NATIONAL MARINE FISHERIES SERVICE
ENDANGERED SPECIES ACT SECTION 7
BIOLOGICAL OPINION

Title:	Biological Opinion on the National Science Foundation's High-Energy Marine Geophysical Survey by the Research Vessel *Marcus G. Langseth* in the Northwest Atlantic Ocean off North Carolina and National Marine Fisheries Service Permits and Conservation Division's Issuance and Possible Renewal of an Incidental Harassment Authorization Pursuant to Section 101(a)(5)(D) of the Marine Mammal Protection Act
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TABLE OF CONTENTS

Page

1 Introduction ... 11
1.1 Background ... 12
1.2 Consultation History ... 12

2 The Assessment Framework ... 14

3 Description of the Proposed Actions ... 17
3.1 National Science Foundation and Lamont-Doherty Earth Observatory of Columbia University's Proposed Action ... 17
3.1.1 Seismic Survey Overview and Objectives ... 18
3.1.2 Research Vessel Specifications ... 20
3.1.3 Airgun Array and Acoustic Receivers Description ... 21
3.1.4 Sub-Bottom Profiler, Multi-Beam Echosounder, Split-Beam Echosounder, and Acoustic Doppler Current Profiler ... 23
3.1.5 Sediment Sampling ... 24
3.2 National Marine Fisheries Service's Proposed Action ... 25
3.2.1 Proposed Incidental Harassment Authorization and Possible Renewal ... 25
3.2.2 Revision to Proposed Incidental Harassment Authorization ... 27
3.2.3 Overview of Proposed Mitigation, Monitoring, and Reporting in the Incidental Harassment Authorization ... 27
3.3 National Science Foundation, Lamont-Doherty Earth Observatory of Columbia University, and National Marine Fisheries Service's Conservation Measures ... 29
3.3.1 Shutdown and Buffer Zones ... 30
3.3.2 Shutdown Procedures ... 37
3.3.3 Pre-Start Clearance and Ramp-Up Procedures ... 39
3.3.4 Vessel-Based Visual Mitigation Monitoring ... 41
3.3.5 Passive Acoustic Monitoring ... 47
3.3.6 Vessel Strike Avoidance Measures ... 49
3.3.7 Seasonal Restrictions ... 50
3.3.8 Additional Conservation Measures Considered ... 50
3.3.9 Reporting ... 52

4 Potential Stressors ... 54
4.1 Pollution ... 54
4.2 Vessel Strike ... 55
4.3 Acoustic Noise from the Research Vessel Noise and Visual Disturbance ... 56
4.4 Acoustic Noise from the Airgun Array ... 58
4.5 Acoustic Noise from the Sub-Bottom Profiler, Multi-Beam Echosounder, Split-Beam Echosounder, and Acoustic Doppler Current Profiler ... 58
4.6 Gear Entanglement and Interaction ... 61

5 Action Area ... 63

6 Endangered Species Act-Listed Species and Designated Critical Habitat Present in the Action Area ... 64

7 Species and Critical Habitat Not Likely to be Adversely Affected ... 67

7.1 Potential Stressors Not Likely to Adversely Affect Endangered Species Act-Listed Marine Mammals, Sea Turtles, and Fishes or Designated Critical Habitat ... 68

7.1.1 Pollution ... 68

7.1.2 Vessel Strike ... 69

7.1.3 Vessel Noise and Visual Disturbance ... 70

7.1.4 Acoustic Noise from the Airgun Array ... 71

7.1.5 Acoustic Noise from Sub-Bottom Profiler, Multi-Beam Echosounder, Split-Beam Echosounder, and Acoustic Doppler Current Profiler ... 75

7.1.6 Gear Entanglement and Interaction ... 75

7.2 Species Not Likely to be Adversely Affected by Potential Stressors Considered Further ... 76

7.2.1 Marine Mammals – Cetaceans ... 76

7.2.2 Marine Reptiles ... 79

7.2.3 Fishes ... 80

7.3 Designated Critical Habitat ... 86

7.3.1 Loggerhead Turtle – Northwest Atlantic Ocean Distinct Population Segment Critical Habitat ... 87

7.3.2 Effects to Designated Critical Habitat ... 90

7.4 Summary of Effects Determinations for Potential Stressors Associated with the Proposed Actions ... 93

8 Species Likely to be Adversely Affected ... 96

8.1 Blue Whale ... 96

8.1.1 Life History ... 97

8.1.2 Population Dynamics ... 97

8.1.3 Vocalization and Hearing ... 99

8.1.4 Status ... 101

8.1.5 Status in the Action Area ... 101

8.1.6 Critical Habitat ... 102

8.1.7 Recovery Goals ... 102

8.2 Fin Whale ... 102

8.2.1 Life History ... 103

8.2.2 Population Dynamics ... 103

8.2.3 Vocalization and Hearing ... 105

8.2.4 Status ... 107

8.2.5 Status in the Action Area ... 107

8.2.6 Critical Habitat 107
8.2.7 Recovery Goals 107
8.3 Sei Whale 108
8.3.1 Life History 108
8.3.2 Population Dynamics 109
8.3.3 Vocalization and Hearing 110
8.3.4 Status 111
8.3.5 Status in the Action Area 111
8.3.6 Critical Habitat 111
8.3.7 Recovery Goals 112
8.4 Sperm Whale 112
8.4.1 Life History 112
8.4.2 Population Dynamics 113
8.4.3 Vocalization and Hearing 114
8.4.4 Status 116
8.4.5 Status in the Action Area 116
8.4.6 Critical Habitat 117
8.4.7 Recovery Goals 117
8.5 Green Turtle – North Atlantic Distinct Population Segment 117
8.5.1 Life History 118
8.5.2 Population Dynamics 119
8.5.3 Vocalization and Hearing 121
8.5.4 Status 122
8.5.5 Status in the Action Area 122
8.5.6 Critical Habitat 123
8.5.7 Recovery Goals 123
8.6 Kemp's Ridley Turtle 123
8.6.1 The species was first listed under the ESA and listed as endangered under the ESA since 1970. Life History 124
8.6.2 Population Dynamics 125
8.6.3 Vocalization and Hearing 126
8.6.4 Status 126
8.6.5 Status in the Action Area 127
8.6.6 Critical Habitat 127
8.6.7 Recovery Goals 127
8.7 Leatherback Turtle 128
8.7.1 Life History 128
8.7.2 Population Dynamics 130
8.7.3 Vocalization and Hearing 132
8.7.4 Status 133

8.7.5 Status in the Action Area ... 134
8.7.6 Critical Habitat ... 134
8.7.7 Recovery Goals ... 134
8.8 Loggerhead Turtle – Northwest Atlantic Ocean Distinct Population Segment ... 135
8.8.1 Life History ... 135
8.8.2 Population Dynamics ... 137
8.8.3 Vocalization and Hearing ... 140
8.8.4 Status ... 140
8.8.5 Status in the Action Area ... 141
8.8.6 Critical Habitat ... 141
8.8.7 Recovery Goals ... 141

9 Environmental Baseline ... 142
9.1 Climate Change ... 143
9.2 Vessel Interactions ... 145
9.2.1 Vessel Strike ... 146
9.2.2 Whale Watching ... 148
9.3 Fisheries ... 149
9.3.1 Fisheries Interactions ... 149
9.4 Pollution ... 151
9.4.1 Marine Debris ... 151
9.4.2 Pollutants and Contaminants ... 153
9.4.3 Hydrocarbons ... 155
9.5 Aquatic Nuisance Species ... 157
9.6 Anthropogenic Sound ... 158
9.6.1 Vessel Sound and Commercial Shipping ... 159
9.6.2 Aircraft ... 162
9.6.3 Seismic Surveys ... 162
9.6.4 Marine Construction ... 163
9.6.5 Active Sonar ... 163
9.6.6 Military Activities ... 164
9.7 Scientific Research Activities ... 165
9.8 Impact of the Baseline on Endangered Species Act-Listed Species ... 166

10 Effects of the Actions ... 167
10.1 Stressors Remaining to be Considered ... 167
10.2 Conservation Measures to Avoid or Minimize Exposure ... 168
10.3 Exposure Analysis ... 168
10.3.1 Estimates of Acoustic Exposure from the Airgun Array for Endangered Species Act-Listed Marine Mammals ... 170
10.3.2 Estimates of Acoustic Exposure from the Airgun Array for Endangered Species Act-Listed Sea Turtles ... 175

10.4 Response Analysis for Endangered Species Act-Listed Marine Mammals and Sea Turtles to the Acoustic Noise from the Airgun Array ... 180
10.4.1 Acoustic Thresholds for Marine Mammals ... 183
10.4.2 Modeled Sound Fields of the Airgun Array for Marine Mammals ... 184
10.4.3 Total Ensonified Area for Harassment for Marine Mammals ... 186
10.4.4 Acoustic Thresholds for Sea Turtles ... 188
10.4.5 Modeled Sound Fields of the Airgun Array for Sea Turtles ... 190
10.4.6 Total Ensonified Area for Harassment for Sea Turtles ... 191
10.4.7 Potential Responses of Marine Mammals to Acoustic Sources ... 194
10.4.8 Potential Responses of Sea Turtles to Acoustic Sources ... 207
10.4.9 Potential Responses of Marine Mammal and Sea Turtle Prey to Acoustic Sources 209
10.5 Summary of Effects ... 215

11 Cumulative Effects ... 216

12 Integration and Synthesis ... 217
12.1 Jeopardy Analysis ... 217
12.2 Blue Whale ... 218
12.3 Fin Whale ... 220
12.4 Sei Whale ... 222
12.5 Sperm Whale ... 224
12.6 Green Turtle – North Atlantic Distinct Population Segment ... 226
12.7 Kemp's Ridley Turtle ... 227
12.8 Leatherback Turtle ... 229
12.9 Loggerhead Turtle – Northwest Atlantic Ocean Distinct Population Segment ... 231

13 Conclusion ... 234

14 Incidental Take Statement ... 234
14.1 Amount or Extent of Take ... 235
14.2 Reasonable and Prudent Measures ... 236
14.3 Terms and Conditions ... 237

15 Conservation Recommendations ... 237

16 Reinitiation Notice ... 240

17 References ... 241

18 Appendices ... 307
18.1 Appendix A – Proposed Incidental Harassment Authorization and Possible Renewal for the National Science Foundation and Lamont-Doherty Earth Observatory's High-Energy Seismic Survey in the Northwest Atlantic Ocean off North Carolina ... 307

LIST OF TABLES

Page

Table 1. Additional details of the Research Vessel *Marcus G. Langseth*..... 20

Table 2. Specifications of the source airgun array to be used by the Research Vessel *Marcus G. Langseth* during the high-energy seismic survey in the Northwest Atlantic Ocean off North Carolina. 22

Table 3. Conservation measures for the high-energy airgun array in the National Marine Fisheries Service Permits and Conservation Division's proposed incidental harassment authorization and possible renewal. 28

Table 4. Predicted distances to permanent threshold shift for impulsive sources for various marine mammal hearing groups and sea turtles that could be received from the 18 airgun array during the high-energy seismic survey in the Northwest Atlantic Ocean off North Carolina (NSF 2022)..... 35

Table 5. Predicted distances to which sound levels of 160 dB re: one µPa (rms) for harassment (Marine Mammal Protection Act Level B harassment) for impulsive sound sources would be received from the 18 airgun array in intermediate and deep water depths for marine mammals during the high-energy seismic survey in the Northwest Atlantic Ocean off North Carolina (NSF 2022). 36

