin International Task Force, GBAP Publication No. EC/GB/04/79.

Geraci, J. R. 1990. Physiological and toxic effects on cetaceans.Pp. 167-197 *In:* Geraci, J.R. and D.J. St. Aubin (eds), Sea Mammals and Oil: Confronting the Risks. Academic Press, Inc.

Gill, J. A., K. Norris, and W.J. Sutherland. 2001. Why behavioural responses may not reflect the population consequences of human disturbance. Biological Conservation 97:265-268.

Glass, Allison H., Timothy V. N. Cole, and Mendy Garron. 2010. Mortality and serious injury determinations for baleen whale stocks along the United States and Canadian Eastern Seaboards, 2004-2008. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northeast Fisheries Science Center.

Godley, B. J. , D. R. Thompson, and R. W. Furness. 1999. Do heavy metal concentrations pose a threat to marine turtles from the Mediterranean Sea? Marine Pollution Bulletin 38:497-502.

Goldbogen, Jeremy A.; Brandon L. Southall; Stacy L. Deruiter; John Calambokidis; Ari S. Friedlaender; Elliott L. Hazen; Erin A. Falcone; Gregory S. Schorr; Annie Douglas; David J. Moretti; Chris Kyburg; Megan F. McKenna; Peter L. Tyack. 2013. Blue whales respond to simulated mid-frequency military sonar. Proceedings of the Royal Society of London Series B Biological Sciences 280(1765):Article 20130657.

Gomez, Catalina, and coauthors. 2016. A systematic review on the behavioural responses of wild marine mammals to noise: The disparity between science and policy. Canadian Journal of Zoology 94(12):801–819.

Goodwin, Lissa, and Peter A. Cotton. 2004. Effects of boat traffic on the behaviour of bottlenose dolphins (Tursiops truncatus). Aquatic Mammals 30(2):279-283.

Goold, J. C., and P.J. Fish. 1998. Broadband spectra of seismic survey air-gun emissions, with reference to dolphin auditory thresholds. Journal of the Acoustical Society of America 103(4):2177-2184.

Goold, J. C., and S.E. Jones. 1995. Time and frequency domain characteristics of sperm whale clicks. Journal of the Acoustical Society of America 98(3):1279-1291.

Goold, J.C., and R.F.W. Coates. 2006. Near source, high frequency air-gun signatures. Paper SC/58/E30, prepared for the International Whaling Commmission (IWC) Seismic Workshop, St. Kitts, 24-25 May 2006. 7p.

Goold, John C. 1999. Behavioural and acoustic observations of sperm whales in Scapa Flow, Orkney Islands. Journal of the Marine Biological Association of the United Kingdom 79(3):541-550.

Gordon, A. N. , A. R. Pople, and J. Ng. 1998. Trace metal concentrations in livers and kidneys of sea turtles from south-eastern Queensland, Australia. Marine and Freshwater Research 49(5):409-414.

Gordon, J., R. Antunes, N. Jaquet, and B. Wursig. 2006. An investigation of sperm whale headings and surface behaviour before, during and after seismic line changes in the Gulf

of Mexico. [Pre-meeting]. Unpublished paper to the IWC Scientific Committee. 10 pp. St Kitts and Nevis, West Indies, June (SC/58/E45).

Gordon, J., and coauthors. 2004. A review of the effects of seismic surveys on marine mammals. Marine Technology Society Journal 37(4):16-34.

Gordon, Jonathan, and coauthors. 2003. A Review of the Effects of Seismic Surveys on Marine Mammals. Marine Technology Society Journal 37(4):16-34.

Götz, T., and V. M. Janik. 2011. Repeated elicitation of the acoustic startle reflex leads to sensation in subsequent avoidance behaviour and induces fear conditioning. BMC Neuroscience 12(30):13.

Graham, N. A. J., and coauthors. 2006. Dynamic fragility of oceanic coral reef ecosystems. Proceedings of the National Academy of Sciences of the United States of America 103(22):8425-8429.

Grant, S.C.H., and P.S. Ross. 2002. Southern Resident killer whales at risk: toxic chemicals in the British Columbia and Washington environment. Fisheries and Oceans Canada., Sidney, B.C.

Green, G. A., and coauthors. 1992. Cetacean distribution and abundance off Oregon and Washington, 1989-1990. Pages 100 *in* J. J. Brueggeman, editor. Oregon and Washington Marine Mammal and Seabird Surveys, volume OCS Study MMS 91-0093. Minerals Management Service, Los Angeles, California.

Green, Gregory A., Richard A. Grotefendt, Mari A. Smultea, C. Edward Bowlby, and Richard A. Rowlett. 1993. Delphinid aerial surveys in Oregon and Washington offshore waters. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, National Marine Mammal Laboratory.

Greene, C. H., and A. J. Pershing. 2003. The flip-side of the North Atlantic Oscillation and modal shifts in slope-water circulation patterns. Limnology and Oceanography 48(1):319-322.

Greene, C. H., and coauthors. 2003a. Trans-Atlantic responses of *Calanus finmarchicus* populations to basin-scale forcing associated with the North Atlantic Oscillation. Progress in Oceanography 58(2-4):301-312.

Greene, Charles, Andrew J. Pershing, Robert D. Kenney, and Jack W. Jossi. 2003b. Impact of climate variability on the recovery of endangered North Atlantic right whales. Oceanography 16(4):98-103.

Greene Jr, C.R., N.S. Altman, and W.J. Richardson. 1999. Bowhead whale calls. Western Geophysical and NMFS.

Greer, A. W., M. Stankiewicz, N. P. Jay, R. W. McAnulty, and A. R. Sykes. 2005. The effect of concurrent corticosteroid induced immuno-suppression and infection with the intestinal parasite *Trichostrongylus colubriformis* on food intake and utilization in both immunologically naive and competent sheep. Animal Science 80:89-99.

Gregory, L. F., and J. R. Schmid. 2001. Stress responses and sexing of wild Kemp's ridley sea turtles (*Lepidochelys kempii*) in the northwestern Gulf of Mexico. General and Comparative Endocrinology 124:66-74.

Gregr, Edward James. 2011. Insights into North Pacific right whale *Eubalaena japonica* habitat from historic whaling records. Endangered Species Research 15(3):223-239.

Guerra, A.; A. F. Gonzalez; F. Rocha. 2004. A review of the records of giant squid in the north-eastern Atlantic and severe injuries in *Architeuthis dux* stranded after acoustic explorations. ICES Annual Science Conference, Vigo, Spain.

Guerra, Melania, Aaron M. Thode, Susanna B. Blackwell, and A. Michael Macrander. 2011. Quantifying seismic survey reverberation off the Alaskan North Slope. Journal of the Acoustical Society of America 130(5):3046-3058.

Gulland, F. M. D., and coauthors. 1999. Adrenal function in wild and rehabilitated Pacific harbor seals (Phoca vitulina richardii) and in seals with phocine herpesvirus-associated adrenal necrosis. Marine Mammal Science 15(3):810-827.

Gustafson, Richard G. 2016. Status Review Update of Eulachon (Thaleichthys pacificus) Listed under the Endangered Species Act: Southern Distinct Population Segment

Halvorsen, M. B., B. M. Casper, F. Matthews, T. J. Carlson, and A. N. Popper. 2012a. Effects of exposure to pile-driving sounds on the lake sturgeon, Nile tilapia and hogchoker. Proceedings of Biological Sciences 279(1748):4705–14.

Halvorsen, M. B., B. M. Casper, C. M. Woodley, T. J. Carlson, and A. N. Popper. 2011. Predicting and mitigating hydroacoustic impacts on fish from pile installations. National Cooperative Highway Research Program, Transportation Research Board, National Academy of Sciences, Washington, DC.

Halvorsen, M. B., B. M. Casper, C. M. Woodley, T. J. Carlson, and A. N. Popper. 2012b. Threshold for onset of injury in Chinook salmon from exposure to impulsive pile driving sounds. PLoS One 7(6):e38968.

Hare, S. R., N. J. Mantua, and R. C. Francis. 1999. Inverse production regimes: Alaska and West Coast Pacific salmon. Fisheries 24(1):6-14.

Hare, Steven R., and Nathan J. Mantua. 2001. An historical narrative on the Pacific Decadal Oscillation, interdecadal climate variability and ecosystem impacts. University of Washington.

Harrington, F.H., and A.M. Veitch. 1992. Calving success of woodland caribou exposed to low-level jet fighter overflights. Arctic 45(3):213-218.

Harris, Catriona M., and coauthors. 2018. Marine mammals and sonar: Dose-response studies, the risk-disturbance hypothesis and the role of exposure context. Journal of Applied Ecology 55(1):396-404.

Harris, R. E., G. W. Miller, and W. J. Richardson. 2001. Seal responses to airgun sounds during summer seismic surveys in the Alaskan Beaufort Sea. Marine Mammal Science 17(4):795-812.

Harris, R.E., T. Elliott, and R.A. Davis. 2007. Results of mitigation and monitoring program, Beaufort Span 2-D marine seismic program, open-water season 2006. GX Technology Corporation, Houston, Texas.

Hartwell, S. I. 2004. Distribution of DDT in sediments off the central California coast. Marine Pollution Bulletin 49(4):299-305.

Harvey, James T., Robin F. Brown, and Bruce R. Mate. 1990. Abundance and distribution of harbor seals (Phoca vitulina) in Oregon, 1975-1983. Northwestern Naturalist 71(3):65-71.

Hassel, A., and coauthors. 2003. Reaction of sandeel to seismic shooting: a field experiment and fishery statistics study. Institute of Marine Research, Bergen, Norway.

Hassel, A., and coauthors. 2004. Influence of seismic shooting on the lesser sandeel (Ammodytes marinus). ICES Journal of Marine Science 61:1165-1173.

Hastings, M. C. 1990. Effects of underwater sound on fish. AT&T Bell Laboratories.

Hatch, L., and coauthors. 2008. Characterizing the relative contributions of large vessels to total ocean noise fields: A case study using the Gerry E. Studds Stellwagen Bank National Marine Sanctuary. Environmental Management 42(5):735-752.

Hauser, D. W., and M. Holst. 2009. Marine mammal and sea turtle monitoring during Lamont-Doherty Earth Observatory's marine seismic program in the Gulf of Alaska, Septmerb-October 2008 LGL, Ltd., King City, Canada.

Hauser, D. W.; Holst, M.; Moulton, V. 2008. Marine mammal and sea turtle monitoring during Lamont-Doherty Earth Observatory's marine seismic program in the Eastern Tropical Pacific, April – August 2008. LGL Ltd., King City, Ontario.

Haver, Samara M., and coauthors. 2018. Monitoring long-term soundscape trends in U.S. Waters: The NOAA/NPS Ocean Noise Reference Station Network. Marine Policy 90:6–13.

Hawkins, A. D., and A. D. F. Johnstone. 1978. The hearing of the Atlantic salmon, *Salmo salar*. Journal of Fish Biology 13(6):655-673.

Hawkins, Anthony D., Ann E. Pembroke, and Arthur N. Popper. 2014. Information gaps in understanding the effects of noise on fishes and invertebrates. Reviews in Fish Biology and Fisheries.

Hayes, Sean A., Elizabeth Josephson, Katherine Maze-Foley, and Patricia E. Rosel. 2017. US Atlantic and Gulf of Mexico Marine Mammal Stock Assessments - 2016. National Marine Fisheries Service Northeast Fisheries Science Center, NMFS-NE-241, Woods Hole, Massachusetts.

Hayhoe, K.;, and coauthors. 2018. In *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II* (Reidmiller, D.R., et al. [eds.]). U.S. Global Change Research Program, Washington, DC, USA.

Hays, G. C. 2000. The implications of variable remigration intervals for the assessment of population size in marine turtles. J Theor Biol 206(2):221-7.

Hazel, J., and E. Gyuris. 2006. Vessel-related mortality of sea turtles in Queensland, Australia. Wildlife Research 33(2):149-154.

Hazel, Julia, Ivan R. Lawler, Helene Marsh, and Simon Robson. 2007. Vessel speed increases collision risk for the green turtle Chelonia mydas. Endangered Species Research 3:105-113.

Hazen, Elliott, and coauthors. 2017. Modeling to aid management of marine top predators in a changing climate. US CLIVAR Variations 15(1):33-40.

Hazen, Elliott L., and coauthors. 2012. Predicted habitat shifts of Pacific top predators in a changing climate. Nature Climate Change 3(3):234-238.

Helker, V. T., and coauthors. 2017. Human-Caused Mortality and Injury of NMFS-Managed Alaska Marine Mammal Stocks, 2011-2015. Alaska Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Deparatment of Commerce, NMFS-AFSC-354, Seattle, Washington.

Helweg, David A., Adam S. Frankel, Jr. Joseph R. Mobley, and Louis M. Herman. 1992. Humpback whale song: Our current understanding. Pages 459-483 *in* J. A. Thomas, R. A. Kastelein, and A. Y. Supin, editors. Marine Mammal Sensory Systems. Plenum Press, New York.

Henderson, David. 1990. Gray whales and whalers on the China coast in 1869. (*Eschrichtius robustus*). Whalewatcher 24(4):14-16.

Henry, Allison G, and coauthors. 2017. Serious Injury and Mortality Determinations for Baleen Whale Stocks along the Gulf of Mexico, United States East Coast, and Atlantic Canadian Provinces, 2011-2015. Northeast Fisheries Science Center, National Marine Fisheries

Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Reference Document 17-19, Woods Hole, Massachusetts.

Henry, Allison G, and coauthors. 2016. Serious Injury and Mortality Determinations for Baleen Whale Stocks along the Gulf of Mexico, Atlantic Canadian Provinces, 2010-2014. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northeast Fisheries Science Center, 16-10, Woods Hole, Massachusetts.

Herraez, P., and coauthors. 2007. Rhabdomyolysis and myoglobinuric nephrosis (capture myopathy) in a striped dolphin. Journal of Wildlife Diseases 43(4):770–774.

Hildebrand, J. A. 2009a. Anthropogenic and natural sources of ambient noise in the ocean. Marine Ecology Progress Series 395:20-May.

Hildebrand, J.A., and coauthors. 2012. Passive Acoustic Monitoring for Marine Mammals in the SOCAL Naval Training Area 2011-2012, Marine Physical Laboratory, Scripps Institution of Oceanography, University of California San Diego.

Hildebrand, John A. 2009b. Metrics for characterizing the sources of ocean anthropogenic noise. Journal of the Acoustical Society of America 125(4):2517.

Hildebrand, John A., and coauthors. 2011. Passive Acoustic Monitoring for Marine Mammals in the SOCAL Naval Training Area 2010-2011. Inter-American Tropical Tuna Commission.

Hill, P. Scott, and Jay Barlow. 1992. Report of a marine mammal survey of the California coast aboard the research vessel McArthur, July 28-November 5, 1991. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center.

Holliday, D.V., R.E. Piper, M.E. Clarke, and C.F. Greenlaw. 1987. The effects of airgun energy release on the eggs, larvae, and adults of the northern anchovy (Engraulis mordax). American Petroleum Institute, Washington, D.C.

Holst, M. 2010. Marine mammal and sea turtle monitoring during Lamont-Doherty Earth Observatory's ETOMO marine seismic program in the northeast Pacific Ocean August-September 2009 LGL, Ltd., King City, Canada.

Holst, M., and coauthors. 2006. Effects of large and small-source seismic surveys on marine mammals and sea turtles. EOS Transactions of the American Geophysical Union 87(36):Joint Assembly Supplement, Abstract OS42A-01.

Holst, M., and M. Smultea. 2008a. Marine mammal and sea turtle monitoring during Lamont-Doherty Earth Observatory's marine seismic program off central America, February-April 2008 LGL, Ltd., King City, Canada.

Holst, M., M. A. Smultea, W. R. Koski, and B. Haley. 2005a. Marine mammal and sea turtle monitoring during Lamont-Doherty Earth Observatory's marine seismic program off the northern Yucatán Peninsula in the southern Gulf of Mexico, January–February 2005. LGL Ltd., LGL Report TA2822-31.

Holst, M., M. Smultea, W. Koski, and Beth Haley. 2005b. Marine mammal and sea turtle monitoring during Lamont-Doherty Earth Observatory’s marine seismic program in the eastern tropical PAcific off central America, November-December 2004. LGL, Ltd., King City, Ontario.

Holst, M., M. Smultea, W. Koski, and Beth Haley. 2005c. Marine mammal and sea turtle monitoring during Lamont-Doherty Earth Observatory’s marine seismic program off the

Northern Yucatán Peninsula in the Southern Gulf of Mexico, January–February 2005. LGL, Ltd., King City, Ontario.

Holst, M., and M.A. Smultea. 2008b. Marine mammal and sea turtle monitoring during Lamont-Doherty Earth Observatory's marine seismic program off Central America, Feburary-April 2008. Lamont-Doherty Earth Observatory of Columbia University, Palisades, New York.

Holt, M. M. 2008. Sound exposure and Southern Resident killer whales (*Orcinus orca*): A review of current knowledge and data gaps. U.S. Department of Commerce, NMFS-NWFSC-89.

Holt, Marla M., Dawn P. Noren, Val Veirs, Candice K. Emmons, and Scott Veirs. 2009. Speaking up: Killer whales (*Orcinus orca*) increase their call amplitude in response to vessel noise. Journal of the Acoustical Society of America 125(1):El27-El32.

Holt, Marla M.; Dawn P. Noren; Val Veirs; Candice K. Emmons; Scott Veirs. 2009. Speaking up: Killer whales (*Orcinus orca*) increase their call amplitude in response to vessel noise. Journal of the Acoustical Society of America 125(1):El27-El32.