Table 6. Predicted distances to which sound levels of 175 dB re: one µPa (rms) for harassment for impulsive sound sources would be received from the 18 airgun array in intermediate and deep water depths for sea turtles during the high-energy seismic survey in the Northwest Atlantic Ocean off North Carolina. 36

Table 7. Endangered Species Act-listed threatened and endangered species and designated critical habitat potentially occurring in the action area that may be affected by the National Science Foundation and Lamont-Doherty Earth Observatory's high-energy seismic survey in the Northwest Atlantic Ocean off North Carolina and National Marine Fisheries Service Permits and Conservation Division's proposed issuance of an incidental harassment authorization and possible renewal..... 65

Table 8. Essential physical and biological features for loggerhead turtle designated critical habitat units..... 87

Table 9. Summary of Endangered Species Act-listed species effects determination by potential stressor associated with the proposed actions. 94

Table 10. Five-year annual average mortalities and serious injuries related to vessel strikes for Endangered Species Act-listed marine mammals for stocks in the Atlantic Ocean within the action area. 147

Table 11. Five-year annual average mortalities and serious injuries related to fisheries interactions for Endangered Species Act-listed marine mammals within the action area. 150

Table 12. Densities of Endangered Species Act-listed marine mammals in the action area during National Science Foundation and Lamont-Doherty Earth Observatory's high-energy seismic survey in the Northwest Atlantic Ocean off North Carolina and National Marine Fisheries Service Permits Division's proposed issuance of an incidental harassment authorization and possible renewal. 171

Table 13. Relevant isopleths, trackline distance, ensonified area, number of survey days, percent increase, and total ensonified areas during the National Science Foundation and Lamont-Doherty Earth Observatory's high-energy seismic survey in the Northwest Atlantic Ocean off North Carolina and National Marine Fisheries Service Permits Division's proposed issuance of an incidental harassment authorization and possible renewal. 173

Table 14. Densities of Endangered Species Act-listed sea turtles in the action area during National Science Foundation and Lamont-Doherty Earth Observatory's high-energy seismic survey in the Northwest Atlantic Ocean off North Carolina. 177

Table 15. Relevant isopleths, trackline distance, ensonified area, percent increase, and total ensonified areas during the National Science Foundation and Lamont-Doherty Earth Observatory's high-energy seismic survey in the Northwest Atlantic Ocean off North Carolina. 178

Table 16. Low- and mid-frequency functional hearing groups, generalized hearing ranges, and acoustic thresholds identifying the onset of permanent threshold shift and temporary threshold shift for marine mammals exposed to impulsive sounds underwater (NOAA 2018). 183

Table 17. Predicted radial distances in meters from the Research Vessel *Marcus G. Langseth* seismic sound sources to isopleth corresponding to the harassment (160 dB re: one µPa [rms]) threshold for marine mammals. 185

Table 18. Modeled radial distances in meters from the Research Vessel *Marcus G. Langseth*'s 18 airgun array corresponding to harm thresholds. 185

Table 19. Total ensonified areas (with 25 percent increase) for Endangered Species Act-listed marine mammals in the action area during the National Science Foundation and Lamont-Doherty Earth Observatory's high-energy seismic survey in the Northwest Atlantic Ocean off North Carolina and National Marine

Fisheries Service Permits Division's proposed issuance of an incidental harassment authorization and possible renewal. 186

Table 20. Density, total ensonified area, and calculated exposures during the National Science Foundation and Lamont-Doherty Earth Observatory's high-energy seismic survey in the Northwest Atlantic Ocean off North Carolina and National Marine Fisheries Service Permits Division's proposed issuance of an incidental harassment authorization and possible renewal. 187

Table 21. 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 Division to the airgun arrays during the high-energy seismic survey in the Northwest Atlantic Ocean off North Carolina. 187

Table 22. 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 Division to the airgun arrays during the high-energy seismic survey in the Northwest Atlantic Ocean off North Carolina. 187

Table 23. Generalized hearing range and acoustic thresholds identifying the onset of permanent threshold shift and temporary threshold shift for sea turtles exposed to impulsive sounds underwater (U.S. Navy 2017). 189

Table 24. Predicted radial distances from the Research Vessel *Marcus G. Langseth*'s airgun array to isopleths corresponding to the behavioral harassment threshold (175 dB re: one µPa [rms]) for sea turtles. 190

Table 25. Modeled radial distances in meters from the Research Vessel *Marcus G. Langseth*'s 18 airgun array corresponding to harm thresholds for sea turtles. 191

Table 26. Total ensonified areas (with 25 percent increase) for Endangered Species Act-listed sea turtles in the action area during the National Science Foundation and Lamont-Doherty Earth Observatory's high-energy seismic survey in the Northwest Atlantic Ocean off North Carolina. 191

Table 27. Density, total ensonified area, and calculated exposures for Endangered Species Act-listed sea turtles during the National Science Foundation and Lamont-Doherty Earth Observatory's high-energy seismic survey in the Northwest Atlantic Ocean off North Carolina. 192

Table 28. Estimated exposure of Endangered Species Act-listed sea turtles calculated by the National Science Foundation and Lamont-Doherty Earth Observatory to the airgun arrays during the high-energy seismic survey in the Northwest Atlantic Ocean off North Carolina. 193

Table 29. Estimated exposure of Endangered Species Act-listed sea turtles calculated by the National Science Foundation and Lamont-Doherty Earth Observatory to the airgun arrays during the high-energy seismic survey in the Northwest Atlantic Ocean off North Carolina. 194

Table 30. Estimated amount of incidental take of Endangered Species Act-listed marine mammals anticipated because of the proposed actions in the Northwest Atlantic Ocean off North Carolina. 235

LIST OF FIGURES

Page

Figure 1. Map of the National Science Foundation and Lamont-Doherty Earth Observatory's high-energy seismic survey in the Northwest Atlantic Ocean off North Carolina and National Marine Fisheries Service Permits and Conservation Division's proposed issuance of an incidental harassment authorization and possible renewal for this consultation. 64

Figure 2. Map identifying designated critical habitat (nearshore reproductive habitat, winter habitat, breeding habitat, constricted migratory habitat, and *Sargassum* habitat) for the threatened Northwest Atlantic Ocean distinct population segment of loggerhead turtle. 90

Figure 3. Map identifying the range of the endangered blue whale. 97

Figure 4. Map identifying the range of the endangered fin whale. 103

Figure 5. Map identifying the range of the endangered sei whale. 108

Figure 6. Map identifying the range of the endangered sperm whale. 112

Figure 7. Map of geographic range of the threatened North Atlantic distinct population segment of green turtle, with location and abundance of nesting females (Seminoff et al. 2015). 118

Figure 8. Map identifying the range of the endangered Kemp's ridley turtle. 124

Figure 9. Map identifying the range of the endangered leatherback turtle. Adapted from Wallace et al. (2013). 128

Figure 10. Map identifying the range of the threatened Northwest Atlantic Ocean distinct population segment of loggerhead turtle. 135

Figure 11. Map of the global vessel traffic density in 2021. Image retrieved from Marine Traffic. 161

Figure 12. Map of vessel traffic density in the Northwest Atlantic Ocean off North Carolina. Image retrieved from Marine Traffic. 162

1 INTRODUCTION

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

Section 7(b)(3) of the ESA requires that at the conclusion of consultation, NMFS provides an opinion stating whether the Federal agency is able to insure its action is not likely to jeopardize ESA-listed species or destroy or adversely modify designated critical habitat. If NMFS determines that the action is likely to jeopardize listed species or destroy or adversely modify critical habitat, NMFS provides a reasonable and prudent alternative that allows the action to proceed in compliance with section 7(a)(2) of the ESA. If an incidental take is expected, section 7(b)(4) requires NMFS to provide an incidental take statement that specifies the impact of any incidental taking and includes reasonable and prudent measures to minimize such impacts and terms and conditions to implement the reasonable and prudent measures. NMFS, by regulation, has determined that an incidental take must be identified when take is "reasonably certain to occur" as a result of the proposed action (50 C.F.R. §402.14(g)(7)).

The Federal action agencies for this consultation are the National Science Foundation (NSF) and the NMFS, Office of Protected Resources, Permits and Conservation Division (Permits Division). Two Federal actions are considered in this biological opinion (opinion). The first is the NSF's proposal to sponsor (fund) a marine geophysical (seismic) survey in the Northwest Atlantic Ocean in spring or summer (tentatively scheduled for May through September) 2023 to be conducted by the Lamont-Doherty Earth Observatory of Columbia University (L-DEO). The second is the NMFS Permits 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 high-energy seismic survey, pursuant to section 101(a)(5)(D) of the MMPA.

This formal consultation was conducted and this opinion and incidental take statement were prepared by NMFS, Office of Protected Resources, ESA Interagency Cooperation Division (hereafter referred to as "we") in accordance with section 7(a)(2) of the ESA and associated implementing regulations at 50 C.F.R. §§402.01-402.17, and agency policy and guidance. On July 5, 2022, the United States District Court for the Northern District of California issued an order vacating the 2019 regulations were revised or added to 50 C.F.R. Part 402 in 2019 ("2019 Regulations," see 84 FR 44976, August 27, 2019) without making a finding on the merits. On

September 1, 2022, the U.S. Court of Appeals for the Ninth Circuit granted a temporary stay of the district court's July 5, 2022 order. On November 14, 2022, the Northern District of California issued an order granting the government's request for voluntary remand without vacating the 2019 regulations. The District Court issued a slightly amended order two days later on November 16, 2022. As a result, the 2019 regulations are in effect and we are applying the 2019 regulations here. For purposes of this consultation, we considered whether the substantive analysis and its conclusions regarding the effects of the proposed actions articulated in the opinion and incidental take statement would be any different under the pre-2019 regulations. We have determined that our analysis and conclusions would not be any different.

This document represents the NMFS ESA Interagency Cooperation Division's opinion on the effects of these actions on threatened and endangered species and critical habit that has been designated for those species (Section 5) in the action area. A complete record of this consultation is on file at the NMFS Office of Protected Resources in Silver Spring, Maryland.

1.1 Background

The NSF is proposing to sponsor a high-energy marine seismic survey for scientific research purposes and data collection in the Northwest Atlantic Ocean off North Carolina in spring or summer (tentatively scheduled for May through September) 2023. The high-energy seismic survey will be conducted by L-DEO. In conjunction with this action, the NMFS Permits Division would issue an IHA and possible renewal under the MMPA for incidental takes of marine mammals that could occur during the NSF and L-DEO's high-energy seismic survey. Over the past two decades, both the NSF and the NMFS Permits Division have conducted similar actions throughout the world. These have been the subject of ESA section 7 consultations and IHAs addressing seismic surveys that included regions of the Northwest Atlantic Ocean such as in the Northwest Atlantic Ocean [2004], Northwest Atlantic Ocean off Martha's Vineyard [2009], Northwest Atlantic Ocean off New Jersey [2014 and 2015], Northwest Atlantic Ocean off North Carolina [2014], and Northwest Atlantic Ocean [2018]). For each action, NMFS Permits Division issued an IHA and we determined that these actions are not likely to jeopardize the continued existence of proposed or ESA-listed species, or result in the destruction or adverse modification of proposed or designated critical habitat.