Houser, Dorian, Steve W. Martin, Laura Yeates, Daniel E. Crocker, and James J. Finneran. 2013. Behavioral responses of bottlenose dolphins (Tursiops truncatus) and California sea lions (Zalophus californianus) to controlled exposures of simulated sonar signals. Pages 98 *in* Twentieth Biennial Conference on the Biology of Marine Mammals, Dunedin, New Zealand.

Houser, Dorian S., David A. Helweg, and Patrick W. B. Moore. 2001. A bandpass filter-bank model of auditory sensitivity in the humpback whale. Aquatic Mammals 27(2):82-91.

Hoyt, E. 2001. Whale Watching 2001: Worldwide Tourism Numbers, Expenditures, and Expanding Socioeconomic Benefits. International Fund for Animal Welfare,, Yarmouth Port, MA, USA.

Hubbs, Carl L. 1956. Back from oblivion. Guadalupe fur seal: Still a living species. Pacific Discovery 9(6):14-21.

Huijser, Léonie A. E., and coauthors. 2018. Population structure of North Atlantic and North Pacific sei whales (Balaenoptera borealis) inferred from mitochondrial control region DNA sequences and microsatellite genotypes. Conservation Genetics.

Hunt, K. E., R. M. Rolland, S. D. Kraus, and S. K. Wasser. 2006. Analysis of fecal glucocorticoids in the North Atlantic right whale (*Eubalaena glacialis*). General and Comparative Endocrinology 148(2):260-72.

Hurrell, J. W. 1995. Decadal trends in the North Atlantic Oscillation: Regional temperatures and precipitation. Science 269:676-679.

Iagc. 2004. Further analysis of 2002 Abrolhos Bank, Brazil humpback whale stradings coincident with seismic surveys. International Association of Geophysical Contractors, Houston, Texas.

Ilyashenko, V. Yu. 2009. How isolated is the 'western' gray whale population? International Whaling Commission Scientific Committee, Madeira, Portugal.

Iorio, Lucia Di, and Christopher W. Clark. 2009. Exposure to seismic survey alters blue whale acoustic communication. Biology Letters in press(in press):in press.

IPCC. 2014. Climate change 2014: Impacts, adaptation, and vulnerability. IPCC Working Group II contribution to AR5. Intergovernmental Panel on Climate Change.

IPCC. 2018. Summary for Policymakers. In: *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global*

greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, Maycock, M. Tignor, and T. Waterfield (eds.)]. World Meteorological Organization, Geneva, Switzerland:32pp.

IUCN. 2012. The IUCN red list of threatened species. Version 2012.2. International Union for Conservation of Nature and Natural Resources.

Ivashchenko, Y. V., P. J. Clapham, and R. L. Brownell Jr. 2013. Soviet catches of whales in the North Pacific: Revised totals. Journal of Cetacean Research and Management 13(1):59-71.

Ivashchenko, Yulia V., Robert L. Brownell Jr., and Phillip J. Clapham. 2014. Distribution of Soviet catches of sperm whales Physeter macrocephalus in the North Pacific. Endangered Species Research 25(3):249-263.

Iwata, H., S. Tanabe, N. Sakai, and R. Tatsukawa. 1993. Distribution of persistent organochlorines in the oceanic air and surface seawater and the role of ocean on their global transport and fate. Environmental Science and Technology

27:1080-1098.

IWC. 2003. Report of the workshop on the western gray whale: Research and monitoring needs. International Whaling Commission.

IWC. 2007a. Annex K: Report of the standing working group on environmental concerns. International Whaling Commission.

IWC. 2007b. Whale population estimates. International Whaling Commission.

IWC. 2012a. Extracts from the IWC64 Scientific Committee report relevant to the WGWAP. International Whaling Commission.

IWC. 2012b. International Whaling Commission: Whaling. http://www.iwcoffice.org/whaling.

IWC. 2016. Report of the Scientific Committee. Journal of Cetacean Research and Management (Supplement) 17.

IWC. 2017a. Aboriginal subsistence whaling catches since 1985. International Whaling Commission.

IWC. 2017b. Catches under objection or under reservation since 1985. International Whaling Commission.

IWC. 2017c. Special permit catches since 1985. International Whaling Commission.

J.L., Keating, J. Barlow, E. Griffiths, and J. Moore. 2018. Passive acoustic survey of cetacean abundance levels (PASCAL-2016) Final Report. U.S. Department of the Interior, Bureau of Ocean Energy Management, Honolulu, HI.

Jackson, J., and coauthors. 2001. Historical overfishing and the recent collapse of coastal ecosystems. Science 293(5530):629-638.

Jacobsen, J.K., L. Massey, and F. Gulland. 2010a. Fatal ingestion of floating net debris by two sperm whales (*Physeter macrocephalus*). Marine Pollution Bulletin 60:765-767.

Jacobsen, Jeff K., Liam Massey, and Frances Gulland. 2010b. Fatal ingestion of floating net debris by two sperm whales (Physeter macrocephalus). Marine Pollution Bulletin 60(5):765-767.

James, M. C., R. A. Myers, and C. A. Ottensmeyer. 2005. Behaviour of leatherback sea turtles, *Dermochelys coriacea*, during the migratory cycle. Proceedings of the Royal Society Biological Sciences Series B 272(1572):1547-1555.

Jay, A.;, and coauthors. 2018. In: *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II* [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA:33-71.

Jefferson, T. A., and B. E. Curry. 1994. Review and evaluation of potential acoustic methods of reducing or eliminating marine mammal-fishery interactions. Marine Mammal Commission, La Jolla, California.

Jenner, C.; M. Jenner; C. Burton; V. Sturrock; C. Salgado Kent; M. Morrice; C. Attard; L. Moller; M. C. Double. 2008. Mark recapture analysis of pygmy blue whales from the Perth Canyon, Western Australia 2000-2005. International Whaling Commission Scientific Committee, Santiago, Chile.

Jensen, A. S., and G. K. Silber. 2004. Large whale ship strike database. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources.

Jessop, T.S. 2001. Modulation of the adrenocortical stress response in marine turtles (Cheloniidae): evidence for a hormonal tactic maximizing maternal reproductive investment Journal of Zoology 254:57-65.

Jessop, T.S., M. Hamann, M.A. Read, and C.J. Limpus. 2000. Evidence for a hormonal tactic maximizing green turtle reproduction in response to a pervasive ecological stressor. General and Comparative Endocrinology 118:407-417.

Jessop, T.S., J. Sumner, V. Lance, and C. Limpus. 2004. Reproduction in shark-attacked sea turtles is supported by stress-reduction mechanisms. Proceedings of the Royal Society Biological Sciences Series B 271:S91-S94.

Jochens, A., and coauthors. 2006. Sperm whale seismic study in the Gulf of Mexico; Summary Report 2002-2004. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2006-034. 352p.

Jochens, A.E., and D. C. Biggs. 2004. Sperm whale seismic study in the Gulf of Mexico: Annual report: Year 2. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2004-067, 167p.

Jochens, Ann E.; Biggs, Douglas C. 2003. Sperm whale seismic study in the Gulf of Mexico. Minerals Management Service, OCS MMS 2003-069, New Orleans.

Johnson, M. , and P. Miller. 2002. Sperm whale diving and vocalization patterns from digital acoustic recording tags and assessing responses of whales to seismic exploration. MMS Information Transfer Meeting, Kenner, LA.

Johnson, S. R., and coauthors. 2007a. A western gray whale mitigation and monitoring program for a 3-D seismic survey, Sakhalin Island, Russia. Environmental Monitoring and Assessment 134(3-Jan):19-Jan.

Johnson, S.R., and coauthors. 2007b. A western gray whale mitigation and monitoring program for a 3-D seismic survey, Sakhalin Island, Russia. Environmental Monitoring and Assessment Available online at http://www.springerlink.com/content/?mode=boolean&k=ti%3a(western+gray+whale)&sortorder=asc. DOI 10.1007/s10661-007-9813-0. 19p.

Jørgensen, R., N. O. Handegard, H. Gjøsæter, and A. Slotte. 2004. Possible vessel avoidance behaviour of capelin in a feeding area and on a spawning ground. Fisheries Research 69(2):251–261.

Kanda, N., M. Goto, and L. A. Pastene. 2006. Genetic characteristics of western North Pacific sei whales, Balaenoptera borealis, as revealed by microsatellites. Marine Biotechnology 8(1):86-93.

Kanda, Naohisa, Mutsuo Goto, Koji Matsuoka, Hideyoshi Yoshida, and Luis A. Pastene. 2011. Stock identity of sei whales in the central North Pacific based on microsatellite analysis of biopsy samples obtained from IWC/Japan joint cetacean sighting survey in 2010. IWC Scientific Committee, Tromso, Norway.

Kanda, Naohisa, Koji Matsuoka, Mutsuo Goto, and Luis A. Pastene. 2015. Genetic study on JARPNII and IWC-POWER samples of sei whales collected widely from the North Pacific at the same time of the year. IWC Scientific Committee, San Diego, California.

Kanda, Naohisa, Koji Matsuoka, Hideyoshi Yoshida, and Luis A. Pastene. 2013. Microsatellite DNA analysis of sei whales obtained from the 2010-2012 IWC-POWER. IWC Scientific Committee, Jeju, Korea.

Kastak, David, Ronald J. Schusterman, Brandon L. Southall, and Colleen J. Reichmuth. 1999. Underwater temporary threshold shift induced by octave-band noise in three species of pinniped. Journal of the Acoustical Society of America 106(2):1142-1148.

Kastak, David; Southall, Brandon L.; Schusterman, Ronald J.; Kastak, Colleen Reichmuth. 2005. Underwater temporary threshold shift in pinnipeds: Effects of noise level and duration. Journal of the Acoustical Society of America 118(5):3154-3163.

Kastelein, Ronald A., Robin Gransier, Lean Hoek, and Juul Olthuis. 2012. Temporary threshold shifts and recovery in a harbor porpoise (Phocoena phocoena) after octave-band noise at 4 kHz. Journal of the Acoustical Society of America 132:3525-3537.

Kato, Hidehiro, and Toshio Kasuya. 2002. Some analyses on the modern whaling catch history of the western North Pacific stock of gray whales (*Eschrichtius robustus*), with special reference to the Ulsan whaling ground. Journal of Cetacean Research and Management 4(3):277-282.

Kaufman, G. A., and D. W. Kaufman. 1994. Changes in body-mass related to capture in the prairie deer mouse (*Peromyscus maniculatus*). Journal of Mammalogy 75(3):681-691.

Keay, Jessica M., Jatinder Singh, Matthew C. Gaunt, and Taranjit Kaur. 2006. Fecal glucocorticoids and their metabolites as indicators of stress in various mammalian species: A literature review. Journal of Zoo and Wildlife Medicine 37(3):234-244.

Keller, J. M., P. D. McClellan-Green, John R. Kucklick, Deborah E. Keil, and Margie M. Peden-Adams. 2006. Effects of organochlorine contaminants on loggerhead sea turtle immunity: Comparison of a correlative field study and *in vitro* exposure experiments. Environmental Health Perspectives 114(1):70-76.

Kenney, Robert D., Martin A. M. Hyman, and Howard E. Winn. 1985. Calculation of standing stocks and energetic requirements of the cetaceans of the northeast United States Outer Continental Shelf. NOAA Technical Memorandum NMFS-F/NEC-41. 99pp.

Kerby, Andrew Sih, Alison M. Bell, and Jacob L. 2004. Two stressors are far deadlier than one. Trends in Ecology and Evolution 19(6):274-276.

Ketten, D.R. . 1997. Structure and function in whale ears. Bioacoustics 8:103-135.

Ketten, Darlene R. 1992. The cetacean ear: Form, frequency, and evolution. Pages 53-75 *in* J. A. Supin, editor. Marine Mammal Sensory Systems. Plenum Press, New York.

Ketten, Darlene R. 1998. Marine Mammal Auditory Systems: A Summary of Audiometroc and Anatomical Data and its Implications for Underwater Acoustic Impacts. U.S. Department of Commerce, NOAA-TM-NMFS-SWFSC-256.

Ketten, Darlene R. 2012. Marine mammal auditory system noise impacts: Evidence and incidence. Pages 6 *in* A. N. P. A. Hawkings, editor. The Effects of Noise on Aquatic Life. Springer Science.

Ketten, Darlene R., and David C. Mountain. 2014. Inner ear frequency maps: First stage audiograms of low to infrasonic hearing in mysticetes. Pages 41 *in* Fifth International Meeting on the Effects of Sounds in the Ocean on Marine Mammals (ESOMM - 2014), Amsterdam, The Netherlands.

Kight, Caitlin R., and John P. Swaddle. 2011. How and why environmental noise impacts animals: An integrative, mechanistic review. Ecology Letters.

Kintisch, E. 2006. As the seas warm: Researchers have a long way to go before they can pinpoint climate-change effects on oceangoing species. Science 313:776-779.

Kipple, B., and C. Gabriele. 2004. Underwater noise from skiffs to ships. S. M. J. F. G. Piatt, editor Fourth Glacier Bay Science Symposium.

Kipple, Blair, and Chris Gabriele. 2007. Underwater noise from skiffs to ships. Pages 172-175 *in* Fourth Glacier Bay Science Symposium.

Kite-Powell, Hauke L., Amy Knowlton, and Moira Brown. 2007. Modeling the effect of vessel speed on right whale ship strike risk. NMFS.

Knudsen, F. R., P. S. Enger, and O. Sand. 1992. Awareness Reactions And Avoidance Responses To Sound In Juvenile Atlantic Salmon, *Salmo-Salar*. Journal of Fish Biology 40(4):523-534.

Knudsen, F. R., P. S. Enger, and O. Sand. 1994. Avoidance responses to low-frequency sound in downstream migrating Atlantic salmon smolt, *Salmo-salar*. Journal of Fish Biology 45(2):227-233.

Kostyuchenko, L.P. 1973. Effects of elastic waves generated in marine seismic prospecting on fish eggs in the Black Sea. Hydrobiological Journal 9(5):45-48.

Krahn, Margaret M., and coauthors. 2007. Persistent organic pollutants and stable isotopes in biopsy samples (2004/2006) from Southern Resident killer whales (*Orcinus orca*). Marine Pollution Bulletin 54(12):1903-1911.

Krahn, Margaret M., and coauthors. 2009. Effects of age, sex and reproductive status on persistent organic pollutant concentrations in ‘‘Southern Resident” killer whales. Marine Pollution Bulletin.

Kraus, Scott D., and coauthors. 2005. North Atlantic right whales in crisis. Science 309(5734):561-562.

Kraus, Scott D., and coauthors. 2016. Recent Scientific Publications Cast Doubt on North Atlantic Right Whale Future. Frontiers in Marine Science.

Kraus, Scott D., John H. Prescott, Amy R. Knowlton, and Gregory S. Stone. 1986. Migration and calving of right whales (*Eubalaena glacialis*) in the western North Atlantic. Report of the International Whaling Commission Special Issue 10:139-144.

Kremser, U., P. Klemm, and W.D. Kötz. 2005. Estimating the risk of temporary acoustic threshold shift, caused by hydroacoustic devices, in whales in the Southern Ocean. Antarctic Science 17(1):3-10.

Kujawa, S. G., and M. C. Liberman. 2009. Adding insult to injury: Cochlear nerve degeneration after “temporary” noise-induced hearing loss. The Journal of Neuroscience 29(45):14077–14085.

Kuznetsov, M. Yu. 2009. Traits of acoustic signalization and generation of sounds by some schooling physostomous fish. Acoustical Physics 55(6):866-875.

Kvadsheim, Petter H., Erik M. Sevaldsen, Lars P. Folkow, and Arnoldus S. Blix. 2010. Behavioural and physiological responses of hooded seals (Cystophora cristata) to 1 to 7 kHz sonar signals. Aquatic Mammals 36(3):239-247.

La Bella, G., and coauthors. 1996. First assessment of effects of air-gun seismic shooting on marine resources in the Central Adriatic Sea. Pages 227-238 *in* Society of Petroleum Engineers, International Conference on Health, Safety and Environment, New Orleans, Louisiana.

La Bella, G.; Cannata, S.; Froglia, C.; Modica, A.; Ratti, S.; Rivas, G. 1996. First assessment of effects of air-gun seismic shooting on marine resources in the Central Adriatic Sea. Pages 227 *in* SPE Health, Safety and Environment in Oil and Gas Exploration and Production Conference, New Orleans, Louisiana.

Laist, D. W., A. R. Knowlton, J. G. Mead, A. S. Collet, and M. Podesta. 2001. Collisions between ships and whales. Marine Mammal Science 17(1):35-75.

Lambert, E., C. Hunter, G.J. Pierce, and C.D. MacLeod. 2010. Sustainable whale-watching tourism and climate change: Towards a framework of resilience. Journal of Sustainable Tourism 18(3):409–427.

Lang, A. R., and coauthors. 2011. Genetic analysis of stock structure and movements of gray whales in the eastern and western North Pacific. International Whaling Commission.

Laplanche, C., O. Adam, M. Lopatka, and J. F. Motsch. 2005. Sperm whales click focussing: Towards an understanding of single sperm whale foraging strategies. Pages 56 *in* Nineteenth Annual Conference of the European Cetacean Society, La Rochelle, France.

Law, K. L., and coauthors. 2010. Plastic accumulation in the North Atlantic subtropical gyre. Science 329(5996):1185-1188.

Learmonth, J. A., and coauthors. 2006a. Potential effects of climate change on marine mammals. Oceanography and Marine Biology: An Annual Review 44:431-464.