1.2 Consultation History

This opinion is based on information provided in the NSF's draft environmental assessment/analysis (*Draft Environmental Assessment/Analysis of Marine Geophysical Surveys by R/V Marcus G. Langseth off North Carolina, Northwest Atlantic Ocean*) prepared pursuant to the National Environmental Policy Act, L-DEO's MMPA IHA application, a public notice for the proposed IHA and possible renewal prepared pursuant to the requirements of the MMPA, monitoring reports from similar activities, published and unpublished scientific information on threatened and endangered species and their surrogates, scientific and commercial information such as reports from government agencies and peer-reviewed literature, opinions on similar

activities, and other sources of information. Our communication with the NSF and NMFS Permits Division regarding this consultation is summarized as follows:

- On October 7, 2022, we received a request from the NSF for ESA section 7 consultation for a high-energy seismic survey to be undertaken in the Northwest Atlantic Ocean off North Carolina in spring or summer (tentatively scheduled for May through September) of 2023. The NSF provided a letter and draft environmental assessment/analysis, in support of the request.
- On October 12, 2022, the L-DEO submitted an IHA application to us and the NMFS Permits Division. NMFS Permits Division deemed the IHA application adequate and complete on January 13, 2023.
- On December 20, 2022, we participated in the NMFS Permits Division's Early Review Team meeting to discuss the NSF and L-DEO's high-energy seismic survey on the Research Vessel (R/V) *Marcus G. Langseth* in the Northwest Atlantic Ocean off North Carolina.
- On December 21, 2022, we provided the NSF with questions on their draft environmental assessment/analysis. The NSF responded to the questions on January 11, 2023. On January 13 and January 17, 2023, we provided the NSF with additional questions on their draft environmental assessment/analysis and the NSF responded to the questions on January 13 and January 18, 2023.
- On January 18, 2023, we determined there was sufficient information to initiate formal consultation. We provided the NSF with an initiation letter on January 26, 2023.
- On March 14, 2023, we received a request for formal consultation pursuant to section 7 of the ESA from the NMFS Permits Division to authorize the incidental harassment of marine mammal species during the NSF and L-DEO's high-energy seismic survey on the R/V *Marcus G. Langseth* in the Northwest Atlantic Ocean off North Carolina. The consultation request package included an initiation memorandum, draft notice of a proposed IHA and request for comments on proposed authorization and possible renewal, and draft IHA.
- On March 22, 2023, we provided comments and edits on the draft notice of a proposed IHA and request for comments on proposed authorization and possible renewal and draft IHA to the NMFS Permits Division and NMFS Permits Division responded to the comments and edits on March 31, 2023.
- On March 23, 2023, NMFS Permits Division published a notice of a proposed IHA and request for comments on proposed authorization and possible renewal in the *Federal Register* soliciting public comment on their intent to issue an IHA for NSF and L-DEO's high-energy marine seismic survey on the R/V *Marcus G. Langseth* in the Northwest Atlantic Ocean off North Carolina.
- On March 31, 2023, we determined there was sufficient information to initiate formal consultation with the NMFS Permits Division. We provided NMFS Permits Division with an initiation letter on April 17, 2023.

- On April 25, 2023, NMFS Permits Division notified us that they did not receive any public comments on the proposed IHA and possible renewal.
- On April 28, 2023, we received a revised IHA from the NMFS Permits Division addressing comments and edits we provided on the draft IHA as well as comments from the NMFS Southeast Regional Office.

2 THE ASSESSMENT FRAMEWORK

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

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

"Destruction or adverse modification" means a direct or indirect alteration that appreciably diminishes the value of 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 turtles, leatherback turtles, and loggerhead turtles used the term primary constituent element or essential features. The critical habitat regulation revisions (81 FR 7414) have since replaced this term "primary constituent element" or "essential features" with physical and biological features (PBFs). The shift in terminology does not change the approach used in conducting a "destruction or adverse modification" analysis, which is the same regardless of whether the original designation identified primary constituent elements, physical or biological features, or essential features. In this opinion, we use the term physical or biological features to mean primary constituent elements or essential features, as appropriate for the specific designated critical habitat.

An ESA section 7 assessment involves the following steps:

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

Potential Stressors (Section 4): We identify and describe the stressors that could occur as a result of the proposed actions and affect ESA-listed species and designated critical habitat.

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

Endangered Species Act-Listed Species and Designated Critical Habitat Present in the Action Area (Section 6): We identify the ESA-listed species and designated critical habitat that are subject to this consultation because they co-occur with the stressors produced by the proposed actions in space and time.

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

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

Environmental Baseline *(*Section 9): We describe the environmental baseline, which refers to the condition of the ESA-listed species in the action area, without the consequences to the ESA-listed species caused by the proposed action. The environmental baseline that 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).

Effects of the Actions (Section 10): Effects of the action are all consequences to ESA-listed species that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur in time and may include consequences occurring outside the immediate area involved in the action (50 C.F.R. §402.17). These are broken into analyses of exposure, response, and risk. To characterize exposure, we identify the number, age (or life stage), and gender of ESA-listed individuals that are likely to be exposed to the stressors and the populations or sub-populations to which those individuals belong. We also consider whether the action "may affect" designated critical habitat. This is our exposure analysis. We evaluate the available evidence to determine how individuals of those ESA-listed species 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 characterize risk to federally-listed species by assessing the consequences of these responses of individuals that are likely to be exposed to the populations those individuals represent, and the species those populations comprise. This is our summary of effects. The adverse modification analysis considers the impacts of the proposed actions on the PBFs and conservation value of designated critical habitat.

Cumulative Effects (Section 11): Cumulative effects are the effects to ESA-listed species and designated critical habitat of future state or private activities that are reasonably certain to occur within the action area (50 C.F.R. §402.02). Effects from future Federal actions that are unrelated

to the proposed action are not considered because they require separate ESA section 7 compliance.

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

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

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

The results of our jeopardy and destruction and adverse modification analyses are summarized in the Conclusion (Section 13). If, in completing the last step in the analysis, we determine that the action under consultation is likely to jeopardize the continued existence of ESA-listed species or destroy or adversely modify designated critical habitat, then we must identify reasonable and prudent alternative(s) to the action, if any, or indicate that to the best of our knowledge there are no reasonable and prudent alternatives (50 C.F.R. §402.14).

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

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

- Information submitted by the NSF and NMFS Permits 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 actions 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 ACTIONS

"Action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by federal agencies (50 C.F.R. §402.02).

Two Federal proposed actions were evaluated during consultation. The first proposed action addressed by this consultation is the NSF's proposal to sponsor a high-energy marine seismic survey on the R/V *Marcus G. Langseth* in the Northwest Atlantic Ocean off North Carolina in spring or summer (tentatively scheduled for May through September) 2023. The high-energy seismic survey would be conducted by L-DEO, which owns and operates the R/V *Marcus G. Langseth*. The second proposed action addressed by this consultation is NMFS Permits Division's issuance of a proposed IHA authorizing non-lethal "takes" by MMPA Level B harassment and possible renewal pursuant to section 101(a)(5)(D) of the MMPA for the NSF and L-DEO's high-energy marine seismic survey in the Northwest Atlantic Ocean off North Carolina.

The NSF and L-DEO's proposed action includes a two-dimensional seismic survey in the United States (U.S. Navy) Exclusive Economic Zone and International Waters in the Northwest Atlantic Ocean off North Carolina. The seismic survey activities would collect data to understand the Cape Fear submarine slide complex. The NSF, as the research funding and action agency, has a mission to "promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense…". The high-energy seismic survey would collect data in support of a research proposal that has been reviewed under the NSF merit review process and has been identified as a NSF program priority to meet the agency's critical need to foster an understanding of Earth processes.

The information presented here is based primarily on the draft environmental assessment/analysis, IHA application, and *Federal Register* notice on the request for comments on the proposed IHA and possible renewal provided by the NSF, L-DEO, and NMFS Permits Division as part of their initiation packages.

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

The NSF proposes to fund a high-energy seismic survey in the Northwest Atlantic Ocean off North Carolina on the R/V *Marcus G. Langseth*. The high-energy seismic survey would be

conducted by L-DEO. An airgun array, sub-bottom profiler, multi-beam echosounder, split-beam echosounder, and acoustic Doppler current profiler would be deployed as energy sources. The NSF and L-DEO will also conduct sediment sampling and magnetic, gravity, and heat flow measurements on the R/V *Marcus G. Langseth*.

3.1.1 Seismic Survey Overview and Objectives

The NSF 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 NSF 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 high-energy seismic survey would examine tsunami hazards associated with large submarine landslide behavior over the past 23 million years in a region off North Carolina. Submarine landslides are a common seafloor feature of the passive margin on both sides of the North Atlantic Ocean. Their presence on the Eastern North Atlantic Margin is the rule rather than the exception. They threaten large population centers along these coasts with possible tsunamis and move material from the shallow to the deep sea during margin evolution. Despite their high prevalence on passive margins and in particular on the U.S. East Coast, very little about their causes, mechanical behavior, and frequency is understood, and their role in the development of the passive margin as it exists today has not been examined. The proposed action would improve understanding of how slope failures operate through time and the manner in which past events might influence subsequent events. The proposed action would provide new constraints for examining tsunami hazards associated with submarine landslides.

Researchers from the University of Texas at Austin and Lamont-Doherty Earth Observatory of Columbia University (L-DEO), propose to conduct a high-energy marine seismic survey for scientific research purposes using an airgun array and other acoustic sound sources in conjunction with sediment sampling (piston and gravity coring), as well as magnetic, gravity, and heat flow measurements in the waters of the Northwest Atlantic Ocean off North Carolina in spring or summer (tentatively scheduled for May through September) 2023. The principal investigators are Drs. H. Daigle (University of Texas at Austin), and A. Becel and C. Grall (L-DEO). The researchers would work in collaboration with international and domestic researchers including the United States Geological Survey (USGS and NSF). Additional research collaborators from the U.S., which are not funded through NSF, include N. Miller (USGS and NSF), J. Kluesner (USGS and NSF), K. Shukla (Brown University), D. Sawyer (Ohio State University), M.B. Magnani (Southern Methodist University), M. Occhi (Virginia Department of Mines, Minerals, and Energy), and L. Worthington (University of New Mexico). Additional international research collaborators, which are not funded through NSF, include L. Ruffine (Ifremer). To achieve the goals of the project, the principal investigators would utilize the two-dimensional seismic reflection capabilities of the R/V *Marcus G. Langseth* in conjunction with sediment sampling and heat flow measurements.

The two-dimensional, high-energy seismic survey would use a towed 18 Bolt airgun array with a maximum discharge volume of approximately 54,077.3 cubic centimeters (3,300 cubic inches) at a depth of six meters (19.7 feet) and one towed hydrophone streamer behind the R/V *Marcus G. Langseth*. The high-energy seismic survey would take place in the U.S. Exclusive Economic Zone and International Waters in the Northwest Atlantic Ocean off North Carolina in (intermediate and deep) waters depths from 200 to 5,500 meters (656.2 to 18,044.2 feet). The seismic survey activities would be conducted along a total of approximately 6,083 kilometers (3,284.6 nautical miles) of tracklines. The closest point of approach during the seismic survey activities would be approximately 5 kilometers (2.7 nautical miles) from the 100 meter (328.1 feet) isobaths, 5.6 kilometers (3 nautical miles) to state waters, and 40 kilometers (21.6 nautical miles) from the coast of Cape Hatteras, North Carolina, respectively. The seismic survey activities would consist of a total of approximately 33 days, including approximately 28 days of airgun array operations, three days of (gravity and piston) coring activities and heat flow measurements, and approximately two days of transit. Equipment deployment and recovery can occur anytime during the seismic survey activities except it would not occur during transit. The R/V *Marcus G. Langseth* is tentatively planning to depart from Norfolk, Virginia on approximately May 9, 2023, and return to Norfolk, Virginia on approximately June 10, 2023. The transit distance from Norfolk, Virginia to the seismic survey area is approximately 200 kilometers (107.9 nautical miles). The schedule for the R/V *Marcus G. Langseth* is available online at: https://www.mfp.us/programme/shipview/marcus%20g.%20langseth. Some minor deviation from the dates is possible, depending on logistics and weather. Due to uncertainties associated with the schedule, sail dates were not provided and likely occurring in May, June, July, August, or September.