Learmonth, J.A., and coauthors. 2006b. Potential effects of climate change on marine mammals. Oceanography and Marine Biology: an Annual Review 44:431-464.

Lemon, M., T. P. Lynch, D. H. Cato, and R. G. Harcourt. 2006. Response of travelling bottlenose dolphins (Tursiops aduncus) to experimental approaches by a powerboat in Jervis Bay, New South Wales, Australia. Biological Conservation 127(4):363-372.

Lenhardt, M. L. 1994. Seismic and very low frequency sound induced behaviors in captive loggerhead marine turtles (*Caretta caretta*). Pages 238-241 *in* K. A. C. Bjorndal, A. B. C. Bolten, D. A. C. Johnson, and P. J. C. Eliazar, editors. Fourteenth Annual Symposium on Sea Turtle Biology and Conservation.

Lenhardt, M. L. 2002. Sea turtle auditory behavior. Journal of the Acoustical Society of America 112(5 Part 2):2314.

Lenhardt, M.L., S. Bellmund, R.A. Byles, S.W. Harkins, and J.A. Musick. 1983. Marine turtle reception of bone conducted sound. The Journal of Auditory Research 23:119-125.

Lesage, V.; Barrette, C.; Kingsley, M. C. S.; Sjare, B. 1999. The effect of vessel noise on the vocal behavior of Belugas in the St. Lawrence River estuary, Canada. Marine Mammal Science 15(1):65-84.

Lesage, V.; C. Barrette; M. C. S. Kingsley. 1993. The effect of noise from an outboard motor and a ferry on the vocal activity of beluga (*Delphinapterus leucas*) in the St. Lawrence Estuary, Canada. Pages 70 *in* Tenth Biennial Conference on the Biology of Marine Mammals, Galveston, Texas.

Levenson, C. 1974. Source level and bistatic target strength of the sperm whale (Physeter catodon) measured from an oceanographic aircraft. Journal of the Acoustic Society of America 55(5):1100-1103.

LGL Ltd. 2008. Environmental Assessment of a Marine Geophysical Survey by the R/V *Marcus G. Langseth* in the Gulf of Alaska, September 2008. Prepared by LGL Ltd., environmental research associates, King City, Ontario for the Lamont-Doherty Earth Observatory, Palisades, New York, and the National Science Foundation, Arlington, Virginia. LGL Report TA4412-1. 204p.

Li, W. C., H. F. Tse, and L. Fok. 2016. Plastic waste in the marine environment: A review of sources, occurrence and effects. Sci Total Environ 566-567:333-349.

Lima, S.L. 1998. Stress and decision making under the risk of predation. Advances in the Study of Behavior 27:215-290.

Ljungblad, D.K., B. Würsig, S.L. Swartz, and J.M. Keene. 1988. Observations on the behavioral responses of bowhead whales (Balaena mysticetus) to active geophysical vessels in the Alaskan Beaufort Sea. Arctic 41(3):183-194.

Lloyd, Brian Donald. 2003. Potential effects of mussel farming on New Zealand's marine mammals and seabirds: A discussion paper. Department of Conservation.

Løkkeborg, S. 1991. Effects of geophysical survey on catching success in longline fishing. Pages 1-9 *in* International Council for the Exploration of the Sea (ICES) Annual Science Conference.

Løkkeborg, S. , and A.V. Soldal. 1993. The influence of seismic explorations on cod (Gadus morhua) behaviour and catch rates. ICES Marine Science Symposium 196:62-67.

Løkkeborg, Svein; Ona, Egil; Vold, Aud; Salthaug, Are; Jech, Josef Michael. 2012. Sounds from seismic air guns: Gear- and species-specific effects on catch rates and fish distribution. Canadian Journal of Fisheries and Aquatic Sciences 69(8):1278-1291.

Lombarte, A., H. Y. Yan, A. N. Popper, J. C. Chang, and C. Platt. 1993. Damage and regeneration of hair cell ciliary bundles in a fish ear following treatment with gentamicin. Hearing Research 66:166-174.

Lopez, P.; Martin, J. 2001. Chemosensory predator recognition induces specific defensive behaviours in a fossorial amphisbaenian. Animal Behaviour 62:259-264.

Lowry, Mark S. 2002. Counts of northern elephant seals at rookeries in the Southern California Bight: 1981-2001. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center.

Luksenburg, JA, and ECM Parsons. 2009. The effects of aircraft on cetaceans: implications for aerial whalewatching. International Whaling Commission, SC/61/WW2.

Lusseau, D. 2006. The short-term behavioral reactions of bottlenose dolphins to interactions with boats in Doubtful Sound, New Zealand. Marine Mammal Science 22(4):802-818.

Lusseau, David. 2003. Effects of tour boats on the behavior of bottlenose dolphins: Using Markov chains to model anthropogenic impacts. Conservation Biology 17(6):1785-1793.

Lutcavage, M. E., P. Plotkin, B. E. Witherington, and P. L. Lutz. 1997. Human impacts on sea turtle survival. Pages 387-409 *in* P. L. L. J. A. Musick, editor. The Biology of Sea Turtles. CRC Press, New York, New York.

Lyrholm, T., and U. Gyllensten. 1998. Global matrilineal population structure in sperm whales as indicated by mitochondrial DNA sequences. Proceedings of the Royal Society B-Biological Sciences 265(1406):1679-1684.

Lysiak, Nadine S. J., Stephen J. Trumble, Amy R. Knowlton, and Michael J. Moore. 2018. Characterizing the Duration and Severity of Fishing Gear Entanglement on a North Atlantic Right Whale (*Eubalaena glacialis*) Using Stable Isotopes, Steroid and Thyroid Hormones in Baleen. Frontiers in Marine Science 5:168.

Macleod, C. D. 2009. Global climate change, range changes and potential implications for the conservation of marine cetaceans: A review and synthesis. Endangered Species Research 7(2):125-136.

Macleod, Colin D., and coauthors. 2005. Climate change and the cetacean community of north-west Scotland. Biological Conservation 124(4):477-483.

Madsen, P. T., and coauthors. 2006. Quantitative measurements of air-gun pulses recorded on sperm whales (*Physeter macrocephalus*) using acoustic tags during controlled exposure experiments. Journal of the Acoustical Society of America 120(4):2366–2379.

Madsen, P. T., B. Møhl, B.K. Nielsen, and M. Wahlberg. 2002a. Male sperm whale behaviour during exposures to distant seismic survey pulses. Aquatic Mammals 28(3):231-240.

Madsen, P. T., B. Møhl, B.K. Nielsen, and M. Wahlberg. 2002b. Male sperm whale behaviour during seismic survey pulses. Aquatic Mammals 28(3):231-240.

Madsen, Peter T., and coauthors. 2003. Sound production in neonate sperm whales. Journal of the Acoustical Society of America 113(6):2988–2991.

Magalhaes, Sara, and coauthors. 2002. Short-term reactions of sperm whales (Physeter macrocephalus) to whale-watching vessels in the Azores. Aquatic Mammals 28(3):267-274.

Malme, C. I., P. R. Miles, C. W. Clark, P. Tyack, and J. E. Bird. 1984a. Investigations of the Potential Effects of Underwater Noise from Petroleum Industry Activities on Migrating Gray Whale Behavior Phase II: January 1984 Migration. U.S. Department of Interior, Minerals Management Service, Alaska OCS Office, Report prepared under Contract No. 14-12-0001-29033, Anchorage, Alaska.

Malme, C. I., P. R. Miles, P. Tyack, C. W. Clark, and J. E. Bird. 1985. Investigation of the potential effects of underwater noise from petroleum industry activities on feeding humpback whale behavior. U.S. Department of Interior, Minerals Management Service, Alaska OCS Office, Report No. 5851, Anchorage, Alaska.

Malme, C.I. , and P.R. Miles. 1985. Behavioral responses of marine mammals (gray whales) to seismic discharges. Pages 253-280 *in* G. D. Greene, F. R. Engelhard, and R. J. Paterson, editors. Proc. Workshop on Effects of Explosives Use in the Marine Environment. Canada Oil & Gas Lands Admininstration, Environmental Protection Branch, Ottawa, Canada.

Malme, C.I., P.R. Miles, C.W. Clark, P. Tyack, and J.E. Bird. 1984b. Investigations of the Potential Effects of Underwater Noise from Petroleum Industry Activities on Migrating Gray Whale Behavior Phase II: January 1984 Migration.Report prepared for the U.S. Department of Interior, Minerals Management Service, Alaska OCS Office under Contract No. 14-12-0001-29033. 357p.

Malme, Charles I., Bernd Wursig, James E. Bird, and Peter Tyack. 1987. Observations of feeding gray whale responses to controlled industrial noise exposure. Pages 55-73 *in* Ninth International Conference on Port and Ocean Engineering Under Arctic Conditions, Fairbanks, Alaska.

Malme, Charles I., Bernd Würsig, James E. Bird, and Peter Tyack. 1986. Behavioral responses of gray whales to industrial noise: Feeding observations and predictive modeling. U.S.

Department of the Interior, Outer Continental Shelf Environmental Assessment Program, Research Unit 675.

Mancia, A., W. Warr, and R. W. Chapman. 2008. A transcriptomic analysis of the stress induced by capture-release health assessment studies in wild dolphins (Tursiops truncatus). Molecular Ecology 17(11):2581-2589.

Mangels, Karl F., and Tim Gerrodette. 1994. Report on cetacean sightings during a marine mammal survey in the eastern tropical Pacific Ocean aboard the NOAA ships McArthur and David Starr Jordan, July 28-November 2, 1992. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center.

Mann, Janet, Richard C. Connor, Lynne M. Barre, and Michael R. Heithaus. 2000. Female reproductive success in bottlenose dolphins (Tursiops sp.): Life history, habitat, provisioning, and group-size effects. Behavioral Ecology 11(2):210-219.

Mantua, N. J., and S. R. Hare. 2002. The Pacific decadal oscillation. Journal of Oceanography 58(1):35-44.

Mantua, N. J., S. R. Hare, Y. Zhang, J. M. Wallace, and R. C. Francis. 1997. A Pacific interdecadal climate oscillation with impacts on salmon production. Bulletin of the American Meteorological Society 78(6):1069-1079.

Marcoux, Marianne, Hall Whitehead, and Luke Rendell. 2006. Coda vocalizations recorded in breeding areas are almost entirely produced by mature female sperm whales (Physeter macrocephalus). Canadian Journal of Zoology 84(4):609-614.

Markon, C., and coauthors. 2018. Alaska. Pages 1185-1241 *in* D. R. Reidmiller, and coeditors, editors. Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, volume II. U.S. Global Change Research Program, Washington, DC, USA.

Mate, B., A. Bradford, G. Tsidulko, V. Vertyankin, and V. Ilyashenko. 2011. Late-feeding season movements of a western North Pacific gray whale off Sakhalin Island, Russia and subsequent migration into the eastern North Pacific. International Whaling Commission-Scientific Committee, Tromso, Norway.

Mate, B.R., K.M. Stafford, and D.K. Ljungblad. 1994. A change in sperm whale (*Physeter macrocephalus*) distribution correlated to seismic surveys in the Gulf of Mexico. Journal of the Acoustic Society of America 96(5 part 2):3268–3269.

Mate, Bruce R., and James T. Harvey. 1987. Acoustical deterrents in marine mammal conflicts with fisheries. Oregon State University, Sea Grant College Program, Corvallis, Oregon.

Mate, Martha H. Winsor; Bruce R. 2013. Seismic survey activity and the proximity of satellite-tagged sperm whales *Physeter macrocephalus* in the Gulf of Mexico. Bioacoustics 17:191-193.

Mateo, J. M. 2007. Ecological and hormonal correlates of antipredator behavior in adult Belding's ground squirrels (Spermophilus beldingi). Behavioral Ecology and Sociobiology 62(1):37-49.

Matkin, C. O., and E. Saulitis. 1997. Restoration notebook: killer whale (*Orcinus orca*). Exxon Valdez Oil Spill Trustee Council, Anchorage, Alaska.

Maybaum, H. L. 1990a. Effects of 3.3 kHz sonar system on humpback whales, Megaptera novaeangliae, in Hawaiian waters. EOS Transactions of the American Geophysical Union 71(2):92.

Maybaum, H.L. 1993. Responses of humpback whales to sonar sounds. Journal of the Acoustical Society of America 94(3 Pt. 2):1848–1849.

Maybaum, Hilary Lynn. 1990b. Effects of a 3.3 kHz sonar system on humpback whales, *Megaptera novaeangliae*, in Hawaiian waters. EOS 71:92.

McCall Howard, M.P. 1999. Sperm whales Physeter macrocephalus in the Gully, Nova Scotia: Population, distribution, and response to seismic surveying. Dalhousie University, Halifax, Nova Scotia.

McCauley, R. D., and coauthors. 2017. Widely used marine seismic survey air gun operations negatively impact zooplankton. Nature Ecology and Evolution 1(7):195.

McCauley, R. D., and coauthors. 2000a. Marine seismic surveys: analysis and propagation of air-gun signals; and effects of air-gun exposure on humpback whales, sea turtles, fishes and squid. Prepared for the Australian Petroleum Production Exploration Association by the Centre for Marine Science and Technology, Project CMST 163, Report R99-15. 203p.

McCauley, R. D., and coauthors. 2000b. Marine seismic surveys - a study of environmental implications. Australian Petroleum Production & Exploration Association (APPEA) Journal 40:692-708.

McCauley, R. D., J. Fewtrell, and A. N. Popper. 2003. High intensity anthropogenic sound damages fish ears. Journal of the Acoustical Society of America 113:5.

McCauley, R.D., M.-N. Jenner, C. Jenner, K.A. McCabe, and J. Murdoch. 1998. The response of humpback whales (*Megaptera novaeangliae*) to offshore seismic survey noise: preliminary results of observations about a working seismic vessel and experimental exposures. APPEA Journal 38:692-707.

McCauley, RD, and C Jenner. 2010. Migratory patterns and estimated population size of pygmy blue whales (Balaenoptera musculus brevicauda) traversing the Western Australian coast based on passive acoustics. IWC SC/62/SH26.

McCauley, Robert D., and coauthors. 2000c. Marine seismic surveys: Analysis and propagation of air-gun signals; and effects of air-gun exposure on humpback whales, sea turtles, fishes and squid. Curtin University of Technology, Western Australia.

McDonald, M. A., J. A. Hildebrand, and S. M. Wiggins. 2006a. Increases in deep ocean ambient noise in the Northeast Pacific west of San Nicolas Island, California. Journal of the Acoustical Society of America 120(2):711-718.

McDonald, M.A., J.A. Hildebrand, S. Webb, L. Dorman, and C.G. Fox. 1993. Vocalizations of blue and fin whales during a midocean ridge airgun experiment. Journal of the Acoustic Society of America 94(3 part 2):1849.

McDonald, M.A., and coauthors. 2005. Sei whale sounds recorded in the Antarctic. Journal of the Acoustical Society of America 118(6):3941-3945.

Mcdonald, Mark A., John Calambokidis, Arthur M. Teranishi, and John A. Hildebrand. 2001. The acoustic calls of blue whales off California with gender data. Journal of the Acoustical Society of America 109(4):1728-1735.

McDonald, Mark A., John A. Hildebrand, and Sarah Mesnick. 2009. Worldwide decline in tonal frequencies of blue whale songs. Endangered Species Research 9(1):13-21.

McDonald, Mark A., John A. Hildebrand, and Spahr C. Webb. 1995. Blue and fin whales observed on a seafloor array in the northeast Pacific. Journal of the Acoustical Society of America 98(2 Part 1):712-721.

McDonald, Mark A., Sarah L. Mesnick, and John A. Hildebrand. 2006b. Biogeographic characterisation of blue whale song worldwide: Using song to identify populations. Journal of Cetacean Research and Management 8(1):55-65.

McKenna, M.F., D. Ross, S.M. Wiggins, and J.A. Hildebrand. 2013. Relationship between container ship underwater noise levels and ship design, operational and oceanographic conditions. Scientific Reports 3:1760.

McKenna, Megan F., Donald Ross, Sean M. Wiggins, and John A. Hildebrand. 2012. Underwater radiated noise from modern commercial ships. Journal of the Acoustical Society of America 131(2):92-103.

McMahon, C. R., and G. C. Hays. 2006. Thermal niche, large-scale movements and implications of climate change for a critically endangered marine vertebrate. Global Change Biology 12(7):1330-1338.

McMahon, Clive R., and Harry R. Burton. 2005. Climate change and seal survival: Evidence for environmentally mediated changes in elephant seal, Mirounga leonina, pup survival. Proceedings of the Royal Society of London Series B Biological Sciences 272(1566):923-928.

McSweeney, D. J., K. C. Chu, W. F. Dolphin, and L. N. Guinee. 1989. North Pacific humpback whale songs - a comparison of southeast Alaskan feeding ground songs with Hawaiian wintering ground songs. Marine Mammal Science 5(2):139-148.

Mearns, A. J. 2001. Long-term contaminant trends and patterns in Puget Sound, the Straits of Juan de Fuca, and the Pacific Coast. T. Droscher, editor 2001 Puget Sound Research Conference. Puget Sound Action Team, Olympia, Washington.

Meier, S. K., and coauthors. 2007a. Distribution and abundance of western gray whales off northeastern Sakhalin Island, Russia, 2001-2003. Environmental Monitoring and Assessment 134(3-Jan):107-136.

Meier, S. K., and coauthors. 2007b. Distribution and abundance of western gray whales off northeastern Sakhalin Island, Russia, 2001-2003. Environmental Monitoring and Assessment 134(1-3):107-136.

Mellinger, D. K., and C. W. Clark. 2003. Blue whale (Balaenoptera musculus) sounds from the North Atlantic. Journal of the Acoustical Society of America 114(2):1108-1119.

Mesnick, S. L., and coauthors. 2011. Sperm whale population structure in the eastern and central North Pacific inferred by the use of single-nucleotide polymorphisms, microsatellites and mitochondrial DNA. Mol Ecol Resour 11 Suppl 1:278-98.

Meyers, J. M. ; R. G. Kope ; G. J. Bryant ; D. J. Teel ; L. J. Lierheimer ; T. C. Wainwright ; W. S. Gr; F. W. Waknitz ; K. Neely ; S. T. Lindley; R. S. Waples. 1998. Status review of Chinook salmon from Washington, Idaho, Oregon, and California. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northwest Fisheries Science Center.

Miksis-Olds, J. L., and S. M. Nichols. 2016. Is low frequency ocean sound increasing globally? J Acoust Soc Am 139(1):501-11.

Miller, G. W. , R. E. Elliot, W. R. Koski, V. D. Moulton, and W. J. Richardson. 1999. Whales. R. W.J., editor. Marine mammal and acoustical monitoring of Western Geophysical's open-water seismic program in the Alaskan Beaufort Sea, 1998.

Miller, G.W., and coauthors. 2005. Monitoring seismic effects on marine mammals—southeastern Beaufort Sea, 2001-2002. Pages 511-542 *in* S. L. Armsworthy, P. J. Cranford, and K. Lee, editors. Offshore Oil and Gas Environmental Effects Monitoring/Approaches and Technologies. Battelle Press, Columbus, Ohio.

Miller, P.J.O., and coauthors. 2009. Using at-sea experiments to study the effects of airguns on the foraging behavior of sperm whales in the Gulf of Mexico. Deep-Sea Research 56:1168–1181.

Miller, Patrick J. O., Mark P. Johnson, and Peter L. Tyack. 2004. Sperm whale behaviour indicates the use of echolocation click buzzes 'creaks' in prey capture. Proceedings of the Royal Society of London Series B Biological Sciences 271(1554):2239-2247.

Misund, O. A. 1997. Underwater acoustics in marine fisheries and fisheries research. Reviews in Fish Biology and Fisheries 7:1–34.

Mitson, R. B., and H. P. Knudsen. 2003. Causes and effects of underwater noise on fish abundance estimation. Aquatic Living Resources 16(3):255-263.

MMC. 2007. Marine mammals and noise: A sound approach to research and management. Marine Mammal Commission.

Moberg, G. P. 2000. Biological response to stress: Implications for animal welfare. Pages 21-Jan *in* G. P. Moberg, and J. A. Mench, editors. The Biology of Animal Stress. Oxford University Press, Oxford, United Kingdom.

Moein Bartol, S., and D.R. Ketten. 2006. Turtle and tuna hearing. Pp.98-103 In: Swimmer, Y. and R. Brill (Eds), Sea Turtle and Pelagic Fish Sensory Biology: Developing Techniques to Reduce Sea Turtle Bycatch in Longline Fisheries. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-PIFSC-7.

Moein, S.E., and coauthors. 1994. Evaluation of seismic sources for repelling sea turtles from hopper dredges. Final Report submitted to the U.S. Army Corps of Engineers, Waterways Experiment Station. Virginia Institute of Marine Science (VIMS), College of William and Mary, Gloucester Point, Virginia. 42p.

Mohl, Bertel, Magnus Wahlberg, Peter T. Madsen, Anders Heerfordt, and Anders Lund. 2003. The monopulsed nature of sperm whale clicks. Journal of the Acoustical Society of America 114(2):1143-1154.

Moncheva, S. P., and L. T. Kamburska. 2002. Plankton stowaways in the Black Sea - Impacts on biodiversity and ecosystem health. Pages 47-51 *in* Alien marine organisms introduced by ships in the Mediterranean and Black seas. CIESM Workshop Monographs, Istanbul, Turkey.

Mongillo, T. M., and coauthors. 2012. Predicted polybrominated diphenyl ether (PBDE) and polychlorinated biphenyl (PCB) accumulation in southern resident killer whales. Marine Ecology Progress Series 453:263-277.

Moore, Emma, and coauthors. 2009a. Entanglements of marine mammals and seabirds in central California and the north-west coast of the United States 2001-2005. Marine Pollution Bulletin 58(7):1045-1051.

Moore, Emma, and coauthors. 2009b. Entanglements of marine mammals and seabirds in central California and the north-west coast of the United States 2001-2005. Marine Pollution Bulletin 58(7):1045–1051.

Moore, P. W. B., and R. J. Schusterman. 1987. Audiometric assessment of northern fur seals, *Callorhinus ursinus*. Marine Mammal Science 3(1):31-53.

Moore, Patrick W. B.; Deborah A. Pawloski. 1990. Investigations on the control of echolocation pulses in the dolphin (*Tursiops truncatus*). Pages 305-316 *in* J. A. T. R. A. Kastelein, editor. Sensory Abilities of Cetaceans: Laboratory and Field Evidence. Plenum Press, New York.

Moore, S.E. , and R.P. Angliss. 2006. Overview of planned seismic surveys offshore northern Alaska, July-October 2006. Paper SC/58/E6 presented to IWC Scientific Committee, St Kitts and Nevis.

Moore, Sue E. 2000. Variability of cetacean distribution and habitat selection in the Alaskan Arctic, autumn 1982-91. Arctic 53(4):448-460.

Moulton, V. D., and J. W. Lawson. 2002. Seals, 2001. W. J. Richardson, editor. Marine Mammal and Acoustical Monitoring of WesternGeco's Open Water Seismic Program in the Alaskan Beaufort Sea, 2001, volume LGL Report TA2564 4. LGL Ltd.

Moulton, V.D. , and G.W. Miller. 2005a. Marine mammal monitoring of a seismic survey on the Scotian Slope, 2003. K. Lee, H. Bain, and G. V. Hurley, editors. Acoustic monitoring and marine mammal surveys in the Gully and outer Scotian Shelf before and during active seismic programs, volume Environmental Studies Research Funds Report No. 151. Fisheries and Oceans Canada Centre for Offshore Oil and Gas Environmental Research, Dartmouth, Nova Scotia.

Moulton, V.D. , and G.W. Miller. 2005b. Marine mammal monitoring of a seismic survey on the Scotian Slope, 2003.

Mrosovsky, N., G. D. Ryan, and M. C. James. 2009. Leatherback turtles: The menace of plastic. Marine Pollution Bulletin 58(2):287–289.

Mundy, P.R., and R.T. Cooney. 2005. Physical and biological background. Pages 15-23 *in* P. R. Mundy, editor. The Gulf of Alaska: Biology and oceanography. Alaska Sea Grant College Program, University of Alaska, Fairbanks, Alaska.

Muto, M.M., and coauthors. 2016. Alaska Marine Mammal Stock Assessments, 2015.

Muto, M.M., and coauthors. 2017. Alaska Marine Mammal Stock Assessments, 2016. Alaska Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, NMFS-AFSC-355, Seattle, Washington.

Nadeem, K., J. E. Moore, Y. Zhang, and H. Chipman. 2016. Integrating population dynamics models and distance sampling data: A spatial hierarchical state-space approach. Ecology 97(7):1735-1745.

Nakamura, N., and coauthors. 2009. Mode shift in the Indian Ocean climate under global warming stress. Geophysical Research Letters 36.

NAS. 2017. Approaches to Understanding the Cumulative Effects of Stressors on Marine Mammals. National Academies of Sciences, Engineering, and Medicine. The National Academies Press, Washington, District of Columbia.

Nations, Christopher S., and coauthors. 2009. Effects of seismic exploration in the Beaufort Sea on bowhead whale call distributions. Journal of the Acoustical Society of America 126(4):2230.

Navy, U.S. 2010. NAVSEA NUWC Keyport Range Complex Extension Environmental Impact Statement/Overseas Environmental Impact Statement. Appendix D: Marine mammal densities and depth distribution. Prepaed by Naval Facilities Engineering Command Northwest for Naval Undersea Warfare Center, Keyport.

Navy, U.S. 2018. U.S. Navy Marine Species Density Database Phase III for the Northwest Training and Testing Study Area. Naval Facilities Engineering Command Pacific, Pearl Harbor, HI.

Nelms, Sarah E., Wendy E. D. Piniak, Caroline R. Weir, and Brendan J. Godley. 2016. Seismic surveys and marine turtles: An underestimated global threat? Biological Conservation 193:49-65.

Neproshin, A, and W Kulikova. 1975. Sound production organs in salmonids. J. Ichthyiol 15:481-485.

Neproshin, YA. 1972. Some physical characteristics of sound in Pacific salmon. Zoologicheskii Zhurnal 51:1025-1030.

New, L. F., and coauthors. 2014. Using short-term measures of behaviour to estimate long-term fitness of southern elephant seals. Marine Ecology Progress Series 496:99-108.

Nieukirk, S.L., K.M. Stafford, D.k. Mellinger, R.P. Dziak, and C.G. Fox. 2004. Low-frequency whale and seismic airgun sounds recorded in the mid-Atlantic Ocean Journal of the Acoustical Society of America 115:1832-1843.

NMFS. 1991. Final recovery plan for the humpback whale (*Megaptera novaeangliae*). National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources, Silver Spring, Maryland.

NMFS. 1998. Recovery plan for the blue whale (Balaenoptera musculus). National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Silver Spring, Maryland.

NMFS. 2006a. Biological Opinion on Permitting Structure Removal Operations on the Gulf of Mexico Outer Continental Shelf and the Authorization for Take of Marine Mammals Incidental to Structure Removals on the Gulf of Mexico Outer Continental Shelf. National Marine Fisheries Service, Silver Spring, Maryland. 131p.

NMFS. 2006b. Biological Opinion on the 2006 Rim-of-the-Pacific Joint Training Exercises (RIMPAC). Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, FPR-2005-6879, Silver Spring, Maryland.

NMFS. 2006c. Biological Opinion on the issuance of Section 10(a)(1)(A) permits to conduct scientific research on the southern resident killer whale (Orcinus orca) distinct population segment and other endangered or threatened species. Northwest Regional Office, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerice, NWR-2006-470, Seattle, Washington.

NMFS. 2006h. Biological Opinion on the Funding and Permitting of Seismic Surveys by the National Science Foundation and the National Marine Fisheries Service in the Eastern Tropical Pacific Ocean from March to April 2006. National Marine Fisheries Service, Silver Spring, Maryland. 76p.

NMFS. 2010a. Final recovery plan for the sperm whale (Physeter macrocephalus). National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources, Silver Spring, Maryland.

NMFS. 2010b. Recovery plan for the fin whale (Balaenoptera physalus). U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources, Silver Spring, Maryland.

NMFS. 2011a. Fin whale (*Balaenoptera physalus*) 5-Year Review: Evaluation and Summary.

NMFS. 2011b. Final recovery plan for the sei whale (Balaenoptera borealis). National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources, Silver Spring, Maryland.

NMFS. 2012. Sei whale (Balaenoptera borealis). 5-year review: Summary and evaluation. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources.

NMFS. 2013. Leatherback Sea Turtle (Dermochelys coriacea) 5-Year Review: Summary and Evaluation. N. a. USFWS, editor.

NMFS. 2015a. Southern Distinct Population Segment of the North American Green Sturgeon (*Acipenser medirostris*). Five-Year Review: Summary and Evaluation. Pages 42 *in*, West Coast Region; Long Beach, California.

NMFS. 2015b. Sperm whale (Physeter macrocephalus) 5-year review: Summary and evaluation. National Marine Fisheries Service, Office of Protected Resources.

NMFS. 2016. Species in the Spotligh Priority Actions: 2016-2020 Pacific Leatherback Turtle *Dermochelys coriacea*.

NMFS. 2017. Letter of concurrence on the issuance of Permit No. 20527 to Ann Pabst for vessel and aerial surveys of blue, fin, North Atlantic right, sei, and sperm whales. Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, FPR-2017-9199, Silver Spring, Maryland.

NMFS, and USFWS. 2007a. 5-year review: Summary and evaluation, green sea turtle (*Chelonia mydas*). National Oceanic and Atmospheric Administration, National Marine Fisheries Service and U.S. Fish and Wildlife Service.

NMFS, and USFWS. 2007b. Loggerhead sea turtle (*Caretta caretta*) 5-year review: Summary and evaluation. National Marine Fisheries Service and U.S. Fish and Wildlife Service, Silver Spring, Maryland.

NMFS, and USFWS. 2008. Recovery plan for the northwest Atlantic population of the loggerhead sea turtle (*Caretta caretta*), second revision. National Marine Fisheries Service and United States Fish and Wildlife Service, Silver Spring, Maryland.

NMFS, and USFWS. 2013a. Hawksbill sea turtle (*Eretmochelys imbricata*) 5-year review: Summary and evaluation National Marine Fisheries Service and U.S. Fish and Wildlife Service, Silver Spring, Maryland.

NMFS, and USFWS. 2013b. Leatherback Sea Turtle (*Dermochelys coriacea*) 5-Year Review: Summary and Evaluation. National Marine Fisheries Service and United States Fish and Wildlife Service, Silver Spring, Maryland.

NMFS, and USFWS. 2013c. Leatherback sea turtle (*Dermochelys coriacea*) 5-year review: Summary and evaluation. National Marine Fisheries Service and U.S. Fish and Wildlife Service, Silver Spring, Maryland.

NMFS, and USFWS. 2015. Kemp's ridley sea turtle (*Lepidochelys kempii*) 5-year review: Summary and evaluation. National Marine Fisheries Service and U.S. Fish and Wildlife Service, Silver Spring, Maryland.

NOAA. 2013. Draft guidance for assessing the effects of anthropogenic sound on marine mammals: acoustic threshold levels for onset of permanent and temporary threshold shifts. National Oceanic and Atmospheric Administration, U.S. Department of Commerce.

NOAA. 2018. Revisions to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0): Underwater Thresholds for Onset of Permanent and Temporary Threshold Shifts. Office of Protected Resources, National

Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Silver Spring, Maryland.

Noda, Katsura, Hideo Akiyoshi, Mica Aoki, Terumasa Shimada, and Fumihito Ohashi. 2007. Relationship between transportation stress and polymorphonuclear cell functions of bottlenose dolphins, *Tursiops truncatus*. Journal of Veterinary Medical Science 69(4):379-383.

Noren, D.P., A.H. Johnson, D. Rehder, and A. Larson. 2009. Close approaches by vessels elicit surface active behaviors by southern resident killer whales. Endangered Species Research 8(3):179–192.

Norris, K.S., and G.W. Harvey. 1972. A theory for the function of the spermaceti organ of the sperm whale. Pages 393–417 *in* S. R. Galler, editor. Animal Orientation and Navigation.

Nowacek, Douglas P., Lesley H. Thorne, David W. Johnston, and Peter L. Tyack. 2007. Responses of cetaceans to anthropogenic noise. Mammal Review 37(2):81-115.

Nowacek, S. M., R. S Wells, and A. R. Solow. 2001. Short-term effects of boat traffic on bottlenose dolphins, *Tursiops truncatus*, in Sarasota Bay, Florida. Marine Mammal Science 17(4):673-688.

Nowacek, S. M.; Wells, R. S.; Solow, A. R. 2001. Short-term effects of boat traffic on bottlenose dolphins, *Tursiops truncatus*, in Sarasota Bay, Florida. Marine Mammal Science 17(4):673-688.

NRC. 2003a. National Research Council: Ocean noise and marine mammals. National Academies Press, Washington, D.C.

NRC. 2003b. Ocean Noise and Marine Mammals. National Research Council of the National Academies of Science. The National Academies Press, Washington, District of Columbia.

NRC. 2005. Marine mammal populations and ocean noise. Determining when noise causes biologically significant effects. National Research Council of the National Academies of Science. The National Academies Press, Washington, District of Columbia.

NRC. 2008. Tackling marine debris in the 21st Century. National Research Council of the National Academies of Science. The National Academies Press, Washington, District of Columbia.

O'hara, James, and J. Ross Wilcox. 1990. Avoidance responses of loggerhead turtles, Caretta caretta, to low frequency sound. Copeia (2):564-567.

O'Connor, S., R. Campbell, H. Cortez, and T. Knowles. 2009. Whale Watching Worldwide: Tourism numbers, expenditures and expanding economic benefits, a special report from the International Fund for Animal Welfare. International Fund for Animal Welfare, Yarmouth, Massachusetts.

Ohsumi, S., and S. Wada. 1974. Status of whale stocks in the North Pacific, 1972. Report of the International Whaling Commission 24:114-126.

Oleson, Erin M., John Calambokidis, Jay Barlow, and John A. Hildebrand. 2007a. Blue whale visual and acoustic encounter rates in the Southern California Bight. Marine Mammal Science 23(3):574-597.

Oleson, Erin M., and coauthors. 2007b. Behavioral context of call production by eastern North Pacific blue whales. Marine Ecology Progress Series 330:269-284.

Oleson, Erin M., Sean M. Wiggins, and John A. Hildebrand. 2007c. Temporal separation of blue whale call types on a southern California feeding ground. Animal Behaviour 74(4):881-894.

Omura, H. , S. Ohsumi, K. N. Nemoto, and T. Kasuya. 1969. Black right whales in the north Pacific. Scientific Reports of the Whales Research Institute 21.

Omura, Hideo. 1988. Distribution and migration of the western Pacific stock of the gray whale (*Eschrichtius robustus*). Scientific Reports of the Whales Research Institute 39:1-10.