The NSF and L-DEO would use conventional seismic survey methodology and the procedures would be similar to those used during previous NSF-funded and L-DEO-conducted seismic surveys. Seismic survey protocols generally involve a predetermined set of tracklines. The seismic data acquisition or sound source vessel travels down a linear trackline for some distance until a line of data is acquired, then turns and acquires data on a different trackline (Figure 1). The order of the seismic survey activities would be determined when operations commence as well as the location of the tracklines are considered representative and may shift from what is depicted in Figure 1 depend on factors such as science drivers, poor data quality, weather, mechanical issues, etc. with the research vessel and/or equipment, etc.

The proposed action would occur 24 hours per day during the high-energy seismic survey. It is assumed the airgun array would be active up to 24 hours per day (possibly 21 hours per day, with three hours per day allotted for repair and regular maintenance) to meet science objectives. There would be additional airgun array operations in the seismic survey area associated with start-ups, line changes and turns, airgun array testing, recovery, and repeat coverage of any areas where initial data quality is considered sub-standard by the project scientists. A section of a trackline may need to be repeated for reasons such as when data quality is poor or missing due to equipment failure (e.g., airgun array or towed hydrophone streamer problems; data acquisition

system issues, research vessel issues); data degradation due to poor weather; interruption due to shutdowns or ramp-ups or trackline deviation for protected species, which would 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 and sea turtles that would occur as a result of the seismic survey activities, the NSF and L-DEO added 25 percent to the total number of operational days (which is the equivalent to adding 25 percent to the total trackline kilometers) to the high-energy seismic survey for their calculations of marine mammal exposures to sounds exceeding the harassment (MMPA Level B harassment for marine mammals) thresholds. All planned seismic data acquisition activities would be conducted by the NSF, L-DEO, and researchers from the University of Texas at Austin, L-DEO, USGS, Brown University, Ohio State University, Southern Methodist University, Virginia Department of Mines, Minerals, and Energy, University of New Mexico, and Ifremer, with onboard assistance by technical staff and the marine operations group. The research vessel would be self-contained, and the scientific party and crew would live aboard the R/V *Marcus G. Langseth* for the entire high-energy seismic survey. The NSF and L-DEO's draft environmental assessment/analysis and IHA application present more detailed information on the proposed action.

3.1.2 Research Vessel Specifications

The high-energy seismic survey would involve one source vessel, the U.S.-flagged R/V *Marcus G. Langseth*. The R/V *Marcus G. Langseth* is owned and operated by L-DEO. The R/V *Marcus G. Langseth* would tow an airgun array as a sound source along tracklines (not predetermined). 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 9.3 kilometers per hour (5 knots). When not towing seismic survey gear, the R/V *Marcus G. Langseth* typically cruises at 18.5 kilometers per hour (10 knots). The maximum speed is approximately 24.1 kilometers per hour (13 knots). It has an operating range of approximately 13,500 kilometers (7,289.4 nautical miles) and an endurance of approximately 30 days. No chase vessel would be used during seismic survey activities. The R/V *Marcus G. Langseth* would also serve as the platform from which vessel-based protected species observers (PSO) (visual) would watch for animals (e.g., marine mammals, sea turtles, and fishes). The PSOs have a 360 degree view from the observation platform on the research vessel. See Table 1 for additional details regarding the R/V *Marcus G. Langseth*.

Table 1. Additional details of the Research Vessel *Marcus G. Langseth*.

Research Vessel *Marcus G. Langseth* Specifications	
Owner	Lamont-Doherty Earth Observatory of Columbia University

Research Vessel *Marcus G. Langseth* Specifications	
Operator	Lamont-Doherty Earth Observatory of Columbia University
Flag	United States of America
Date Built or Modified	Built in 1991 Modified in 2004
Gross Tonnage	3,834
Accommodation Capacity	55 including approximately 20 Crew and 35 Scientists/Researchers

3.1.3 Airgun Array and Acoustic Receivers Description

The energy source for the high-energy seismic survey was chosen by the NSF to be the lowest practical to meet the scientific objectives. During the high-energy seismic survey, marine technicians on the R/V *Marcus G. Langseth* would 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 high-energy seismic survey would consist of up to 18 airguns (each airgun is 655.5 to 5,899.3 cubic centimeters [40 to 360 cubic inches]) with a total discharge volume of approximately 54,077.3 cubic centimeters (3,300 cubic inches) (Table 2). All airguns in the array would be fired simultaneously. The airgun array would be towed behind the R/V *Marcus G. Langseth*. The shot interval would be approximately 10.6 seconds (approximately 25 meters [82 feet] per second) for the two-dimensional high-energy seismic survey. The firing pressure of the airgun array would be approximately 2,000 pounds per square inch (psi). The airgun array would be towed approximately 140 meters (459.3 feet) behind the research vessel (depending on Beaufort sea state) at a tow depth of six meters (19.7 feet) and spaced as two string distributed approximately six by 16 meters (19.7 by 52.5 feet) for the high-energy seismic survey. Weather conditions permitting, it is anticipated that seismic survey activities would not exceed approximately 672 hours (28 days) of airgun array operations. It is expected that the airgun array would be active 24 hours per day during the high-energy seismic survey. Airguns would operate continually during the seismic survey period except for

unscheduled shutdowns. See Table 2 for the specifications of the R/V *Marcus G. Langseth*'s airgun array configurations, source output, position, tow depths, air discharge volume, dominant frequency components, pulse duration, and shot interval associated with the high-energy seismic survey in the Northwest Atlantic Ocean off North Carolina.

Table 2. Specifications of the source airgun array to be used by the Research Vessel *Marcus G. Langseth* during the high-energy seismic survey in the Northwest Atlantic Ocean off North Carolina.

Source Airgun Array Specifications	
Energy Source – Number of Airguns	18 Bolt 1500LL and 1900LLX Airguns (40 to 360 in^3 each for 3,300 in^3 total) (2,000 psi) Two strings each containing nine operating airguns and one spare.
Source Output (Downward) of 18 Airgun Array	Peak-to-Peak = 259 dB re: one µPa [rms]) 0-to-Peak = 252 dB re: one µPa [rms])
Position	Two strings distributed approximately 6 by 16 m (19.7 by 52.5 ft) apart Approximately 140 m (459.3 ft) Astern
Tow Depth	6 m (19.7 ft)
Air Discharge Volume of 18 Airgun Array	Approximately 3,300 in^3
Dominant Frequency Components	2 to 188 Hz
Pulse Duration	Approximately 0.01 Seconds
Shot Interval	Approximately 25 m or 10.6 Seconds

in^3=cubic inches, psi=pounds per square inch, dB=decibel, µPa=micro Pascal, rms=root mean square, m=meters, ft=feet, Hz=Hertz.

The receiving system would consist of a five kilometer (2.7 nautical mile) long hydrophone streamer towed at a depth of six meters (19.7 feet) and a 600 meter (1,968.5 feet) long hydrophone streamer towed at a depth of two to three meters (6.6 to 9.8 feet) during the high-energy seismic survey. The towed hydrophone streamers are a Sercel Sentinel solid-state flexible polymer streamer (i.e., not filled with gel or oil). Only one hydrophone streamer would be towed at a time. As the airgun array is towed along the tracklines, the towed hydrophone streamer would receive the returning acoustic signals and transfer the data to the onboard processing system. The towed hydrophone streamer are internally configured differently and researchers determine which are used depending on the needs for scientific research. The turning rate of the R/V *Marcus G. Langseth* with the airgun array and towed hydrophone streamer deployed is slow (limited to five degrees per minute) and the maneuverability of the research vessel would be limited during seismic survey activities.

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

Along with operations of the airgun array, four additional acoustical data acquisition systems would operate during the high-energy seismic survey from the R/V *Marcus G. Langseth*. The Knudsen Chirp 3260 sub-bottom profiler at 3.5 kilohertz (kHz), Kongsberg EM 122 multi-beam echosounder at 10.5 to 13 kHz, and Simrad EK80 split-beam echosounder at 38 kHz would map the ocean floor during the high-energy seismic survey. The Teledyne RDI Ocean Surveyor acoustic Doppler current profiler at 75 kHz would measure water current velocities. The sub-bottom profiler, multi-beam echosounder, split-beam echosounder, and acoustic Doppler current profiler sound sources would operate continuously from the R/V *Marcus G. Langseth*, including simultaneously with the airgun array as well as during transit to and from the seismic survey area, or when the airgun array is not operating.

3.1.4.1 Sub-Bottom Profiler

The ocean floor would be mapped with a Knudsen Chirp 3260 sub-bottom profiler. The sub-bottom profiler is normally operated to provide information about the near seafloor sedimentary features and the bottom topography that is mapped simultaneously by the multi-beam echosounder. The beam is transmitted as a 27 degree cone, which is directed downward by a 3.5 kHz transducer mounted to the hull of the research vessel. The nominal power output is ten kilowatts, but the actual maximum radiated power is 3 kilowatts or 222 decibels (dB) re: one µPa at one 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). The sub-bottom profiler would be operated continuously during the seismic survey activities and transits.

3.1.4.2 Multi-Beam Echosounder

The ocean floor would be mapped with the Kongsberg EM122 multi-beam echosounder. The multi-beam echosounder is a hull-mounted system operating at a frequency of 10.5 to 13 (usually 12) kHz. The transmitting beamwidth is very narrow, zero or two degrees fore-aft and 150 degrees (maximum) athwartship (i.e., perpendicular to the research vessel's line of travel). The maximum sound source level is 242 dB re: one µPa at one meter (rms). Each ping consists of eight (in water greater than 1,000 meters [3,280.8 feet] successive fan-shaped transmissions, each ensonifying a sector that extends one degree fore-aft. Continuous-wave signals increase from two to 15 milliseconds long in water depths up to 2,600 meters (8,530.2 feet) and frequency modulated chirp signals up to 100 milliseconds long are used in water greater than 2,600 meters (8,530.2 feet). The successive transmissions span an overall cross-track angular extent of about 150 degrees, with two milliseconds gaps between the pings for successive sectors. The multi-beam echosounder emits a series of 0.7 to 200 millisecond pulses. The multi-beam echosounder would be operated continuously during the seismic survey activities and transits.

3.1.4.3 Split-Beam Echosounder

The ocean floor would be mapped with the Simrad EK80 split-beam echosounder. The split-beam echosounder would be provided by the USGS to collect mid-water echosounding data. The split-beam echosounder would be mounted and towed on a metal pole over the side of the research vessel, it would not be hull-mounted. The split-beam echosounder operates at a frequency of 38 kHz with a seven degree beamwidth and at a frequency of 18 kHz with a beamwidth of 11 degrees. The pulse duration is eight milliseconds and the ping repetition rate would be one second. The maximum source level is 212 to 229 dB re: one µPa at one meter. The split-beam echosounder would be operated continuously during the seismic survey activities and transits.

3.1.4.4 Acoustic Doppler Current Profiler

The Teledyne RDI Ocean Surveyor acoustic Doppler current profilers would be mounted on the hull of the R/V *Marcus G. Langseth* to measure the speed (velocity), direction, and depth of the water currents. The Teledyne RDI Ocean Surveyor acoustic Doppler current profiler would operate at a frequency of 75 kHz and a maximum sound source level of 224 dB re: one µPa at one meter (rms) over a conically-shaped 30 degree beam. The transmitting beamwidth is 30 degrees. The acoustic Doppler current profiler emits a series of 11 to 37 millisecond pulses and has a ping rate is 0.7 seconds. An acoustic Doppler current profiler would be operated continuously during the seismic survey activities and transits.