Oros, J.; Gonzalez-Diaz, O. M.; Monagas, P. 2009. High levels of polychlorinated biphenyls in tissues of Atlantic turtles stranded in the Canary Islands, Spain. Chemosphere 74(3):473-478.

Osborne, Richard, John Calambokidis, and Eleanor M. Dorsey. 1988. A guide to marine mammals of greater Puget Sound. Island Publishers, Anacortes, Washington.

Palka, D. 2012. Cetacean abundance estimates in US northwestern Atlantic Ocean waters from summer 2011 line transect survey.

Parente, C.L., J.P. Araujo, and M.E. Araujo. 2007. Diversity of cetaceans as tool in monitoring environmental impacts of seismic surveys. Biota Neotropica 7(1).

Parker, D. M., W. J. Cooke, and G. H. Balazs. 2005. Diet of oceanic loggerhead sea turtles (Caretta caretta) in the central North Pacific. Fishery Bulletin 103:142-152.

Parks, S. E. 2003. Response of North Atlantic right whales (Eubalaena glacialis) to playback of calls recorded from surface active groups in both the North and South Atlantic. Marine Mammal Science 19(3):563-580.

Parks, Susan E. 2009a. Assessment of acoustic adaptations for noise compensation in marine mammals. Office of Naval Research.

Parks, Susan E. 2009b. Assessment of acoustic adaptations for noise compensation in marine mammals. Office of Naval Research, Award Number: N00014-08-1-0967.

Parks, Susan E., C. W. Clark, and P. L. Tyack. 2007. Short- and long-term changes in right whale calling behavior: The potential effects of noise on acoustic communication. Journal of the Acoustical Society of America 122(6):3725-3731.

Parks, Susan E., and Christopher W. Clark. 2007. Acoustic communication: Social sounds and the potential impacts of noise. Pages 310-332 *in* S. D. K. R. Rolland, editor. The Urban Whale: North Atlantic Right Whales at the Crossroads. Harvard University Press, Cambridge, Massahusetts.

Parks, Susan E., Mack P. Johnson, Douglas P. Nowacek, and Peter L. Tyack. 2012. Changes in vocal behavior of North Atlantic right whales in increased noise. Pages 4 *in* A. N. P. A. Hawkings, editor. The Effects of Noise on Aquatic Life. Springer Science.

Parks, Susan E., Mark Johnson, Douglas Nowacek, and Peter L. Tyack. 2011. Individual right whales call louder in increased environmental noise. Biology Letters 7(1):33-35.

Parks, Susan E., Ildar Urazghildiiev, and Christopher W. Clark. 2009. Variability in ambient noise levels and call parameters of North Atlantic right whales in three habitat areas. Journal of the Acoustical Society of America 125(2):1230-1239.

Parks, Susan E.; C. W. Clark; P. L. Tyack. 2007. Short- and long-term changes in right whale calling behavior: The potential effects of noise on acoustic communication. Journal of the Acoustical Society of America 122(6):3725-3731.

Parry, G. D., S. Heislers, G. F. Werner, M. D. Asplin, and A. Gason. 2002. Assessment of environmental effects of seismic testing on scallop fisheries in Bass Strait. Marine and Fresh-water Resources Institute, Report No. 50.

Parsons, E. C. M. 2012. The Negative Impacts of Whale-Watching. Journal of Marine Biology 2012:1-9.

Patenaude, N. J., and coauthors. 2002. Aircraft sound and disturbance to bowhead and beluga whales during spring migration in the Alaskan Beaufort Sea. Marine Mammal Science 18(2):309-335.

Patterson, B., and G. R. Hamilton. 1964. Repetitive 20 cycle per second biological hydroacoustic signals at Bermuda. Marine Bio-acoustics, W N Tavolga ed. Pergamon Press Oxford. p.125-145. Proceedings of a Symposium held at the Lerner Marine Laboratory Bimini Bahamas April.

Patterson, P. D. 1966. Hearing in the turtle. Journal of Auditory Research 6:453.

Pavan, G., and coauthors. 2000. Time patterns of sperm whale codas recorded in the Mediterranean Sea 1985-1996. Journal of the Acoustical Society of America 107(6):3487-3495.

Payne, J. F.; J. Coady; D. White. 2009. Potential effects of seismic airgun discharges on monkfish eggs (Lophius americanus) and larvae., St. John's, Newfoundland.

Payne, K., and R. Payne. 1985. Large scale changes over 19 years in songs of humpback whales in Bermuda. Zeitschrift fur Tierpsychologie 68:89-114.

Payne, Katharine. 1985. Singing in humpback whales. Whalewatcher 19(1):3-6.

Payne, Katharine, Peter Tyack, and Roger Payne. 1983. Progressive changes in the songs of humpback whales (*Megaptera novaeangliae*): A detailed analysis of two seasons in Hawaii. Pages 9-57 *in* R. Payne, editor. Communication and Behavior of Whales. Westview Press, Boulder, CO.

Payne, P. Michael, John R. Nicolas, Loretta O'brien, and Kevin D. Powers. 1986. The distribution of the humpback whale, Megaptera novaeangliae, on Georges Bank and in the Gulf of Maine in relation to densities of the sand eel, Ammodytes americanus. Fishery Bulletin 84(2):271-277.

Payne, P. Michael, and coauthors. 1990. Recent fluctuations in the abundance of baleen whales in the southern Gulf of Maine in relation to changes in prey abundance. Fishery Bulletin 88(4):687-696.

Payne, R.S. 1970. Songs of the humpback whale. Capital Records, Hollywood.

Payne, Roger S., and Scott Mcvay. 1971. Songs of humpback whales. Humpbacks emit sounds in long, predictable patterns ranging over frequencies audible to humans. Science 173(3997):585-597.

Payne, Roger, and Douglas Webb. 1971. Orientation by means of long range acoustic signaling in baleen whales. Annals of the New York Academy of Sciences 188(1):110-141.

Pearson, W. H., J.R. Skalski, and C.I. Malme. 1992. Effects of sounds from a geophysical survey device on behavior of captive rockfish (*Sebastes* spp.). Canadian Journal of Fisheries and Aquatic Sciences 49:1343-1356.

Pecl, G.T., and G.D. Jackson. 2008. The potential impacts of climate change on inshore squid: Biology, ecology and fisheries. Reviews in Fish Biology and Fisheries 18:373-385.

Pershing, A.J., and coauthors. 2001. Oceanographic responses to climate in the Northwest Atlantic. Oceanography 14(3):76-82.

Peterson, Richard S., Carl L. Hubbs, Roger L. Gentry, and Robert L. Delong. 1968. The Guadalupe fur seal: Habitat, behavior, population size and field identification. Journal of Mammalogy 49(4):665-675.

Pham, C. K., and coauthors. 2017. Plastic ingestion in oceanic-stage loggerhead sea turtles (*Caretta caretta*) off the North Atlantic subtropical gyre. Mar Pollut Bull.

Philbrick, Valerie A., Paul C. Fiedler, Lisa T. Ballance, and David A. Demer. 2003. Report of ecosystem studies conducted during the 2001 Oregon, California, and Washington (ORCAWALE) marine mammal survey on the research vessels David Starr Jordan and McArthur. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center.

Pickett, G.D., D.R. Eaton, R.M.H. Seaby, and G.P. Arnold. 1994. Results of bass tagging in Poole Bay during 1992. MAFF Direct. Fish. Res., Lowestoft, Endland.

Pierson, M. O. 1978. A study of the population dynamics and breeding behavior of the Guadalupe fur seal, (*Arctocephalus townsendi*). University of California, Santa Cruz.

Piniak, Wendy Erin Dow. 2012. Acoustic ecology of sea turtles: Implications for conservation. Duke University.

Pirotta, V., A. Grech, I. D. Jonsen, W. F. Laurance, and R. G. Harcourt. 2019. Consequences of global shipping traffic for marine giants. Frontiers in Ecology and the Environment 17(1):39-46.

Polefka, Shiva. 2004. Anthropogenic noise and the Channel Islands National Marine Sanctuary: How noise affects sanctuary resources, and what we can do about it. A report by the Environmental Defense Center, Santa Barbara, CA. 53pp. September 28, 2004.

Poloczanska, E. S., C. J. Limpus, and G. C. Hays. 2009. Vulnerability of marine turtles in climate change. Pages 151-211 *in* Advances in MArine Biology, volume 56. Academic Press, New York.

Polyakov, Igor V., Vladimir A. Alexeev, Uma S. Bhatt, Evgenia I. Polyakova, and Xiangdong Zhang. 2009. North Atlantic warming: patterns of long-term trend and multidecadal variability. Climate Dynamics 34(3-Feb):439-457.

Popper, A. N. 1977. Comparative structure of the fish ear. Journal of the Acoustical Society of America 61(S1):S76-S76.

Popper, A. N., and coauthors. 2007. The effects of high-intensity, low-frequency active sonar on rainbow trout. Journal of the Acoustical Society of America 122(1):623-635.

Popper, A. N., and coauthors. 2005. Effects of exposure to seismic airgun use on hearing of three fish species. Journal of the Acoustical Society of America 117(6):3958-3971.

Popper, A.N., and A. D. Hawkins. 2014. Assessing the impact of underwater sounds on fishes and other forms of marine life. Acoustics Today 10(2):30-41.

Popper, Anthony D . Hawkins, and Arthur N. 2014. Assessing the impact of underwater sounds on fishes and other forms of marine life. Acoustics Today 10(2):30-41.

Popper, Arthur N., and Mardi C. Hastings. 2009. The effects of human-generated sound on fish. Integrative Zoology 4:43-52.

Popper, Arthur N., and coauthors. 2014. Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report prepared by ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI. Pages 33-51 *in* ASA S3/SC1.4 TR-2014 Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report prepared by ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI.

Potter, J. R., and coauthors. 2007. Visual and Passive Acoustic Marine Mammal Observations and High-Frequency Seismic Source Characteristics Recorded During a Seismic Survey. IEEE Journal of Oceanic Engineering 32(2):469-483.

Price, C. S., and coauthors. 2017. Protected Species Marnine Aquaculture Interactions. NOAA Technical Memorandum NOS NCCOS 211.

Price, Carol Seals, and James A Morris. 2013. Marine cage culture and the environment: Twenty-first century science informing a sustainable industry.

Price, Edwin R, and coauthors. 2004. Size, growth, and reproductive output of adult female leatherback turtles *Dermochelys coriacea*. Endangered Species Research 5:1-8.

Price, S. 2017. Rare right whale sightings in Southern California. CBS News 8.

Pughiuc, D. 2010. Invasive species: Ballast water battles. Seaways.

Putnam, N.F., and coauthors. 2013. Evidence for geomagnetic imprinting as a homing mechanism in Pacific salmon. Current Biology 23:312-316.

Raaymakers, S. 2003. The GEF/UNDP/IMO global ballast water management programme integrating science, shipping and society to save our seas. Proceedings of the Institute of Marine Engineering, Science and Technology Part B: Journal of Design and Operations (B4):2-10.

Raaymakers, S., and R. Hilliard. 2002. Harmful aquatic organisms in ships' ballast water - Ballast water risk assessment. Pages 103-110 *in* Alien marine organisms introduced by ships in the Mediterranean and Black seas. CIESM Workshop Monographs, Istanbul, Turkey.

Ramajo, Laura, and coauthors. 2016. Food supply confers calcifiers resistance to ocean acidification. Scientific Reports 6:19374.

Rankin, Shannon, Don Ljungblad, Chris Clark, and Hidehiro Kato. 2005. Vocalisations of Antarctic blue whales, *Balaenoptera musculus intermedia*, recorded during the 2001/2002 and 2002/2003 IWC/SOWER circumpolar cruises, Area V, Antarctica. Journal of Cetacean Research and Management 7(1):13-20.

Redfern, J. V.; M. F. McKenna; T. J. Moore; J. Calambokidis; M. L. Deangelis; E. A. Becker; J. Barlow; K. A. Forney; P. C. Fiedler; S. J. Chivers. 2013. Assessing the risk of ships striking large whales in marine spatial planning. Conservation Biology 27(2):292-302.

Reep, Roger L., and coauthors. 2011. Manatee vibrissae: Evidence for a lateral line function. Annals of the New York Academy of Sciences 1225(1):101-109.

Reeves, R. R. , B. S. Stewart, P. Clapham, and J. Powell. 2002. Guide to marine mammals of the world. Knopf, New York.

Reeves, Randall R., Tim D. Smith, and Elizabeth A. Josephson. 2008. Observations of western gray whales by ship-based whalers in the 19th century. IWC Scientific Committee, Santiago, Chile.

Reilly, S.B., and coauthors. 2013. *Balaenoptera physalus*. The IUCN Red List of Threatened Species. The IUCN Red List of Threatened Species 2013:e.T2478A44210520.

Reina, R. D., Philippe A Mayor, J. R. Spotila, Rotney Piedra, and F. V. Paladino. 2002. Nesting ecology of the leatherback turtle, *Dermochelys coriacea*, at Parque Nacional Marino Las Baulas, Costa Rica: 1988-1989 to 1999-2000. Copeia 2002(3):653-664.

Rendell, L., S. L. Mesnick, M. L. Dalebout, J. Burtenshaw, and H. Whitehead. 2012. Can genetic differences explain vocal dialect variation in sperm whales, Physeter macrocephalus? Behav Genet 42(2):332-43.

Rendell, Luke, and Hal Whitehead. 2004. Do sperm whales share coda vocalizations? Insights into coda usage from acoustic size measurement. Animal Behaviour 67(5):865-874.

Richardson, W., C. Greene, C. Malme, and D. Thomson. 1995a. Ambient noise. Pages 547 *in* Marine Mammals and Noise. Academic Press, Inc.

Richardson, W. J. 1995. Marine mammal hearing. Pages 205-240 *in* C. R. W. J. G. J. Richardson, C. I. Malme, and D. H. Thomson, editors. Marine Mammals and Noise. Academic Press, San Diego, California.

Richardson, W. J., B. Würsig, and C.R. Greene, Jr. 1986a. Reactions of bowhead whales, *Balaena mysticetus*, to seismic exploration in the Canadian Beaufort Sea. Journal of the Acoustical Society of America 79(4):1117-1128.

Richardson, W. John, Charles R. Jr. Greene, Charles I. Malme, and Denis H. Thomson. 1995b. Marine Mammals and Noise. Academic Press, Inc., San Diego, California.

Richardson, W. John, Charles R. Greene, Charles I. Malme, and Denis H. Thomson. 1995c. Marine Mammals and Noise. Academic Press, Inc., San Diego, California.

Richardson, W. John, Charles R. Greene Jr., Charles I. Malme, and Denis H. Thomson. 1995d. Marine Mammals and Noise. Academic Press, Inc., San Diego, California.

Richardson, W. John, Bernd Würsig, and Charles R. Jr. Greene. 1986b. Reactions of bowhead whales, *Balaena mysticetus*, to seismic exploration in the Canadian Beaufort Sea. Journal of the Acoustical Society of America 79(4):1117-1128.

Richardson, W.J., C. R. Greene Jr., C. I. Malme, and D. H. Thomson. 1995e. Marine mammals and noise. Academic Press; San Diego, California.

Richardson, W.J., G.W. Miller, and C.R. Jr. Greene. 1999. Displacement of migrating bowhead whales by sounds from seismic surveys in shallow waters of the Beaufort Sea. Journal of the Acoustical Society of America 106(4-2):2281.

Richter, C. F., S. M. Dawson, and E. Slooten. 2003. Sperm whale watching off Kaikoura, New Zealand: Effects of current activities on surfacing and vocalisation patterns. Science for Conservation 219.

Ridgway, Sam H., Ernest Glen Wever, James G. McCormick, Jerry Palin, and John H. Anderson. 1969. Hearing in the giant sea turtle, Chelonoa mydas. Proceedings of the National Academies of Science 64.

Rivers, J. A. 1997. Blue whale, Balaenoptera musculus, vocalizations from the waters off central California. Marine Mammal Science 13(2):186-195.

Robertson, Frances C., and coauthors. 2013. Seismic operations have variable effects on dive-cycle behavior of bowhead whales in the Beaufort Sea. Endangered Species Research 21(2):143-160.

Robinson, Robert A., and coauthors. 2005. Climate change and migratory species. Defra Research, British Trust for Ornithology, Norfolk, U.K. .

Rockwood, R. C., J. Calambokidis, and J. Jahncke. 2017. High mortality of blue, humpback and fin whales from modeling of vessel collisions on the U.S. West Coast suggests population impacts and insufficient protection. PLoS One 12(8):e0183052.

Roe, J. H.; Morreale, S. J.; Paladino, F. V.; Shillinger, G. L.; Benson, S. R.; Eckert, S. A.; Bailey, H.; Tomillo, P. S.; Bograd, S. J.; Eguchi, T.; Dutton, P. H.; Seminoff, J. A.; Block, B. A.; Spotila, J. R. 2014. Predicting bycatch hotspots for endangered leatherback turtles on longlines in the Pacific Ocean. Proceedings of the Roayal Society B-Biological Sciences 281(1777).

Rolland, R. M., and coauthors. 2012a. Evidence that ship noise increases stress in right whales. Proc Biol Sci 279(1737):2363-8.

Rolland, Rosalind M., and coauthors. 2012b. Evidence that ship noise increases stress in right whales. Proceedings of the Royal Society of London Series B Biological Sciences 279(1737):2363-2368.

Roman, Joe, and Stephen R. Palumbi. 2003. Whales before whaling in the North Atlantic. Science 301(5632):508-510.

Romanenko, Evgeniy V.; Victor Ya. Kitain. 1992. The functioning of the echolocation system of *Tursiops truncatus* during noise masking. Pages 415-419 *in* J. A. T. R. A. K. A. Y. Supin, editor. Marine Mammal Sensory Systems. Plenum Press, New York.

Romano, T. A., and coauthors. 2004. Anthropogenic sound and marine mammal health: Measures of the nervous and immune systems before and after intense sound exposure. Canadian Journal of Fisheries and Aquatic Sciences 61:1124-1134.

Romano, Tracy A., and coauthors. 2002. Immune response, stress, and environment: Implications for cetaceans. Pages 253-279 *in* Molecular and Cell Biology of Marine Mammals. Krieger Publishing Co., Malabar, Florida.

Romero, L. M., C. J. Meister, N. E. Cyr, G. J. Kenagy, and J. C. Wingfield. 2008. Seasonal glucocorticoid responses to capture in wild free-living mammals. American Journal of Physiology-Regulatory Integrative and Comparative Physiology 294(2):R614-R622.

Romero, L.M. 2004. Physiological stress in ecology: Lessons from biomedical research. Trends in Ecology and Evolution 19(5):249-255.

Ross, D. 1976. Mechanics of Underwater Noise. Pergamon Press, New York.

Ross, D. 1993. On ocean underwater ambient noise. Acoustics Bulletin 18:8-May.

Ross, D. 2005. Ship Sources of Ambient Noise. IEEE Journal of Oceanic Engineering 30(2):257-261.

Ross, Peter S. 2002. The role of immunotoxic environmental contaminants in facilitating the emergence of infectious diseases in marine mammals. Human and Ecological Risk Assessment 8(2):277-292.

Rostad, A., S. Kaartvedt, T. A. Klevjer, and W. Melle. 2006. Fish are attracted to vessels. ICES Journal of Marine Science 63(8):1431–1437.

Royer, T. C. 2005. Hydrographic responses at a coastal site in the northern Gulf of Alaska to seasonal and interannual forcing. Deep-Sea Research Part Ii-Topical Studies in Oceanography 52(1-2):267-288.

Ruholl, Elke Burkhardt; Olaf Boebel; Horst Bornemann; Christoph. 2013. Risk assessment of scientific sonars. Bioacoustics 17:235-237.

Saeki, K. , H. Sakakibara, H. Sakai, T. Kunito, and S. Tanabe. 2000. Arsenic accumulation in three species of sea turtles. Biometals 13(3):241-250.

Sahoo, G. , R. K. Sahoo, and P. Mohanty-Hejmadi. 1996. Distribution of heavy metals in the eggs and hatchlings of olive ridley sea turtle, Lepidochelys olivacea, from Gahirmatha, Orissa. Indian Journal of Marine Sciences 25(4):371-372.

Saji, N. H., B. N. Goswami, P. N. Vinayachandran, and T. Yamagata. 1999. A dipole mode in the tropical Indian Ocean. Nature 401(6751):360-363.

Samaran, F., C. Guinet, O. Adam, J. F. Motsch, and Y. Cansi. 2010. Source level estimation of two blue whale subspecies in southwestern Indian Ocean. Journal of the Acoustical Society of America 127(6):3800–3808.

Samuel, Y. , S. J. Morreale, C. W. Clark , C. H. Greene, and M. E. Richmond. 2005. Underwater, low-frequency noise in a coastal sea turtle habitat. The Journal of the Acoustical Society of America 117(3):1465-1472.

Samuels, Amy, Lars Bejder, and Sonja Heinrich. 2000. A review of the literature pertaining to swimming with wild dolphins. Final report to the Marine Mammal Commission. Contract No. T74463123. 58pp.

Scarff, James E. 1986a. Historic and present distribution of the right whale (*Eubalaena glacialis*) in the eastern North Pacific south of 50°N and east of 180°W. Report of the International Whaling Commission Special Issue 10:43-63.

Scarff, James E. 1986b. Historic and present distribution of the right whale (Eubalaena glacialis) in the eastern North Pacific south of 50oN and east of 180oW. Report of the International Whaling Commission (Special Issue 10):43-63.

Scheidat, Meike, Cristina Castro, Janira Gonzalez, and Rob Williams. 2004. Behavioural responses of humpback whales (Megaptera novaeangliae) to whalewatching boats near Isla de la Plata, Machalilla National Park, Ecuador. Journal of Cetacean Research and Management 6(1):63-68.

Schevill, W. E., W. A. Watkins, and R. H. Backus. 1964. The 20-cycle signals and Balaenoptera (fin whales). Pages 147-152 *in* W. N. Tavolga, editor Marine Bio-acoustics. Pergamon Press, Lerner Marine Laboratory, Bimini, Bahamas.

Schlundt, Carolyn E.; James J. Finneran; Donald A. Carder; Sam H. Ridgway. 2000. Temporary shift in masked hearing thresholds of bottlenose dolphins, *Tursiops truncatus*, and white whales, *Delphinapterus leucas*, after exposure to intense tones. Journal of the Acoustical Society of America 107(6):3496-3508.

Schuyler, Qamar, Britta Denise Hardesty, Chris Wilcox, and Kathy Townsend. 2012. To eat or not to eat? Debris selectivity by marine turtles. PLoS ONE 7(7):e40884.

Seminoff, Jeffrey A., C.D. Allen, G.H. Balazs, T. Eguchi, H.L. Haas, S.A. Hargrove, M. P. Jensen, D.L. Klemm, A.M. Lauritsen, S.L. MacPherson, P. Opay, E.E. Possardt, S.L. Pultz, E.E. Seney, K.S. Van Houtan, R.S. Waples. 2015. Status Review of the Green Turtle (Chelonia mydas) Under the U.S. Endangered Species Act. Pages 571 *in*. NOAA Technical Memorandum, La Jolla, CA.

Sepulveda, Maritza, Patricia Inostroza, M. Jose Perez-Alvarez, Doris Oliva, and Rodrigo Moraga. 2009. Seasonal variation in the abundance of South American sea lions Otaria flavescens (Shaw, 1800) in Chanaral Island, Reserva Nacional Pinguino de Humboldt, Chile. Revista de Biología Marina y Oceanografía 44(3):685-689.

Shelden, Kim E. W., Sue E. Moore, Janice M. Waite, Paul R. Wade, and David J. Rugh. 2005. Historic and current habitat use by North Pacific right whales *Eubalaena japonica* in the Bering Sea and Gulf of Alaska. Mammal Review 35(2):129-155.

Shoop, C.R., and R.D. Kenney. 1992. Seasonal distributions and abundances of loggerhead and leatherback sea turtles in waters of the northeastern United States. Herpetological Monographs 6:43-67.

Silber, G. 1986a. The relationship of social vocalizations to surface behavior and aggression in the Hawaiian humpback whale (*Megaptera novaeangliae*). Canadian Journal of Zoology 64:2075-2080.

Silber, G. K. 1986b. The relationship of social vocalizations to surface behavior and aggression in the Hawaiian humpback whale (*Megaptera novaeangliae*). Canadian Journal of Zoology 64(10):2075-2080.

Simao, S. M., and S. C. Moreira. 2005. Vocalizations of a female humpback whale in Arraial do Cabo (Rj, Brazil). Marine Mammal Science 21(1):150-153.

Simmonds, Mark P. 2005a. Whale watching and monitoring: some considerations. International Whaling Commission, SC/57/WW5, Cambridge, United Kingdom.

Simmonds, Mark P. 2005b. Whale watching and monitoring: some considerations. Unpublished paper submitted to the Scientific Committee of the International Whaling Commission SC/57/WW5, Cambridge, United Kingdom.

Simmonds, Mark P., and Wendy J. Eliott. 2009. Climate change and cetaceans: Concerns and recent developments. Journal of the Marine Biological Association of the United Kingdom 89(1):203-210.

Simmonds, Mark P., and Stephen J. Isaac. 2007a. The impacts of climate change on marine mammals: Early signs of significant problems. Oryx 41(1):19-26.

Simmonds, Mark P., and Stephen J. Isaac. 2007b. The impacts of climate change on marine mammals: Early signs of significant problems. Oryx 41(1):19-26.

Sirovic, Ana, John A. Hildebrand, and Sean M. Wiggins. 2007. Blue and fin whale call source levels and propagation range in the Southern Ocean. Journal of the Acoustical Society of America 122(2):1208-1215.

Sirovic, Ana, Lauren N. Williams, Sara M. Kerosky, Sean M. Wiggins, and John A. Hildebrand. 2012. Temporal separation of two fin whale call types across the eastern North Pacific. Marine Biology 160(1):47-57.

Skalski, J. R.; Pearson, W. H.; Malme, C. I. 1992. Effects of sounds from a geophysical survey device on catch-per-unit-effort in a hook-and-line fishery for rockfish (*Sebastes* spp.). Canadian Journal of Fisheries and Aquatic Sciences 49:1357-1365.

Slotte, A., K. Hansen, J. Dalen, and E. Ona. 2004. Acoustic mapping of pelagic fish distribution and abundance in relation to a seismic shooting area off the Norwegian west coast. Fisheries Research 67:143-150.

Smith, Joshua N., Anne W. Goldizen, Rebecca A. Dunlop, and Michael J. Noad. 2008. Songs of male humpback whales, Megaptera novaeangliae, are involved in intersexual interactions. Animal Behaviour 76(2):467-477.

Smith, Michael E., Allison B. Coffin, Diane L. Miller, and Arthur N. Popper. 2006. Anatomical and functional recovery of the goldfish (Carassius auratus) ear following noise exposure. Journal of Experimental Biology 209(21):4193-4202.

Smultea, M. A., W. R. Koski, and T. J. Norris. 2005. Marine mammal monitoring during Lamont-Doherty Earth Observatory’s marine seismic study of the Blanco Fracture Zone in the northeastern Pacific Ocean, October-November 2004. LGL Ltd. Environmental Research Associates, LGL Report TA2822-29.

Smultea, M., and M. Holst. 2003. Marine mammal monitoring during Lamont-Doherty Earth Observatory's seismic study in the Hess Deep area of the eastern equatorial tropical Pacific, July 2003. Prepared for Lamont-Doherty Earth Observatory, Palisades, New York, and the National Marine Fisheries Service, Silver Spring, Maryland, by LGL Ltd., environmental research associates. LGL Report TA2822-16.

Smultea, M.A., M. Holst, W.R. Koski, and S. Stoltz. 2004. Marine mammal monitoring during Lamont-Doherty Earth Observatory’s seismic program in the Southeast Caribbean Sea and adjacent Atlantic Ocean, April–June 2004. LGL Rep. TA2822-26. Report from LGL Ltd., King City, Ontario, for Lamont-Doherty Earth Observatory of Columbia Univ., Palisades, NY, and National Marine Fisheries Service, Silver Spring, MD. 106 p.

Smultea, Mari A., J. Joseph R. Mobley, Dagmar Fertl, and Gregory L. Fulling. 2008. An unusual reaction and other observations of sperm whales near fixed-wing aircraft. Gulf and Caribbean Research 20:75–80.

Southall, B. L., and coauthors. 2007a. Marine mammal noise exposure criteria: initial scientific recommendations. Aquatic Mammals 33(4):411-521.

Southall, B. L., and coauthors. 2007b. Marine mammal noise exposure criteria: Initial scientific recommendations. Aquatic Mammals 33(4):411-521.

Southall, B. L., D. P. Nowacek, P. J. O. Miller, and P. L. Tyack. 2016. Experimental field studies to measure behavioral responses of cetaceans to sonar. Endangered Species Research 31:293-315.

Southall, B.; Bowles, A.; Ellison, W.; Finneran, J.; Gentry, R.; Greene, C.; Kastak, D.; Ketten, D.; Miller, J.; Nachtigall, P.; Richardson, W.; Thomas, J.; Tyack, P. 2007. Aquatic mammals marine mammal noise exposure criteria: Initial scientific recommendations. Aquatic Mammals 33(4):122.

Southall, B.L., and coauthors. 2007c. Marine mammal noise exposure criteria: Initial scientific recommendations. Aquatic Mammals 33:411-521.

Southall, Brandon L.; Teri Rowles; Frances Gulland; Robin W. Baird; Paul D. Jepson. 2013. Final report of the Independent Scientific Review Panel investigating potential contributing factors to a 2008 mass stranding of melonheaded whales (*Peponocephala electra*) in Antsohihy, Madagascar. Independent Scientific Review Panel.

Spotila, J. R., and coauthors. 1996. Worldwide population decline of *Dermochelys coriacea*: Are leatherback turtles going extinct? Chelonian Conservation and Biology 2(2):209-222.

Spotila, J.R., Richard D. Reina, Anthony C. Steyermark, Pamela T. Plotkin, and Frank V. Paladino. 2000. Pacific leatherback turtles face extinction. Nature 405:529-530.

Spring, Debbie. 2011. L-DEO seismic survey turtle mortality. National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

Sremba, A. L., B. Hancock-Hanser, T. A. Branch, R. L. LeDuc, and C. S. Baker. 2012. Circumpolar diversity and geographic differentiation of mtDNA in the critically endangered Antarctic blue whale (*Balaenoptera musculus intermedia*). PLoS One 7(3):e32579.

St. Aubin, D. J., and J. R. Geraci. 1988. Capture and handling stress suppresses circulating levels of thyroxine (T4) and triiodothyronine (T3) in beluga whale, *Delphinapterus leucas*. Physiological Zoology 61(2):170-175.

St. Aubin, D. J., S. H. Ridgway, R. S. Wells, and H. Rhinehart. 1996. Dolphin thyroid and adrenal hormones: Circulating levels in wild and semidomesticated Tursiops truncatus, and influence of sex, age, and season. Marine Mammal Science 12(1):13-Jan.

Stabeno, P. J., and coauthors. 2004. Meteorology and oceanography of the northern Gulf of Alaska. Continental Shelf Research 24-Jan(8-Jul):859-897.

Stadler, John H, and David P Woodbury. 2009. Assessing the effects to fishes from pile driving: application of new hydroacoustic criteria. Internoise 2009.

Stafford, Kathleen M., Christopher G. Fox, and David S. Clark. 1998. Long-range acoustic detection and localization of blue whale calls in the northeast Pacific Ocean (*Balaenoptera musculus*). Journal of the Acoustical Society of America 104(6):3616-3625.

Stafford, Kathleen M., and Sue E. Moore. 2005. Atypical calling by a blue whale in the Gulf of Alaska. Journal of the Acoustical Society of America 117(5):2724-2727.

Stafford, Kathleen M., Sharon L. Nieukirk, and Christopher G. Fox. 2001. Geographic and seasonal variation of blue whale calls in the North Pacific (*Balaenoptera musculus*). Journal of Cetacean Research and Management 3(1):65-76.

Stenseth, Nils Chr., and coauthors. 2002. Ecological effects of climate fluctuations. Science 297(5585):1292-1296.

Stewart, Brent S., Pamela K. Yochem, Robert L. Delong, and George A. Antonelis Jr. 1987. Interactions between Guadalupe fur seals and California sea lions at San Nicolas and San Miguel Islands, California. Pages 103-106 *in* J. P. C. R. L. Gentry, editor. Status, Biology, and Ecology of Fur Seals, Cambridge.

Stewart, K. R.; Keller, J. M.; Templeton, R.; Kucklick, J. R.; Johnson, C. 2011. Monitoring persistent organic pollutants in leatherback turtles (*Dermochelys coriacea*) confirms maternal transfer. Marine Pollution Bulletin 62(7):1396-1409.

Stimpert, Alison K., David N. Wiley, Whitlow W. L. Au, Mark P. Johnson, and Roland Arsenault. 2007. 'Megapclicks': Acoustic click trains and buzzes produced during night-time foraging of humpback whales (Megaptera novaeangliae). Biology Letters 3(5):467-470.

Stone, C.J. 2003. The effects of seismic activity on marine mammals in UK waters 1998-2000. Joint Nature Conservation Committee, Aberdeen, Scotland.

Stone, Carolyn J., Karen Hall, Sónia Mendes, and Mark L. Tasker. 2017. The effects of seismic operations in UK waters: analysis of Marine Mammal Observer data. Journal of Cetacean Research and Management 16:71–85.

Stone, Carolyn J., and Mark L. Tasker. 2006. The effects of seismic airguns on cetaceans in UK waters. Journal of Cetacean Research and Management 8(3):255-263.

Storelli, M. , M. G. Barone, and G. O. Marcotrigiano. 2007. Polychlorinated biphenyls and other chlorinated organic contaminants in the tissues of Mediterranean loggerhead turtle Caretta caretta. Science of the Total Environment 273 (2-3:456-463.

Storelli, M. , M. G. Barone, A. Storelli, and G. O. Marcotrigiano. 2008. Total and subcellular distribution of trace elements (Cd, Cu and Zn) in the liver and kidney of green turtles (Chelonia mydas) from the Mediterranean Sea. Chemosphere 70(5):908-913.

Strayer, D. L. 2010. Alien species in fresh waters: Ecological effects, interactions with other stressors, and prospects for the future. Freshwater Biology 55:152-174.

Swingle, W. M., S. G. Barco, T. D. Pitchford, W. A. Mclellan, and D. A. Pabst. 1993. Appearance of juvenile humpback whales feeding in the nearshore waters of Virginia. Marine Mammal Science 9(3):309-315.

Tal, Dror, Hofit Shachar-Bener, Dov Hershkovitz, Yehuda Arieli, and Avi Shupak. 2015. Evidence for the initiation of decompression sickness by exposure to intense underwater sound. Journal of Neurophysiology 114(3):1521-1529.