3.1.5 Sediment Sampling

Core samples are open cylindrical devices that are inserted or driven into the seafloor to sample sediment or benthic organisms. The depth a sampler penetrates the sediment is a function of the bottom type, the type of sampler, and its configuration (e.g., ballast weight). The individual core samples are collected in polycarbonate tubes which also capture the supernatant liquid to preserve sediment/water interface.

Approximately ten to 20 cores would be collected from the R/V *Marcus G. Langseth* throughout the seismic survey area above locations where strong bottom simulating reflectors have been imaged and/or near locations of seafloor gas seeps. A bottom simulating reflector is a geologic feature with a reflection that roughly parallels the seafloor reflection, presumably caused by the contrast between an overlying clathrate (i.e., gas hydrate) and underlying gas-saturated sediments or occasionally by opal transition. These are especially seen in deep water where subseafloor sediments are at low temperature, but under substantial pressure. The locations would be determined during the high-energy seismic survey based on the seismic survey data collected. Gravity and piston coring would collect sediment samples at various coring sites. Heat flow measurements for thermal data would be collected with outrigger temperature probes mounted to the outside of a piston core barrel. The core data would allow for the documentation of sediment physical properties and pore fluids. Depending upon logistics, availability of staff, and other considerations, coring activities may take place in a separate, future scientific cruise.

The piston corer would consist of a 12 meter (39.3 feet) long pipe that takes a core sample that is approximately ten centimeters (3.9 inches) in diameter and a weight stand. The core pipe would weigh approximately 70 kilograms (154.3 pounds) and the weight stand would weight approximately 1,270 kilograms (2,799.9 pounds) and is approximately 90 centimeters (35.4 inches) in diameter. A piston corer would be lowered by wire to near the seabed were a tripping mechanism would release the corer and allow it to fall to the seabed, where the heavy weight stand would drive the core pipe into the seabed. A sliding piston inside the core barrel would reduce inside wall friction with the sediment and assists in the evacuation of displaced water from the top of the corer. The gravity corer would consist of a three meter (9.8 feet) long core pipe that takes a core sample approximately ten centimeter (3.9 inches) in diameter, a head weight of approximately 45 centimeters (17.7 inches) in diameter, and a stabilizing fin. It would "free fall" from the research vessel, and its stabilizing fin would ensure that the corer penetrates the seabed in a straight line. The coring equipment would be deployed over the side of the vessel with standard oceanographic wire. The wire would be taut with the weight of the equipment preventing species entanglements. Thermal data (heat flow measurements) would be collected with passive outrigger temperature probes mounted to the outside of a piston core barrel. Some substitution in equipment may be necessary; however, any substituted equipment would be similar generally in size and operation. All equipment would be retrieved after use.

Gravity measurements would be passively collected with a gravimeter onboard the research vessel and magnetic measurements would also be passively collected by a towed magnetometer towed behind the research vessel.

3.2 National Marine Fisheries Service's Proposed Action

On October 12, 2022, NMFS Permits Division received a request from the NSF and L-DEO for an IHA to take marine mammals incidental to conducting a high-energy marine seismic survey in the Northwest Atlantic Ocean off North Carolina. On January 13, 2023, NMFS Permits Division deemed the NSF and L-DEO's application for an IHA to be adequate and complete. The NSF and L-DEO's request is for take of a small number of 30 species of marine mammals by MMPA Level A and Level B harassment. No ESA-listed marine mammals are expected to be taken by MMPA Level A harassment. Neither the NSF and L-DEO nor NMFS Permits Division expects serious injury or mortality to result from the seismic survey activities, therefore, an IHA is appropriate. The planned high-energy seismic survey is not expected to exceed one year; hence, the NMFS Permits Division does not expect subsequent MMPA IHAs would be issued for this proposed action. The NMFS Permits Division proposes to issue the IHA on or after April 24, 2023, so that the NSF and L-DEO would have the IHA prior to the start of the high-energy seismic survey because the NSF and L-DEO has tentatively scheduled the research vessel to leave port on May 9, 2023.

3.2.1 Proposed Incidental Harassment Authorization and Possible Renewal

The NMFS Permits Division is proposing to issue an IHA authorizing non-lethal "takes" by MMPA Level B harassment of marine mammals incidental to the planned high-energy seismic

survey. The IHA would be valid for a period of one year from the date of issuance (tentatively April 2023 through April 2024). The IHA would authorize the incidental harassment of the following threatened and endangered marine mammal species: blue whale (*Balaenoptera musculus*), fin whale (*Balaenoptera physalus*), sei whale (*Balaenoptera borealis*), and sperm whale (*Physeter macrocephalus*). The proposed IHA identifies requirements that the NSF and L-DEO must comply with as part of its authorization. The NMFS Permits Division does not expect the NSF and L-DEO's planned high-energy seismic survey to exceed one year and do not expect subsequent MMPA IHAs would be issued for this particular specified activity. Nevertheless, NMFS Permits Division recognizes that delays to the specified activity have the potential to occur and as a result, may issue a one-year renewal to the IHA.

On a case-by-case basis, NMFS Permits Division may issue a one-time, one-year IHA renewal following notice to the public providing an additional 15-days for public comment when (1) up to another year of identical, or nearly identical, activities as described in the description of the proposed activity section of the *Federal Register* notice (88 FR 17646 to 17677) is planned or (2) the activities as described in the description of the proposed activity section of the *Federal Register* notice (88 FR 17646 to 17677) would not be completed by the time the IHA expires and a second IHA (renewal) would allow for completion of the activities beyond the original dates and duration, provided all of the following conditions are met:

- A request for renewal is received no later than 60 days prior to the needed renewal IHA effective date (recognizing that the renewal IHA expiration date cannot extend beyond one year from the expiration of the initial IHA);
- The request for renewal must include the following: (1) an explanation that the activities to be conducted under the proposed renewal IHA are identical to the activities analyzed under the initial IHA, are a subset of the activities, or include changes so minor (e.g., reduction in airgun array volume) that the changes do not affect the previous analyses, mitigation and monitoring requirements, or take estimates (with the exception of reducing the type or amount of take); and (2) a preliminary monitoring report showing the results of the required monitoring to date and an explanation showing that the monitoring results do not indicate impacts of a scale or nature not previously analyzed or authorized.
- Upon review of the request for renewal, the status of the affected species or stocks, and any other pertinent information, NMFS Permits Division determines that there are no more than minor changes in the activities, the mitigation and monitoring measures would remain the same and appropriate, and the findings in the initial IHA remain valid.

On March 23, 2023, NMFS Permits Division published a notice of proposed IHA and request for comments on proposed IHA and possible renewal in the *Federal Register* (88 FR 17646 to 17677). The public comment period closed on April 24, 2023. The NMFS Permits Division did not receive any public comments. Appendix A (Section 18) contains the NMFS Permits Division's proposed IHA and possible renewal. The text in Appendix A (Section 18) was taken

directly from the proposed IHA and possible renewal provided to us in the consultation initiation package.

3.2.2 Revision to Proposed Incidental Harassment Authorization

The NMFS Permits Division has made revisions to the proposed IHA since the notice was published in the *Federal Register* on March 23, 2023 (88 FR 17646 to 17677). The revisions to the proposed IHA include notification via email to NMFS Southeast Regional Office on the start and end of seismic survey activities and daily PSO logs if any activities (non-seismic) are conducted between November 1 through April 30 as well as observation of a 18.5 kilometers per hour (10 knot) speed restriction in specific areas designated by NMFS for the protection of North Atlantic right whales from vessel strikes .

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

In order to issue an IHA under section 101(a)(5)(D) of the MMPA, NMFS Permits Division must set forth permissible methods of taking pursuant to the activity, and other means of effecting the least practicable impact on the species or stock and its habitat, paying particular attention to rookeries, mating grounds, and areas of similar significance, and on the availability of the species or stock for taking for certain subsistence uses (latter not applicable for the proposed actions). NMFS Permits Division regulations require applicants for incidental take authorizations to include information about the availability and feasibility (economic and technological) of equipment, methods, and manner of conducting the activity or other means of effecting the least practicable adverse impact upon the affected species or stocks and their habitat (50 C.F.R. §216.104(a)(11)).

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

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

In order to satisfy the MMPA's least practicable adverse impact standard, NMFS Permits Division has evaluated a suite of basic mitigation protocols for seismic surveys that are required regardless of the status of a stock. Additional or enhanced protections may be required for species whose stocks are in particularly poor health and/or subject to some significant additional

stressor that lessens that stock's ability to weather the effects of the specified activities without worsening its status. The NMFS Permits Division reviewed seismic mitigation protocols required or recommended elsewhere (HESS 1999; JNCC 2017; Kyhn et al. 2011; Nowacek et al. 2013), recommendations received during public comment periods for previous actions, and the available scientific literature. The NMFS Permits Division also considered recommendations given in a number of review articles (Compton et al. 2008; Parsons et al. 2009; Weir and Dolman 2007; Wright and Cosentino 2015). This review and consideration of public comments regarding previous similar activities has led to development of the protocols included here. The mitigation and monitoring measures that would be adopted during the high-energy seismic survey, include, but are not limited to shutdown and buffer zones, shutdown procedures, pre-start clearance and ramp-up procedures, vessel-based visual mitigation monitoring, passive acoustic monitoring, vessel strike avoidance measures, and seasonal restrictions (described in Table 3 below).

Table 3. Conservation measures for the high-energy airgun array in the National Marine Fisheries Service Permits and Conservation Division's proposed incidental harassment authorization and possible renewal.

Conservation Measures	High-Energy Airgun Array (18 Airguns with 3,300 in^3 Total Discharge Volume)
Shutdown Zones	500 m (all marine mammals) 1,500 m (all beaked whales and *Kogia* species, large whales with calf, and an aggregation [i.e., six or more animals] of large whales)
Buffer Zones	500 m (from 500 to 1,000 m)
Shutdown Procedures	Shutdown required for marine mammals detected within defined shutdown zone; re-start allowed following clearance period of 15 or 30 minutes.
Pre-Start Clearance and Ramp-Up Procedures	30 minute clearance period of the following shutdown zone: 500 m (all marine mammals) Following detection within shutdown zone, animal must be observed exiting or additional period of 15 or 30 minutes.
Ramp-Up Procedures	Activation of one airgun of the smallest volume in airgun array and continue in stages by doubling the number of active elements at commencement of each stage, with each stage of approximately same duration. Duration must not be less than 20 minutes.
Vessel-Based Visual Mitigation Monitoring	Minimum of two NMFS-approved visual PSOs on duty during daylight hours (30 minutes before sunrise through 30 minutes after sunset); general limit of four consecutive hours on watch followed by a break of at least one hour; maximum of 12 hours on watch per 24-hour period.
Passive Acoustic Monitoring	One NMFS-approved PSO on duty during daylight and nighttime 24 hours per day; general limit of four consecutive hours on watch

Conservation Measures	High-Energy Airgun Array (18 Airguns with 3,300 in^3 Total Discharge Volume)
	followed by a break of at least one hour; maximum of 12 hours on watch per 24-hour period.
Vessel Strike Avoidance Measures	Vigilant watch by PSOs and crew; vessel speeds reduced when assemblages of marine mammals observed near the research vessel; maintain a minimum separation distance between species of concern; avoid vessel course changes in the vicinity of marine mammals.
Seasonal Restrictions	Limit use of airgun array to May 1 through October 31. No use of the airgun array is allowed from November 1 through April 30 to protect North Atlantic right whales.

in^3=cubic inches, m=meters, PSO=protected species observer.

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

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

The NSF and L-DEO IHA application indicated that it reviewed monitoring and mitigation measures implemented during seismic surveys authorized by NMFS Permits Division under previous IHAs, as well as recommended best practices in Richardson et al. (1995), Pierson et al. (1998), Weir and Dolman (2007), Nowacek et al. (2013), Wright (2014), Wright and Consentino (2015), and Acosta et al. (2017) and has incorporated a suite of monitoring and mitigation measures into their proposed actions based on the above sources.

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

- Shutdown and buffer zones;
- Shutdown procedures;
- Pre-start clearance and ramp-up procedures;
- Vessel-based visual monitoring by NMFS-approved PSOs;
- Passive acoustic monitoring;
- Vessel strike avoidance measures;

- Additional conservation measures considered; and
- Reporting.

We discuss the shutdown and buffer zones in more detail in the next section (see below). Additional details for the other mitigation and monitoring measures (e.g., shutdown and ramp-up procedures) as well as reporting can be found in NMFS Permits Division *Federal Register* notice of proposed IHA and possible renewal (88 FR 17646 to 17677) and Appendix A (Section 18).

3.3.1 Shutdown and Buffer Zones

The NMFS Permits Division would require, and the NSF and L-DEO would implement, shutdown and buffer 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 NSF and L-DEO included mitigation and monitoring measures for sea turtles as part of its proposed action. The shutdown zones are areas within which occurrence of a marine mammal or sea turtle triggers a shutdown of the airgun array, to reduce exposure of marine mammals or sea turtles to sound levels expected to have adverse effects on the species or habitats. These shutdown 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. The buffer zone means an area beyond the shutdown zone to be monitored for the presence of marine mammals and sea turtles that may enter the shutdown zone.

3.3.1.1 Ensonified Area

Since the NMFS *Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing* (NOAA 2016) and 2018 revision (NOAA 2018), we recognized that ensonified area/volume could be more technically challenging to predict because of the duration component in the new thresholds, we developed a User Spreadsheet that includes tools to help predict a simple isopleth that can be used in conjunction with marine mammal density or occurrence to help predict takes. We note that because of some of the assumptions included in the methods used for these tools (e.g., stationary receiver with no vertical or horizontal movement in response to the sound source), we anticipate that isopleths produced are typically going to be overestimates of some degree, which may result in some degree of overestimate of adverse effects. 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 would qualitatively address the output where appropriate. For mobile sound sources, such as seismic survey activities, the User Spreadsheet predicts the closest distance at which a stationary animal would not incur permanent threshold shift (PTS) if the sound source traveled by the animal in a straight line at a constant speed. Inputs used in the User Spreadsheet and the resulting isopleths are described further in the NSF's draft environmental assessment/analysis and L-DEO's IHA application and NMFS Permits Division's proposed IHA and possible renewal (88 FR 17646 to 17677).

The L-DEO conducted modeling on behalf of the NSF, University of Texas at Austin, L-DEO, USGS, Brown University, Ohio State University, Southern Methodist University, Virginia Department of Mines, Minerals, and Energy, University of New Mexico, and Ifremer. The L-DEO model results are used to determine the 160 dB re: one µPa (rms) radius for the two GI-airgun array in deep water (greater than 1,000 meters [3,280.8 feet]) down to a maximum water depth of 2,000 meters (6,561.7 feet). Received sound levels were predicted by L-DEO's model (Diebold et al. 2010b), 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: one 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. 2010b; Tolstoy et al. 2009a). Results of the propagation measurements (Tolstoy et al. 2009a) 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 six meters [19.7 feet]) from in the seismic survey activities (2 to 4 meters [6.6 to 13.1 feet]). Because propagation varies with airgun array depth, correction factors have been applied to the distances reported by Tolstoy et al. (2009a).

For deep and intermediate water depths, the field measurements in the Gulf of Mexico cannot be used readily to derive ESA harm and harassment isopleths, as at those sites the calibration hydrophone was located at a roughly constant depth of 350 to 500 meters (1,148.3 to 1,640.4 feet), which may not intersect all the sound pressure level isopleths at their widest point from the sea surface down to the maximum relevant water depth for marine mammals of approximately 2,000 meters (6,561.7 feet) (Costa and Williams 1999). At short ranges, where the direct arrivals dominate and the effects of seafloor interactions are minimal, the data recorded at the deep and slope sites are suitable for comparison with modeled levels at the depth of the calibration hydrophone. At longer ranges, the comparison with the model, constructed from the maximum sound pressure level through the entire water column at varying distances from the airgun array, is the most relevant.

In deep and intermediate water depths, comparisons at short ranges between sound levels for direct arrivals recorded by the calibration hydrophone and L-DEO model results from the same airgun array tow depth are in good agreement (see Figure 12 and Figure 14 of NSF and USGS's *Final Programmatic Environmental Impact Statement/Overseas Environmental Impact Statement for Marine Seismic Research Funded by the National Science Foundation or Conducted by the U.S. Geological Survey* [PEIS] 2011). Consequently, isopleths falling within this domain can be predicted reliably by the L-DEO model, although they may be imperfectly

sampled by measurements recorded at a single depth. At greater distances, the calibration data show that seafloor-reflected and sub-seafloor-refracted arrivals dominate, whereas the direct arrivals become weak and/or incoherent (see Figures 11, 12, and 16 of Appendix H of NSF USGS PEIS 2011). Aside from local topography effects, the region around the critical distance is where the observed levels rise closest to the L-DEO model curve. However, the observed sound levels are found to fall almost entirely below the L-DEO model curve. Thus, analysis of the Gulf of Mexico calibration measurements demonstrates that although simple, the L-DEO model is a robust tool for conservatively estimating isopleths.

The high-energy seismic survey would acquire seismic data with 18 airguns at a tow depth of six meters (19.7 feet). For water depths greater than 1,000 meters (3,280.8 feet), L-DEO used the deep water radii obtained from model results down to a maximum water depth of 2,000 meters (6,561.7 feet) for the airgun array. A simple scaling factor is calculated from the ratios of the isopleths determined by the deep-water mode, which are essentially a measure of the energy radiated by the airgun array. The radii for intermediate water depths of 100 to 1,000 meters (328.1 to 3,280.8 feet) are derived from the deep-water ones by applying a correction factor (multiplication) of 1.5, such that observed levels at very near offsets fall below the corrected mitigation curve (see Figure 16 of in Appendix H of the NSF USGS PEIS 2011). The estimated distances to the 160 dB re: one µPa (rms) isopleths for the 18 airgun array in the intermediate and deep water depth category are in Table 5.

The sound source levels (values for cumulative sound exposure level [SEL_{cum}] and peak sound pressure level [SPL]) were derived from calculating the modeled farfield signature. The farfield signature is often used as a theoretical representation of the source level. To compute the farfield signature, the source level is estimated at a large distance below the airgun array and this source level is back projected mathematically to a notional distance of one meter (3.3 feet) from the airgun arrays geometrical center. However, when the sound source is an airgun array of multiple airguns separated in space, the source level from the theoretical farfield signature is not necessarily the best measurement of the source level that is physically achieved at the sound source (Tolstoy et al. 2009a). Near the sound source (at short ranges, distances less than one kilometer [0.54 nautical miles]), the pulses of sound pressure from each individual airgun in the airgun array of the sound source do not stack constructively, as they do for the theoretical farfield signature. The pulses from the different airguns spread out in time such that the sound source levels observed or modeled are the result of the summation of pulses from a few airguns, not the full airgun array (Tolstoy et al. 2009a). At larger distances, away from the center of the airgun array, sound pressure of all the airguns in the airgun array stack coherently, but not within one time sample, resulting in smaller sound source levels (a few dB) than the sound source level derived from the farfield signature. Because the farfield signature does not take into account the large airgun array effect near the sound source and is calculated as a point source, the modified farfield signature is a more appropriate measure of the sound source level for distributed sound sources, such as airgun arrays. For this smaller airgun array, the modified farfield changes would

be correspondingly smaller as well, but we use this method for consistency across all airgun array sizes.

NSF and L-DEO used the same acoustic modeling methodology as used for estimating the 160 dB re: one µPa (rms) isopleths with a small grid step of one meters (3.3 feet) in both the inline and depth directions to estimate the SEL_{cum} and peak SPL. The propagation modeling takes into account all airgun array interactions at short distances from the sound source, including interactions between subarrays, which are modeled using NUCLEUS software to estimate the notional signature and MATLAB software to calculate the pressure signal at each mesh point of the grid.

In order to more realistically incorporate the NMFS' technical guidance for auditory injury of marine mammals (NOAA 2018) weighting functions over the airgun array's full acoustic band, unweighted spectrum data (modeled in one Hertz [Hz] bands) were used to make adjustments to unweighted spectrum levels, by frequency, according to the weighting functions for each relevant marine mammal hearing group. These adjusted and weighted spectrum levels were then converted to pressures (µPa) in order to integrate them over the entire broadband spectrum, resulting in broadband weighted sound source levels by hearing group that can be directly incorporated within the User Spreadsheet (i.e., to override the User Spreadsheet's more simple weighting factor adjustment). Using the User Spreadsheet's "safe distance" methodology for mobile sound sources (Sivle et al. 2014) with the hearing group-specific weighted sound source levels, and inputs assuming spherical spreading propagation and sound source velocities and shot intervals specific to the planned seismic survey activities, potential radial distances to auditory injury isopleths were then calculated for SEL_{cum} thresholds. The estimated distances to the isopleths for ESA harm for the 18 airgun array in each water depth category are in Table 5. More details of the modeling methodology and inputs to the User Spreadsheet are in Appendix A of the NSF and L-DEO's IHA application.

Auditory injury is unlikely to occur for low-frequency and mid-frequency cetaceans given very small modeled isopleths of injury for those species (up to a maximum of 101.9 meters [334.3 feet] for low-frequency cetaceans, 11.2 meters (36.7 feet) for mid-frequency cetaceans, and 11.8 meters (38.7 feet) for sea turtles for the 18 airgun array), in context of distributed sound source dynamics. The sound source level of the airgun array is a theoretical definition assuming a point source and measurement in the farfield of the sound source (MacGillivray 2006). As described by Caldwell and Dragoset (2000a), an airgun array is not a point source, but one that spans a small area. In the farfield, individual elements in airgun arrays would effectively work as one sound source because individual pressure peaks would have coalesced into one relatively broad pulse. The airgun array can then be considered a "point source." For distances within the nearfield, i.e., approximately two to three times the airgun array dimensions, pressure peaks from individual elements do not arrive simultaneously because the observation point is not equidistant from each element. The effect is destructive interference of the outputs of each element, so that peak pressures in the nearfield would be significantly lower than the output of the largest

individual element. Here, the estimated MMPA Level A harassment isopleth distances would in all cases be expected to be within the nearfield of the airgun array where the definition of sound source level breaks down breaks down in all cases. Therefore, actual locations within this distance of the center of the airgun array where the sound level exceeds relevant criteria for MMPA Level B harassment would not necessarily exist. In general, Caldwell and Dragoset (2000a) suggest that the nearfield for airgun arrays is considered to extend out to approximately 250 meters (820.2 feet). The NMFS Permits Division does not propose to authorize any MMPA Level A harassment for these species.