Tapilatu, R. F., and coauthors. 2013. Long-term decline of the western Pacific leatherback, *Dermochelys coriacea*: A globally important sea turtle population. Ecosphere 4:15.

Taylor, A. H., M. B. Jordon, and J. A. Stephens. 1998. Gulf Stream shifts following ENSO events. Nature 393:68.

Taylor, Barbara, and coauthors. 2004. A call for research to assess risk of acoustic impact on beaked whale populations. International Whaling Commission Scientific Committee.

Tennessen, J. B., and S. E. Parks. 2016. Acoustic propagation modeling indicates vocal compensation in noise improves communication range for North Atlantic right whales. Endangered Species Research 30:225-237.

Terdalkar, S., A. S. Kulkarni, S. N. Kumbhar, and J. Matheickal. 2005. Bio-economic risks of ballast water carried in ships, with special reference to harmful algal blooms. Nature, Environment and Pollution Technology 4(1):43-47.

Terhune, John M. 1999. Pitch separation as a possible jamming-avoidance mechanism in underwater calls of bearded seals (Erignathus barbatus). Canadian Journal of Zoology 77(7):1025-1034.

TEWG. 2007. An Assessment of the Leatherback Turtle Population in the Atlantic Ocean. Pages 116 *in* NOAA Technical Memorandum.

Thode, A.M. et al. 2017. Towed array passive acoustic operations for bioacoustic applications: ASA/JNCC workshop summary, March 14-18, 2016. Scripps Institution of Oceanography, La Jolla, CA, USA.:77.

Thode, Aaron, Janice Straley, Christopher O. Tiemann, Kendall Folkert, and Victoria O'connell. 2007. Observations of potential acoustic cues that attract sperm whales to longline fishing in the Gulf of Alaska. Journal of the Acoustical Society of America 122(2):1265-1277.

Thomas, Jeanette A.; Jeffrey L. Pawloski; Whitlow W. L. Au. 1990. Masked hearing abilities in a false killer whale (*Pseudorca crassidens*). Pages 395-404 *in* J. A. T. R. A. Kastelein, editor. Sensory Abilities of Cetaceans: Laboratory and Field Evidence. Plenum Press, New York.

Thomas, Peter O., Randall R. Reeves, and Robert L. Brownell. 2016. Status of the world's baleen whales. Marine Mammal Science 32(2):682-734.

Thompson, D., M. Sjoberg, E. B. Bryant, P. Lovell, and A. Bjorge. 1998. Behavioural and physiological responses of harbour (Phoca vitulina) and grey (Halichoerus grypus) seals to seismic surveys. Pages 134 *in* The World Marine Mammal Science Conference, Monaco.

Thompson, P. O., L. T. Findley, O. Vidal, and W. C. Cummings. 1996. Underwater sounds of blue whales, *Balaenoptera musculus*, in the Gulf of California, Mexico. Marine Mammal Science 12(2):288-293.

Thompson, P.O., W.C. Cummings, and S.J. Ha. 1986a. Sounds, source levels, and associated behavior of humpback whales, southeast Alaska. Journal of the Acoustical Society of America 80:735-740.

Thompson, Paul O., William C. Cummings, and Samuel J. Ha. 1986b. Sounds, source levels, and associated behavior of humpback whales, Southeast Alaska. Journal of the Acoustical Society of America 80(3):735-740.

Thompson, Paul O., Lloyd T. Findley, and Omar Vidal. 1992. 20-Hz pulses and other vocalizations of fin whales, *Balaenoptera physalus*, in the Gulf of California, Mexico. Journal of the Acoustical Society of America 92(6):3051-3057.

Thomsen, B. 2002. An experiment on how seismic shooting affects caged fish. University of Aberdeen, Aberdeen, Scotland.

Thomson, C. A., and J. R. Geraci. 1986. Cortisol, aldosterone, and leukocytes in the stress response of bottlenose dolphins, *Tursiops truncatus*. Canadian Journal of Fisheries and Aquatic Sciences 43(5):1010-1016.

Thomson, D. H., and W. J. Richardson. 1995a. Marine mammal sounds. W. J. Richardson, J. C. R. Greene, C. I. Malme, and D. H. Thomson, editors. Marine Mammals and Noise. Academic Press, San Diego, California.

Thomson, D.H. , and W.J. Richardson. 1995b. Marine mammal sounds. Pages 159-204 *in* W. J. Richardson, C. R. G. Jr., C. I. Malme, and D. H. Thomson, editors. Marine Mammals and Noise. Academic Press, San Diego.

Thomson, Denis H., and W. John Richardson. 1995c. Marine mammal sounds. Pages 159–204 *in* W. J. Richardson, C. R. Greene, C. I. Malme, and D. H. Thomson, editors. Marine Mammals and Noise. Academic Press, San Diego.

Todd, S., J. Lien, and A. Verhulst. 1992. Orientation of humpback whales (Megaptera novaengliae) and minke whales (Balaenoptera acutorostrata) to acoustic alarm devices designed to reduce entrapment in fishing gear. J. A. Thomas, R. A. Kastelein, and A. Y. Supin, editors. Marine mammal sensory systems. Plenum Press, New York, New York.

Tolstoy, M., and coauthors. 2009. Broadband calibration of R/V Marcus G. Langseth four-string seismic sources. Geochemistry Geophysics Geosystems 10.

Tolstoy, M.; J. B. Diebold; S. C. Webb; D. R. Bohnenstiehl; E. Chapp; R. C. Holmes; M. Rawson. 2004. Broadband calibration of *R/V Ewing* seismic sources. Geophysical Research Letters 31(14):4.

Townsend, C. H. 1924. The northern elephant seal and the Guadalupe fur seal. Natural History 24(5):567-577.

Trumble, S. J., and coauthors. 2018. Baleen whale cortisol levels reveal a physiological response to 20th century whaling. Nature Communications 9(1):4587.

Turnpenny, A.W.H., and J.R. Nedwell. 1994. The effects on marine fish, diving mammals and birds of underwater sound generated by seismic surveys. Consultancy Report, Fawley Aquatic Research Laboratories, Ltd. FCR 089/94. 50p.

Turnpenny, A.W.H., K.P. Thatcher, and J.R. Nedwell. 1994. The effects on fish and other marine animals of high-level underwater sound. Research Report for the Defence Research Agency, Fawley Aquatic Research Laboratories, Ltd., FRR 127/94. 34p.

Tyack, P. 1983a. Differential response of humpback whales, *Megaptera novaeangliae*, to playback of song or social sounds. Behavioral Ecology and Sociobiology 13(1):49-55.

Tyack, P. , and H. Whitehead. 1983. Male competition in large groups of wintering humpback whales. Behaviour 83:132-153.

Tyack, P., M. Johnson, and P. Miller. 2003. Tracking responses of sperm whales to experimental exposures of airguns. Pages 115-120 *in* A. E. Jochens, and D. C. Biggs, editors. Sperm whale seismic study in the Gulf of Mexico/Annual Report: Year 1, volume OCS Study MMS 2003-069. Texas A&M University and Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, Louisiana.

Tyack, Peter. 1983b. Differential response of humpback whales, Megaptera novaeangliae, to playback of song or social sounds. Behavioral Ecology and Sociobiology 13(1):49-55.

Tyack, Peter L. 1999. Communication and cognition. Pages 287-323 *in* J. E. R. I. S. A. Rommel, editor. Biology of Marine Mammals. Smithsonian Institution Press, Washington.

Tyurneva, Olga Yu., Yuri M. Yakovlev, and Vladimir V. Vertyankin. 2009. Photographic identification of the Korean-Okhotsk gray whale (*Eschrichtius robustus*) offshore northeast Sakhalin Island and southeast Kamchatka Peninsula (Russia), 2008. Unpublished paper to the IWC Scientific Committee, Madeira, Portugal.

U.S. Department of the Navy. 2015. Northwest Training and Testing Environmental Impact Statement/Overseas Environmental Impact Statement, Final. Naval Facilities Engineering Command, Northwest, Silverdale, WA.

U.S. Navy. 2010. Annual Range Complex Exercise Report 2 August 2009 to 1 August 2010 U.S. Navy Southern California (SOCAL) Range Complex and Hawaii Range Complex (HRC).

U.S. Navy. 2012. Marine Species Monitoring for the U.S. Navy's Southern California Range Complex- Annual Report 2012. U.S. Pacific Fleet, Environmental Readiness Division, U.S. Department of the Navy, Pearl Harbor, HI.

U.S. Navy. 2017. Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III). Space and Naval Warfare Systems Command, U.S Navy, Department of Defence, San Diego, California.

Unger, Bianca, and coauthors. 2016. Large amounts of marine debris found in sperm whales stranded along the North Sea coast in early 2016. Marine Pollution Bulletin 112(1):134-141.

Van der Hoop, J., P. Corkeron, and M. Moore. 2017. Entanglement is a costly life-history stage in large whales. Ecology and Evolution 7(1):92–106.

Van der Hoop, J. M., and coauthors. 2013a. Assessment of management to mitigate anthropogenic effects on large whales. Conservation Biology 27(1):121-33.

Van Der Hoop, Julie, and coauthors. 2013b. Assessment of management to mitigate anthropogenic effects on large whales. Conservation Biology 27(1):121-133.

VanBlaricom, G.R., J.L. Ruediger, C.S. Friedman, D.D. Woodard, and R.P. Hedrick. 1993. Discovery of withering syndrome among black abalone Haliotis cracherodii Leach, 1814, populations at San Nicolas Island, California. . Journal of Shellfish Research 12:185-188.

Vanderlaan, A. S., and C. T. Taggart. 2007. Vessel collisions with whales: The probability of lethal injury based on vessel speed. Marine Mammal Science 23(1):144-156.

Vladimirov, V. A., and coauthors. 2006a. Results of 2005 western gray whale studies in coastal waters off northeastern Sakhalin. Unpublished paper to the IWC Scientific Committee. 12 pp. St Kitts and Nevis, West Indies, June (SC/58/BRG28).

Vladimirov, V. A., and coauthors. 2006b. Distribution and abundance of western gray whales off the northeast coast of Sakhalin Island (Russia), 2005. Unpublished paper to the IWC Scientific Committee. 12 pp. St Kitts and Nevis, West Indies, June (SC/58/BRG29).

Vladimirov, V. A., and coauthors. 2005. Distribution and abundance of western gray whales off the northeast coast of Sakhalin Island (Russia), 2004. Unpublished paper to the IWC Scientific Committee. 6 pp. Ulsan, Korea, June (SC/57/BRG23).

Vladimirov, V. A., and coauthors. 2008. Distribution and abundance of western gray whales off the northeast coast of Sakhalin Island (Russia), 2007. IWC Scientific Committee, Santiago, Chile.

Vladimirov, V. A., S. P. Starodymov, M. S. Kornienko, and J. E. Muir. 2010. Distribution and abundance of western gray whales in the waters off northeast Sakhalin Island, Russia, 2004-2009. Unpublished paper to the IWC Scientific Committee, Agadir, Morocco.

Vladimirov, Valeriy A., Sergey P. Starodymov, Alexey G. Afanasyev-Grigoryev, and Vladimir V. Vertyankin. 2009. Distribution and abundance of western gray whales off the northeast coast of Sakhalin Island, Russia, 2008. Unpublished paper to the IWC Scientific Committee, Madeira, Portugal.

Von Saunder, Alexandra, and Jay Barlow. 1999. A report of the Oregon, California, and Washington line-transect experiment (ORCAWALE) conducted in west coast waters during summer/fall 1996. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center.

Wada, Shiro, and Ken-Ichi Numachi. 1991. Allozyme analyses of genetic differentiation among the populations and species of the Balaenoptora. Report of the International Whaling Commission Special Issue 13:125-154.

Wade, P. M. , and coauthors. 2006. Acoustic detection and satellite tracking leads to discovery of rare concentration of endangered North Pacific right whales. Biology Letters 2:417-419.

Wade, P.R., and coauthors. 2016. Estimates of abundance and migratory destination for North Pacific humpback whales in both summer feeding areas and winter mating and calving areas. Pages SC/66b/IA/21 *in* International Whaling Commission Scientific Committee.

Wallace, Bryan P., Susan S. Kilham, Frank V. Paladino, and James R. Spotila. 2006. Energy budget calculations indicate resource limitation in Eastern Pacific leatherback turtles. Marine Ecology Progress Series 318:263-270.

Wallace, Bryan P., and coauthors. 2013. Impacts of fisheries bycatch on marine turtle populations worldwide: toward conservation and research priorities. Ecosphere 4(3):art40.

Wallace, Bryan P., and coauthors. 2010. Global patterns of marine turtle bycatch. Convervation Letters.

Wallace, Bryan P., and coauthors. 2007. Maternal investment in reproduction and its consequences in leatherback turtles. Oecologia 152(1):37-47.

Wardle, C.S. , and coauthors. 2001. Effects of seismic air guns on marine fish. Continental Shelf Research 21:1005-1027.

Waring, G. T., Elizabeth Josephson, Carol P. Fairfield, and Katherine Maze-Foley. 2008. U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments - 2007. National Marine Fisheries Service Northeast Fisheries Science Center, NOAA Technical Memorandum NMFS-NE-205, Woods Hole, Massachusetts.

Waring, Gordon T., Elizabeth Josephson, Katherine Maze-Foley, and Patricia E. Rosel. 2016. US Atlantic and Gulf of Mexico Marine Mammal Stock Assessments - 2015. National Marine Fisheries Service Northeast Fisheries Science Center

NMFS-NE-238, Woods Hole, Massachusetts.

Watkins, W. A. 1986a. Whale Reactions to Human Activities in Cape-Cod Waters. Marine Mammal Science 2(4):251-262.

Watkins, W. A., K. E. Moore, and P. L. Tyack. 1985. Sperm whale acoustic behaviors in the southeast Caribbean. Cetology 49:1-15.

Watkins, W. A., and W. E. Schevill. 1975a. Sperm whales (Physeter catodon) react to pingers. Deep Sea Research and Oceanogaphic Abstracts 22(3):123-129 +1pl.

Watkins, W. A., and W.E. Schevill. 1975b. Sperm whales (*Physeter catodon*) react to pingers. Deep-Sea Research 22:123-129.

Watkins, W.A. 1977. Acoustic behavior of sperm whales. Oceanus 20:50-58.

Watkins, William A. 1981. Activities and underwater sounds of fin whales (*Balaenoptera physalus*). Scientific Reports of the Whales Research Institute Tokyo 33:83–118.

Watkins, William A. 1986b. Whale Reactions to Human Activities in Cape-Cod Waters. Marine Mammal Science 2(4):251–262.

Watkins, William A., and William E. Schevill. 1977. Spatial distribution of Physeter catodon (sperm whales) underwater. Deep Sea Research 24(7):693-699.

Watkins, William A., Peter Tyack, Karen E. Moore, and James E. Bird. 1987. The 20-Hz signals of finback whales (Balaenoptera physalus). Journal of the Acoustical Society of America 82(6):1901-1912.

Watters, D.L., M.M. Yoklavich, M.S. Love, and D.M. Schroeder. 2010. Assessing marine debris in deep seafloor habitats off California. Marine Pollution Bulletin 60:131–138.

WDFW. 2012. Washington Division of Fish and Wildlife 2012 Annual Report: Sea Turtles.

Weber, D. S., B. S. Stewart, and N. Lehman. 2004. Genetic consequences of a severe population bottleneck in the Guadalupe fur seal (*Arctocephalus townsendi*). Journal of Heredity 95(2):144-153.

Weilgart, L. S., and Hal Whitehead. 1997a. Group-specific dialects and geographical variation in coda repertoire in South Pacific sperm whales. Behavioral Ecology and Sociobiology 40(5):277-285.

Weilgart, L., and H. Whitehead. 1993. Coda communication by sperm whales (*Physeter macrocephalus*) off the Galápagos Islands. Canadian Journal of Zoology 71(4):744–752.

Weilgart, L.S., and H. Whitehead. 1997b. Group-specific dialects and geographical variation in coda repertoire in South Pacific sperm whales. Behavioral Ecology and Sociobiology 40:277-285.

Weir, C.R. 2008. Overt responses of humpback whales (Megaptera novaeangliae), sperm whales (Physeter macro-cephalus), and Atlantic spotted dolphins (Stenella frontalis) to seismic exploration off Angola. Aquatic Mammals 34(1):71-83.

Weir, C.R., A. Frantzis, P. Alexiadou, and J.C. Goold. 2007. The burst-pulse nature of 'squeal' sounds emitted by sperm whales (*Physeter macrocephalus*). Journal of the Marine Biological Association of the U.K. 87(1):39-46.

Weir, Caroline R. 2007. Observations of Marine Turtles in Relation to Seismic Airgun Sound off Angola. Marine Turtle Newsletter 116:17-20.

Weirathmueller, Michelle J., William S. D. Wilcock, and Dax C. Soule. 2013. Source levels of fin whale 20 Hz pulses measured in the Northeast Pacific Ocean. Journal of the Acoustical Society of America 133(2):741-749.

Weirathmueller, Michelle J.; William S. D. Wilcock; Dax C. Soule. 2013. Source levels of fin whale 20Hz pulses measured in the Northeast Pacific Ocean. Journal of the Acoustical Society of America 133(2):741-749.

Weller, D. W., and coauthors. 2003. Summer sightings of western gray whales in the Okhotsk and western Bering Seas. International Whaling Commission Scientific Committee, Berlin.

Weller, David W., and coauthors. 2013. Report of the National Marine Fisheries Service gray whale stock identification workshop. National Marine Fisheries Service Gray Whale Stock Identification Workshop. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center.

Weller, David W., and coauthors. 2012. Movements of gray whales between the western and eastern North Pacific. Endangered Species Research 18(3):193-199.