3.3.1.2 Establishment of Shutdown and Buffer Zones

An shutdown zone is a defined area within which occurrence of a marine mammal or sea turtle triggers mitigation action intended to reduce the potential for certain outcomes (e.g., auditory injury, disruption of critical behaviors or behavioral patterns). The PSOs would establish a default (minimum) shutdown zone with a 500 meter (1,640.4 feet) radius for visual monitoring for the 18 airgun arrays during the high-energy seismic survey. The shutdown zone encompasses the area at and below the sea surface and would be based on the radial distance from any element (the edges) of the airgun array (rather than being based on the center of the airgun array or around the research vessel itself) (0 to 500 meters [0 to 1,640.4 feet]). With certain exceptions (described below), if a marine mammal appears within, enters, or appears on course to enter this shutdown zone, the airgun array would be shutdown.

The buffer zone means an area beyond the shutdown zone to be monitored for the presence of marine mammals and sea turtles that may enter the shutdown zone. The PSOs would also establish and monitor a 500 meter (1,640.4 feet) buffer zone for the high-energy seismic survey. The buffer zone encompasses the area at and below the sea surface from the edge of the shutdown 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]). The buffer zone would serve to focus visual observation effort, but not limit such effort. During the use of the sound source, occurrence of marine mammals within the buffer zone (but outside the shutdown zone) would be communicated to the operator to prepare for potential shutdown of the airgun array.

The 500 meter (1,640.4 feet) shutdown zone, with additional 500 meter (1,640.4 feet) buffer zone, would 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 PSOs would typically be able to conduct effective observational effort. Additionally, the shutdown zone is expected to minimize the likelihood that marine mammals would be exposed to sound levels likely to result in more severe behavioral responses. Although significantly greater distances may be observed from an elevated platform under good conditions, we believe that this distance is regularly attainable for PSOs using binoculars and the naked eye during typical conditions. In this case, the 500 meter (1,640.4 feet) and 150 meter (492.1 feet) radial distances would also be expected to contain sound levels that would exceed the ESA harm threshold based on SEL_{cum} criteria for all marine mammal hearing

groups and sea turtles, respectively. The pre-start clearance zone simply represents the addition of a buffer zone to the shutdown zone, doubling the size of the shutdown zone during pre-start clearance and ramp-up procedures.

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

Table 4. Predicted distances to permanent threshold shift for impulsive sources for various marine mammal hearing groups and sea turtles that could be received from the 18 airgun array during the high-energy seismic survey in the Northwest Atlantic Ocean off North Carolina (NSF 2022).

Threshold	Low Frequency Cetaceans (m)	Mid-Frequency Cetaceans (m)	Sea Turtles (m)
Sound Source – 18 Airgun Array			
SEL_{cum}	101.9	0	11.8
Peak SPL_{flat}	23.3	11.2	9.95

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

The NSF and L-DEO's draft environmental assessment/analysis and IHA application have a detailed description of the modeling for the R/V *Marcus G. Langseth*'s 18 airgun array at a tow depth of six meters (19.7 feet) as well as the resulting isopleths to thresholds for the various marine mammal hearing groups (Table 4). The sound levels and distances for this airgun array configuration would be used in the ensuing analysis, as it has the greatest energy output of the proposed configuration; therefore, it is the most conservative approach. Predicted distances to MMPA Level A harassment isopleths, which vary based on marine mammal hearing groups, were calculated based on modeling performed by L-DEO using the NUCLEUS source modeling software program and the NMFS User Spreadsheet (https://www.fisheries.noaa.gov/action/user-manual-optional-spreadsheet-tool-2018-acoustic-technical-guidance). The largest distance of the dual criteria (SEL_{cum} or Peak SPL_{flat}) was used to calculate MMPA Level A harassment and threshold distances for marine mammals. The 160 dB re: one µPa (rms) isopleth is the distance at which MMPA Level B harassment is expected to occur (Table 5). The 175 dB re: one µPa (rms) isopleth represents our best understanding of the threshold at which sea turtles exhibit behavioral responses to seismic airgun arrays (Table 6).

Table 5. Predicted distances to which sound levels of 160 dB re: one µPa (rms) for harassment (Marine Mammal Protection Act Level B harassment) for impulsive sound sources would be received from the 18 airgun array in intermediate and deep water depths for marine mammals during the high-energy seismic survey in the Northwest Atlantic Ocean off North Carolina (NSF 2022).

Sound Source	Volume (in^3)	Tow Depth (m)	Water Depth (m)	Predicted Distance to Threshold (160 dB re: one µPa [rms]) (m)
18 Airgun Array	3,300	6	100 to 1,000	4,329
18 Airgun Array	3,300	6	Greater than 1,000	2,866

in^3=cubic inches, m=meters, µPa=micro Pascal, rms=root mean square.

The NSF and L-DEO would implement an shutdown zone for sea turtles. A shutdown zone of 150 meters (492.1 feet) would be used as a shutdown distance for sea turtles for the 18 airgun array. This distance is practicable for PSOs to implement shutdowns, and is sufficiently large to prevent sea turtles from being exposed to sound levels that could result in PTS. The buffer zone would correspond to the predicted 175 dB re: one µPa (rms) behavioral threshold distances to which sound source levels would be received from the 18 airgun array in intermediate and deep water depths described in Table 6.

Table 6. Predicted distances to which sound levels of 175 dB re: one µPa (rms) for harassment for impulsive sound sources would be received from the 18 airgun array in intermediate and deep water depths for sea turtles during the high-energy seismic survey in the Northwest Atlantic Ocean off North Carolina.

Sound Source	Volume (in^3)	Tow Depth (m)	Water Depth (m)	Predicted Distance to Threshold (175 dB re: one µPa [rms]) (m)
18 Airgun Array	3,300	6	100 to 1,000	909
18 Airgun Array	3,300	6	Greater than 1,000	606

in^3=cubic inches, m=meters, dB=decibels, µPa=micro Pascal, rms=root mean square.

An extended shutdown zone of 1,500 meters (1,640.4 feet) for the high-energy seismic survey, would be implemented for all beaked whales, dwarf and pygmy sperm whales (*Kogia* spp.), aggregations of six or more large whales (i.e., any baleen whale or sperm whale) and/or a large whale with a calf (calf is defined as an animal less than two-thirds the body size of an adult

observed to be in close association with an adult). No buffer of this extended shutdown zone is required.

A recent retrospective analysis of acoustic propagation of the sound sources on the R/V *Marcus G. Langseth* in a coastal/continental shelf environment from the Cascadia Margin off Washington suggests that modeled isopleths were two to three times larger than measured in shallow water, so they are expected to be very conservative (Crone et al. 2014). Similarly, data collected by Crone et al. (2017) during a high-energy seismic survey off New Jersey in 2014 and 2015 confirmed that in situ measurements and estimates of the 160 dB re: one µPa (rms) distances collected by the towed hydrophone streamer on the R/V *Marcus G. Langseth* were two to three times smaller than the predicted isopleths. Consistent with (Tolstoy et al. 2009b) and (Diebold et al. 2006)(Diebold et al. 2010a), the modeling done by L-DEO with in situ received sound levels have confirmed that the isopleths generated for this high-energy seismic survey are conservative and likely larger (more protective) than those described in the NMFS *Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing* (NOAA 2016) and *NOAA 2018 Revision to Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing* (NOAA 2018).

3.3.2 Shutdown Procedures

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

Following a shutdown, airgun array activity would not resume until the marine mammal has cleared the shutdown zone. The animal would be considered to have cleared the shutdown zone if:

- It is visually observed to have departed the shutdown zone (i.e., the animal is not required to fully exit the buffer zone where applicable); or
- If it has not been seen within the shutdown zone after a clearance period of

  - 15 minutes in the case of small odontocetes, or
  - 30 minutes in the case of mysticetes and all other odontocetes, with no further observation of the marine mammal(s).

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

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

Upon implementation of shutdown, the airgun array may be reactivated after the marine mammal(s) has been observed exiting the applicable shutdown zone (i.e., animal is not required to fully exit the buffer zone where applicable) or following the applicable clearance period described above with no further visual observation of the marine mammal(s). Shutdown of the airgun array would also be required upon visual observation of a marine mammal species for which authorization has not been granted, or a marine mammal species for which authorization has been granted but the authorized number of takes are met, observed approaching, or observed within MMPA Level A and Level B harassment zones.

In addition to the shutdown procedure described above, the NMFS Permits Division's MMPA IHA would require the airgun array be shutdown at a distance of 1,500 meters (4,921.3 feet) when:

- All beaked whales;
- Dwarf and pygmy sperm whales (*Kogia* spp.);
- Any large whale (defined as any 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); and/or
- An aggregation of six or more large whales is observed.

No buffer zone is required for the extended 1,500 meter (4,921.3 feet) shutdown zone.

In addition to the shutdown procedure described above, the NMFS Permits Division's MMPA IHA would require the airgun array be shutdown upon detection (acoustic or visual) of a North Atlantic right whale at any distance.

The NSF and L-DEO will implement a shutdown at a distance of 150 meters (492.1 feet) for ESA-listed sea turtles. The airgun array would be shut-down if a sea turtle is seen approaching or within the shutdown zone. Following a shutdown for ESA-listed sea turtles, the airgun array will

not resume until the ESA-listed sea turtle has cleared the shutdown zone. The animal would be considered to have cleared the shutdown zone if:

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

More details on shutdown procedures can be found in Appendix A, which contains the NMFS Permits Division's proposed IHA and possible renewal (Section 18) of this consultation.

3.3.3 Pre-Start Clearance and Ramp-Up Procedures

A 30-minute pre-start clearance observation period ensures no protected species are observed within the buffer zone and shutdown zone (or extended shutdown zone) prior to the beginning of ramp-up. During pre-start clearance is the only time observations of protected species in the buffer zone will prevent operations (i.e., the beginning of ramp-up). Ramp-up (sometimes referred to as "soft-start") means the gradual and systematic increase of emitted sound levels from an airgun array. The intent of ramp-up is to warn protected species of pending seismic survey actions (if the sound source is sufficiently aversive) and to allow sufficient time for those animals to leave the immediate vicinity prior to the sound source reaching full intensity. A ramp-up procedure, involving a step-wise increase in the number of airguns firing and total airgun array volume until all operational airguns are activated and the full volume is achieved, is required at all times as part of the activation of the airgun array. Ramp-up begins by first activating a single airgun of the smallest volume, followed by doubling the number of active elements in stages until the full complement of airgun arrays are active. Two PSOs would be required to monitor during ramp-up.

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

- The operator must notify a designated PSO of the planned start of ramp-up as agreed upon with the lead PSO;
    - The notification time must not be less than 60 minutes prior to the planned ramp-up in order to allow the PSOs time to monitor the shutdown zone and buffer zone for 30 minutes prior to the initiation of ramp-up (pre-start clearance);
    - One of the PSOs conducting pre-start clearance observations must be notified again immediately prior to initiating ramp-up procedures and the operator must receive confirmation from the PSO to proceed;
- Ramp-ups must be scheduled so as to minimize the time spent with the airgun array activated prior to reaching the designated run-in;
- Ramp-up must not be initiated if any marine mammal is within the applicable shutdown zone or buffer zone.
    - If a marine mammal is observed within the applicable shutdown zone or the buffer zone during the 30 minute pre-start clearance period, ramp-up may not begin until the animal(s) has been observed exiting the shutdown or buffer zones or until an additional time period has elapsed with no further sightings (15

minutes for small odontocetes, and 30 minutes for mysticetes and all other odontocetes.