Wever, E. G., and J. A. Vernon. 1956. The sensitivity of the turtle's ear as shown by its electrical potentials. Proceedings of the National Academy of Sciences of the United States of America 42:213-222.

Whitehead, Hal. 2009. Sperm whale: Physeter macrocephalus. Pages 1091-1097 *in* W. F. P. B. W. J. G. M. Thewissen, editor. Encyclopedia of Marine Mammals, Second edition. Academic Press, San Diego.

Whitehead, Hal, Jenny Christal, and Susan Dufault. 1997. Past and distant whaling and the rapid decline of sperm whales off the Galapagos Islands. (Physeter macrocephalus). Conservation Biology 11(6):1387-1396.

Whitehead, Hal, and Linda Weilgart. 1991. Patterns of visually observable behaviour and vocalizations in groups of female sperm whales. Behaviour 118(3/4):275-295.

Wiggins, Sean M., Erin M. Oleson, Mark A. Mcdonald, and John A. Hildebrand. 2005. Blue whale (Balaenoptera musculus) diel call patterns offshore of southern California. Aquatic Mammals 31(2):161-168.

Wilcove, D. S., D. Rothstein, J. Dubow, A. Phillips, and E. Losos. 1998. Quantifying threats to imperiled species in the United States. BioScience 48(8):607-615.

Wilcox, C., and coauthors. 2015. Understanding the sources and effects of abandoned, lost, and discarded fishing gear on marine turtles in northern Australia. Conservation Biology 29(1):198-206.

Wiley, David N., Regina A. Asmutis, Thomas D. Pitchford, and Damon P. Gannon. 1995. Stranding and mortality of humpback whales, *Megaptera novaeangliae*, in the mid-Atlantic and southeast United States, 1985-1992. Fishery Bulletin 93(1):196-205.

Williams, Rob M., Andrew W. Trites, and David E. Bain. 2002. Behavioural responses of killer whales (*Orcinus orca*) to whale-watching boats: Opportunistic observations and experimental approaches. Journal of Zoology 256(2):255–270.

Willis-Norton, Ellen;, and coauthors. 2015. Climate change impacts on leatherback turtle pelagic habitat in the Southeast Pacific. Deep Sea Research Part II: Topical Studies in Oceanography 113:260-267.

Winn, H. E., P. J. Perkins, and T. Poulter. 1970a. Sounds of the humpback whale. 7th Annual Conf Biological Sonar. Stanford Research Institute, Menlo Park, California.

Winn, Howard E., Paul J. Perkins, and Thomas C. Poulter. 1970b. Sounds of the humpback whale. Proceedings of the 7th Annual Conference on Biological Sonar and Diving Mammals, Stanford Research Institute Menlo Park CA. p.39-52.

Winsor, M.H. , and B.R. Mate. 2006. Seismic survey activity and the proximity of satellite tagged sperm whales.

Winsor, Martha H., Ladd M. Irvine, and Bruce R. Mate. 2017. Analysis of the Spatial Distribution of Satellite-Tagged Sperm Whales (Physeter macrocephalus) in Close Proximity to Seismic Surveys in the Gulf of Mexico. Aquatic Mammals 43(4):439-446.

Winsor, Martha H., and Bruce R. Mate. 2013. Seismic survey activity and the proximity of satellite-tagged sperm whales *Physeter macrocephalus* in the Gulf of Mexico. Bioacoustics 17:191-193.

Work, Paul A., Adam L. Sapp, David W. Scott, and Mark G. Dodd. 2010a. Influence of small vessel operation and propulsion system on loggerhead sea turtle injuries. Journal of Experimental Marine Biology and Ecology 393(1-2):168-175.

Work, Paul A., Adam L. Sapp, David W. Scott, and Mark G. Dodd. 2010b. Influence of small vessel operation and propulsion system on loggerhead sea turtle injuries. Journal of Experimental Marine Biology and Ecology 393(1-2):168–175.

Woude, Sylvia van der. 2013. Assessing effects of an acoustic marine geophysical survey on the behaviour of bottlenose dolphins *Tursiops truncatus*. Bioacoustics 17:188-190.

Würsig, B.G., and coauthors. 1999. Gray whales summering off Sakhalin Island, Far East Russia: July-October 1997. A joint U.S.-Russian scientific investigation. Final Report.

Sakhalin Energy Investment Co. Ltd and Exxon Neftegaz Ltd, Yuzhno-Sakhalinsk, Russia.

Wursig, Bernd, Spencer K. Lynn, Thomas A. Jefferson, and Keith D. Mullin. 1998. Behaviour of cetaceans in the northern Gulf of Mexico relative to survey ships and aircraft. Aquatic Mammals 24(1):41-50.

Wysocki, L. E., S. Amoser, and F. Ladich. 2007. Diversity in ambient noise in European freshwater habitats: Noise levels, spectral profiles, and impact on fishes. Journal of the Acoustical Society of America 121(5):2559-2566.

Yablokov, A. V., and L. S. Bogoslovskaya. 1984. A review of Russian research on the biology and commercial whaling of the gray whale. Pages 465-486 *in* M. L. J. S. L. S. S. Leatherwood, editor. The Gray Whale, Eschrichtius robustus. Academic Press, New York.

Yakovlev, Y. M., and O. Y. Tyurneva. 2005. A note on photo-identification of the western gray whale (Eschrictius robustus) on the northeastern Sakhalin shelf, Russia, 2002-2004. International Whaling Commission Scientific Committee, Ulsan, Korea.

Yazvenko, S. B., and coauthors. 2007. Feeding of western gray whales during a seismic survey near Sakhalin Island, Russia. Environmental Monitoring and Assessment 134(3-Jan):93-106.

Zaitseva, K. A., V. P. Morozov, and A. I. Akopian. 1980. Comparative characteristics of spatial hearing in the dolphin *Tursiops truncatus* and man. Neuroscience and Behavioral Physiology 10(2):180-182.

Zerbini, Alexandre, Amy S. Kennedy, Brenda K. Rone, Catherine L. Berchok, and Phillip J. Clapham. 2010. Habitat use of North Pacific right whales in the Bering Sea during summer as revealed by sighting and telemetry data. Pages 153 *in* Alaska Marine Science Symposium, Anchorage, Alaska.

Zimmer, W. M. X., and P. L. Tyack. 2007. Repetitive shallow dives pose decompression risk in deep-diving beaked whales. Marine Mammal Science 23(4):888-925.

Zoidis, A. M., and coauthors. 2008. Vocalizations produced by humpback whale (*Megaptera novaeangliae*) calves recorded in Hawaii. The Journal of the Acoustical Society of America 123(3):1737-1746.

19 APPENDICES

19.1 Appendix A – Proposed Incidental Harassment Authorization

The text below was taken directly from the proposed incidental harassment authorization provided to us in the consultation initiation package from the NMFS Permits and Conservation Division as well as the notice of proposed incidental harassment authorization and request for comments published in the *Federal Register* on June 10, 2019 (84 FR 26940). The final incidental harassment authorization may have minor changes that will not affect this opinion.

INCIDENTAL HARASSMENT AUTHORIZATION

The Lamont-Doherty Earth Observatory of Columbia University (L-DEO) and is hereby authorized under section 101(a)(5)(D) of the Marine Mammal Protection Act (MMPA; 16 U.S.C. 1371(a)(5)(D)) to harass marine mammals incidental to a marine geophysical survey in the Northeast Pacific Ocean, when adhering to the following terms and conditions.

1. This Incidental Harassment Authorization (IHA) is valid for a period of one year from the date of issuance.

2. This IHA is valid only for marine geophysical activity as specified in L-DEO's IHA application and using an array aboard the R/V *Langseth* with characteristics specified in the IHA application, in the Northeast Pacific Ocean near the Axial volcano and seamount.

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 and numbers authorized for taking are listed in Table 1 (attached).

    (c) The taking by serious injury, or death of any of the species listed in condition 3(b) of the Authorization or any taking of any other species of marine mammal is prohibited and may result in the modification, suspension, or revocation of this IHA.

    (d) L-DEO or the vessel operator must conduct briefings between PSOs and vessel crew prior to the start of all seismic operations, and when new personnel join the work, in order to explain responsibilities, communication procedures, marine mammal monitoring protocol, and operational procedures.

4. Mitigation Measures

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

(a) L-DEO must use at least five dedicated, trained, NMFS-approved Protected Species Observers (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 mitigation requirements.

(b) At least one of the visual and two 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 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 visual 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, including nighttime ramp-ups, of the airgun array. Visual monitoring of the exclusion and buffer zones must begin no less than 30 minutes prior to ramp-up and must continue until one hour after use of the 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.

(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) Acoustic PSOs must immediately communicate all detections to visual PSOs, when visual PSOs are on duty, including any determination by the PSO regarding species identification, distance, and bearing and the degree of confidence in the determination.

(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) PSOs must establish and monitor a 500 m exclusion zone and 1,000 m buffer zone. The exclusion zone encompasses the area at and below the sea surface out to a radius of 500 meters from the edges of the airgun array (0–500 meters). The buffer zone encompasses the area at and below the sea surface from the edge of the 0–500 meter exclusion zone, out to a radius of 1,000 meters from the edges of the airgun array (500–1,000 meters). PSOs must monitor beyond 1,000 meters and enumerate any takes that occur beyond the buffer zone.

(ii) An extended 1,500 m exclusion zone must be established for all beaked whales, and dwarf and pygmy sperm whales.

(f) Pre-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-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, pygmy sperm whales, dwarf sperm whales, beaked whales, pilot 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 observation of a marine mammal within the exclusion zone. Once ramp-up has begun, observations of marine mammals within the buffer zone do not require shutdown or powerdown, but such observation must be communicated to the operator to prepare for the potential shutdown or powerdown.

(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 and powerdown (*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-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-clearance watch of 30 min 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-clearance of 30 min.

(g) Shutdown and Powerdown

(i) Any PSO on duty has the authority to delay the start of survey operations or to call for shutdown or powerdown of the acoustic source if a marine mammal is detected within the 500 m exclusion zone (100 m when shutdown has been waived as described in 4(g)(v).

(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 and powerdown 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 powerdown) and (1) a marine mammal (excluding delphinids) 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 questions regarding a PSO shutdown must be resolved after deactivation.

(iii) Shutdown must occur whenever PAM alone (without visual sighting), confirms presence of marine mammal(s) (other than delphinids) in the 500 m exclusion zone. During daylight hours, if the acoustic PSO cannot confirm presence within exclusion zone, visual PSOs must be notified but shutdown is not required.

(iv) The airgun array must be shut down if a marine mammal species for which take was not authorized, or a species for which authorization was granted but the takes have been met, approaches the Level A or Level B harassment zones.

(v) The airgun array must be shut down if a North Pacific right whale is observed at any distance.

(vi) The airgun array must be shut down if any 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) or an aggregation of six or more large whales is observed at any distance.

(vi) The shutdown requirement shall be waived for small dolphins of the following genera: *Tursiops, Delphinus, Stenella, Lagenorhynchus, and Lissodelphis*.

a. The acoustic source must be powered down to 40-in^3 airgun if an individual belonging to these genera is visually detected within the 500 m exclusion zone.

b. When the acoustic source is powered down to the 40-in^3 airgun due to the presence of dolphins specified in 4(g)(v), an exclusion zone of 100 m and Level B harassment zone of 430 m will be in effect for species other than specified dolphin genera that may approach the survey vessel.

c. Powerdown conditions must be maintained until delphinids, for which shutdown is waived, are no longer observed within the 500 m exclusion zone, following which full-power operations may be resumed without ramp-up. Visual PSOs may elect to waive the powerdown requirement if delphinids for which shutdown is waived appear to be voluntarily approaching the vessel for the purpose of interacting with the vessel or towed gear, and must use best professional judgment in making this decision.

d. If PSOs observe any behaviors in delphinids for which shutdown is waived that indicate an adverse reaction, then powerdown must be initiated.

e. Visual PSOs must use best professional judgment 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 one of the delphinid genera for which shutdown is waived).

(vii) 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, pygmy sperm whales, dwarf sperm whales, beaked whales, pilot whales, and Risso's dolphins) with no further observation of the marine mammal(s).

(h) Vessel operators and crews 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 mammal. A visual observer aboard the vessel must monitor a vessel strike avoidance zone around the vessel (specific distances detailed below), to ensure the potential for strike is minimized.

(i) Vessel speeds must be reduced to 10 knots or less when mother/calf pairs, pods, or large assemblages of any marine mammal are observed near a vessel.

(ii) Vessels must maintain a minimum separation distance of 100 m from large whales (i.e., sperm whales and all baleen whales).

(iii) Vessels must attempt to maintain a minimum separation distance of 50 m from all other marine mammals, with an exception made for those animals that approach the vessel.

(iv) When marine mammals are sighted while a vessel is underway, the vessel must take action as necessary to avoid violating the relevant separation distance. If marine mammals are sighted within the relevant separation distance, the vessel must reduce speed and shift the engine to neutral, not engaging the engines until animals are clear of the area. This recommendation does not apply to any vessel towing gear.

(i) 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 km of the survey operations, where the NMFS stranding network is engaged in herding or other interventions to return animals to the water, the Director of OPR, NMFS (or designee) will advise L-DEO of the need to implement shutdown procedures for all active acoustic sources operating within

50 km of the stranding. Shutdown procedures for live stranding or milling marine mammals include the following:

(i) 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 the IHA-holder that the shutdown around the animals' location is no longer needed.

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

(iii) If further observations of the marine mammals indicate the potential for re-stranding, additional coordination with the IHA-holder 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.

5. Monitoring Requirements

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

(a) The operator must provide PSOs with bigeye binoculars (e.g., 25 x 150; 2.7 view angle; individual ocular focus; height control) of appropriate quality (i.e., Fujinon or equivalent) 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 the acoustic PSO that will be using it during the trip for which monitoring is required.

(ii) At least one night-vision device suited for the marine environment for use during nighttime pre-clearance and ramp-up that features automatic brightness and gain control, bright light protection, infrared illumination, and/or optics suited for low-light situations (e.g., Exelis PVS-7 night vision goggles; Night Optics D-300 night vision monocular; FLIR M324XP thermal imaging camera or equivalents).

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

(iv) Global Positioning Units (GPS) (at least one per PSO, plus backups).

(v) Digital single-lens reflex cameras of appropriate quality that capture photographs and video (i.e., Canon or equivalent) (at least one per PSO, plus backups).

(vi) Compasses (at least one per PSO, plus backups).

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

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

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

(i) PSOs must be independent, dedicated, trained visual and acoustic PSOs and must be employed by a third-party observer provider.

(ii) PSOs must have no tasks other than to conduct observational effort (visual or acoustic), 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

(iii) PSOs must have successfully completed an approved 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.

(iv) PSOs can act as acoustic or visual observers (but not at the same time) as long as they demonstrate that their training and experience are sufficient to perform the task at hand.

(v) NMFS must review and approve PSO resumes.

(vi) 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.

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

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

(ix) 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.

(x) 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 names (source vessel and other vessels associated with survey) and call signs;

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

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

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 should 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. The draft report must include the following:

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

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

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

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

(vi) Raw observational data;

(vii) Summary of the information submitted in interim monthly reports as well as additional data collected as described above in Data Collection and the IHA;

(viii) Estimates of the number and nature of exposures that occurred above the harassment threshold based on PSO observations, including an estimate of those that were not detected in consideration of both the characteristics and behaviors of the species of marine mammals that affect detectability, as well as the environmental factors that affect detectability;

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

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

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

(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 Office of Protected Resources (OPR) (301-427-8401), NMFS and the NMFS West Coast Regional Stranding Coordinator (866-767-6114) 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 OPR, NMFS and to regional stranding coordinators 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).

(iii) 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 (example circumstances noted below), and an investigation into the stranding is being pursued, NMFS will submit a written request to the IHA-holder 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.

a. Status of all sound source use in the 48 hours preceding the estimated time of stranding and within 50 km of the discovery/notification of the stranding by NMFS; and

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

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

9. Renewals - On a case-by-case basis, NMFS may issue a second one-year IHA without additional notice when 1) another year of identical or nearly identical activities as described in the Specified Activities section is planned or 2) the activities would not be completed by the time the IHA expires and a second IHA would allow for completion of the activities beyond that described in the Dates and Duration section, provided all of the following conditions are met:

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

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

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

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

(iii) Upon review of the request for renewal, the status of the affected species or stocks, and any other pertinent information, NMFS determines that there are no more than minor changes in the activities, the mitigation and

monitoring measures remain the same and appropriate, and the original findings remain valid.

_____ _____

Donna S. Wieting, Date

Director, Office of Protected Resources,

National Marine Fisheries Service.

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

Species	**Level B**	**Level A**	**Total Authorized Take**
Humpback whale	32	3	35
Minke whale	23	2	25
Sei whale	6	2	8
Fin whale	74	7	81
Blue whale	19	2	21
Sperm whale	48	0	48
Cuvier's and *Mesoplodon* beaked whales	138	0	138
Baird's beaked whale	15	0	15
Bottlenose dolphin	13	0	13
Striped dolphin	176	0	176
Short-beaked common dolphin	2,356	0	2,356
Pacific white-sided dolphin	329	0	329
Northern right-whale dolphin	749	0	754
Risso's dolphin	132	0	132
False killer whale	5	0	5
Killer whale	17	0	17
Short-finned pilot whale	18	0	18
Kogia spp.	29	2	31
Dall's porpoise	786	43	829
Northern fur seal	201	0	201
Guadalupe fur seal	65	0	65
Northern elephant seal	629	0	629