- Ramp-up must begin by activating a single airgun of the smallest volume in the airgun array and must continue in stages by doubling the number of active airguns at the commencement of each stage, with each stage of approximately the same duration. Duration must not be less than 20 minutes. The operator must provide information to the PSO documenting the appropriate procedures were followed;
- PSOs must monitor the shutdown and buffer zones during ramp-up.
    - Ramp-up may not be initiated or must cease and the airgun array must be shutdown upon acoustic detection or visual observation of a marine mammal within the applicable shutdown zone.
    - Once ramp-up has begun, detections of marine mammals within the buffer zone do not require shutdown, but such observation must be communicated to the operator to prepare for the potential shutdown;
- Ramp-up may occur at times of poor visibility, including nighttime, if appropriate passive acoustic monitoring has occurred with no detections in the 30 minutes prior to beginning ramp-up where operational planning cannot reasonably avoid such circumstances. Ramp-up may occur at night and during poor visibility if the shutdown and buffer zone have been continually monitored by PSOs for 30 minutes prior to ramp-up. Airgun array activation may only occur at times of poor visibility where operational planning cannot reasonably avoid such circumstances;
- If the airgun array is shutdown for brief periods (i.e., less than 30 minutes) for reasons other than that described for shutdown (e.g., mechanical difficulty), it may be activated again without ramp-up if PSOs have maintained constant acoustic and/or visual monitoring and no acoustic or visual detections of marine mammals have occurred within the applicable shutdown zone.
    - For any longer shutdown, pre-start clearance observation and ramp-up are required. For any shutdown at night or in periods of poor visibility (e.g., Beaufort sea state four or greater), ramp-up is required, but if the shutdown period was brief and constant observation was maintained, pre-start clearance watch of 30 minutes is not required; and
- Testing of the airgun array involving all elements requires normal mitigation protocols (e.g., ramp-up). Testing limited to individual sound source elements or strings of the airgun array does not require ramp-up but does require pre-start clearance (visual monitoring for 30 minutes).

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

More details on pre-start clearance and ramp-up procedures can be found in Appendix A, which contains the NMFS Permits Division's proposed IHA and possible renewal (Section 18), of this consultation.

3.3.4 Vessel-Based Visual Mitigation Monitoring

Visual monitoring of the shutdown zones and adjacent waters (buffer zone) is intended to establish and, when visual conditions allow, maintain zones around the sound source that are clear of marine mammals, thereby reducing or eliminating the potential for injury and minimizing the potential for more severe behavioral reactions for animals occurring closer to the research vessel. Visual monitoring of the buffer zone is intended to (1) provide additional protection to naïve marine mammals that may be in the area during pre-start clearance; and (2) during use of the airgun array, aid in establishing and maintaining the shutdown zone by alerting the visual PSO and crew of marine mammals that are outside of, but may approach and enter, the shutdown zone.

Visual monitoring requires the use of trained PSOs to scan the ocean surface visually for the presence of protected species (e.g., marine mammals, sea turtles, and fish). The area to be scanned visually includes primarily the shutdown zone, within which observation of certain protected species requires shutdown of the airgun array, but also the buffer zone and the surrounding waters (to the extent possible depending on environmental conditions). The buffer zone means an area beyond the shutdown zone to be monitored for the presence of marine mammals that may enter the shutdown zone. During pre-start clearance monitoring (i.e., before ramp-up begins), the buffer zone also acts as an extension of the shutdown zone in that observations of marine mammals within the buffer zone would also prevent airgun array operations from beginning (i.e., ramp-up). The standard shutdown zone is 500 meters (1,640.4 feet) for high-energy seismic surveys from the edges of the airgun array. For high-energy seismic surveys, the buffer zone encompasses the area at and below the sea surface from the edge of the 0 to 500 meter (0 to 1,640.4 feet) shutdown 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]). The 1,000 meter (3,280.8 feet) zone (shutdown zone and buffer zone) represents the pre-start clearance zone.

The NSF and L-DEO must use at least five independent, dedicated, trained, NMFS-approved PSOs aboard the R/V *Marcus G. Langseth*. The PSOs would have rotating shifts to monitor for protected species. Two PSOs would be on visual watch at all times during daytime hours (and nighttime ramp-ups, if applicable). A third PSO would be available on standby via radio to assist with sighting documentation if needed. The operator would work with the selected third-party PSO provider to ensure the PSOs have all the equipment (including backup equipment) needed to adequately perform necessary tasks, including accurate determination of distance and bearing to observed marine mammals. NSF and L-DEO must provide PSO resumes to NMFS for approval.

The operator will work with the selected third-party PSO provider to ensure the PSOs have all the equipment (including back-up 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:

- Big-Eye reticle binoculars (e.g., 25 by 150, 2.7 view angle, individual ocular focus, height control) of appropriate quality solely for PSO use. These must be pedestal-mounted on the deck at the most appropriate vantage point that provides for optimal visual observation of the sea surface, PSO safety, and safe operation of the research vessel.
- Handheld reticle binoculars (e.g., seven by 50) of appropriate quality (at least one per PSO, plus backups);
- Global Positioning Unit (GPS, plus backup);
- Digital single-lens reflex cameras of appropriate quality that capture photographs and video (plus backups);
- Compass (plus backup);
- Radios for communication among vessel crew and PSOs (at least one per PSO, plus bakcups); and
- Any other tools necessary to adequately perform necessary PSO tasks.

The PSOs (acoustic and visual) must have the following requirements and qualifications:

- PSOs must be independent, dedicated, and trained and must be employed by a third-party observer provider;
- PSOs must have no tasks other than to conduct observational effort, collect and record observation data, and communicate with and instruct relevant vessel crew with regard to the presence of protected species (marine mammals, sea turtles, and fish) and mitigation requirements (including brief alerts regarding maritime hazards);
- PSOs must have successfully completed an acceptable PSO training course appropriate for their designated task (acoustic or visual). PSOs must have successfully completed relevant training, including completion of all required coursework and passing a written and/or oral examination developed for the training program;
- NMFS must review and approve PSO resumes accompanied by a relevant training course information packet that includes the name and qualifications (i.e., experience, training completed, or educational background) of the instructor(s), the course outline or syllabus, and course reference material as well as a document stating successful completion of the course;
- NMFS should have one week to approve PSOs from the time that the necessary information is submitted, after which PSOs meeting the minimum requirements must automatically be considered approved;
- One visual PSO with experience must be designated as the lead for the PSO team. The lead PSO must coordinate duty schedules and roles for the PSO team and serve as

primary point of contact for the vessel operator. (Note that the responsibility of coordinating duty schedules and roles may instead by assigned to a shore-based, third-party monitoring coordinator.) To the maximum extent practicable, the lead PSO must devise the duty schedule such that experienced PSOs are on duty with those PSOs with appropriate training but who have not yet gained relevant experience.

- 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;
- 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 courses in math or statistics; and
- The educational requirements may be waived if the PSO has acquired the relevant skills through alternate experience. Requests for such a waiver should be submitted to NMFS and must include written justification. Requests should 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 must demonstrate good standing and consistently good performance of PSO duties.
- Individual PSOs may perform acoustic and visual duties, though not at the same time.

At least one of the visual PSOs and two of the acoustic PSOs aboard the research vessel must have a minimum of 90 days at-sea experience working in that role during deep penetration or high-energy seismic surveys, with no more than 18 months elapsed since the conclusion of the at-sea experience. One visual PSO with such experience should be designated as the lead for the entire PSO team. The lead PSO should serve as the primary point of contact for the vessel operator and ensure all PSO requirements per the MMPA IHA are met. To the maximum extent practicable, the experienced PSOs would be scheduled to be on duty with those PSOs 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 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 nighttime ramp-ups of the airgun array. Visual monitoring of the shutdown and buffer zones must begin no less than 30 minutes prior to ramp-up and must continue until one hour after use of the airgun array ceases or until 30 minutes past sunset. Visual PSOs should coordinate to ensure 360 degree visual coverage around the research vessel from the most appropriate observation positions, and must conduct visual observations using reticled

binoculars and the naked eye while free from distractions and in a consistent, systematic, and diligent manner.

The PSOs would establish and monitor the buffer and shutdown zones. The buffer and shutdown zones would be based upon the radial distance from the edges of the airgun array rather than being based on the center of the airgun array or around the research vessel itself. During use of the airgun array (i.e., anytime the airgun array is active, including ramp-up), occurrences of marine mammals within the buffer zone (but outside the shutdown zone) would be communicated to the operator to prepare for the potential shutdown of the airgun array. Visual PSOs would immediately communicate all visual observations to the acoustic PSO on duty, including any determination by the PSO regarding species identification, distance, and bearing, and the degree of confidence in the determination.

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 shutdown zone, will be communicated to the operator to prepare for the potential shutdown of the airgun array. Any observations of marine mammals by crew members would be relayed to the PSO team. During good conditions (e.g., daylight hours, Beaufort sea state three or less), visual PSOs would conduct visual observations when the airgun array is not operating (e.g., while the airgun array and towed hydrophone streamer are being deployed or recovered from the water, during transits) for comparison of sighting rates and behavior with and without use of the airgun array and between acquisition periods, to the maximum extent practicable. The NSF and L-DEO must ensure that relevant personnel and PSOs participate in a joint onboard briefing led by the vessel operator and lead PSO to ensure that responsibilities, communication procedures, protocols for monitoring of protected species, operational procedures, and IHA requirements are clearly understood.

Visual PSOs may be on watch for a general limit 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 PSO. Combined observational duties (acoustic and visual but not at the same time) may not exceed 12 hours of observation per 24-hour period for any individual PSO. However, during off-hours the resting PSO may be called for consultation if a second opinion be needed. Other vessel crew would also be instructed to assist in detecting marine mammals and implementing mitigation requirements, if practical. Before the start of the high-energy seismic survey, the crew would be given additional instruction in detecting marine mammals and implementing mitigation measures. The PSOs would be in communication (e.g., direct radio contact) with the research vessel's officers on the bridge and scientists in the laboratory during seismic survey activities so that they can advise promptly of the need for the implementation of shutdown procedures of the airgun array or vessel strike avoidance measures. The PSOs would use radios to directly contact vessel operators, crew, and researchers. The vessel operators, science support personnel, and science party must comply immediately with the PSO's call to shutdown the airgun array or for vessel strike avoidance measures.

When visual PSOs would stationed on the observation platform of the R/V *Marcus G. Langseth*, eye level would be approximately 21.5 meters (70.5 feet) above sea level, and the position provides an approximate 360 degree view around the research vessel. Visual PSOs would systematically scan around the research vessel with Big-Eye reticle binoculars (25 by 150), handheld reticle binoculars (e.g., seven by 50 Fujinon), and with the naked eye. Handheld reticle binoculars (seven by 50 Fujinon or equivalent) are usually equipped with a built-in daylight compass and the range reticle, which would be used to measure distances to animals. The PSOs would also have optical range finders, thermal imaging devices (FLIR M324 thermal imaging system), and night vision devices (ITT F500 Series Generation 3 binocular-image intensifier or equivalent) during darkness, if necessary. At a minimum the night, the night vision device should feature automatic brightness and gain control, bright light protection, infrared illumination, and optics suited for low-light situations. At least one PSO would conduct visual monitoring at all times during daytime periods when the R/V *Marcus G. Langseth* is underway when not conducting seismic survey activities, such as during transits.

For data collection purposes, PSOs must use standardized data collection forms, whether hard copy or electronic. The PSOs must record detailed information about any implementation of mitigation requirements, including the distance of animals to the sound source and description of specific actions that ensued, the behavior of the animal(s), any observed changes in behavior before and after implementation of mitigation, and if shutdown was implemented, the length of time before any subsequent ramp-up of the airgun array. If required mitigation was not implemented, PSO should record a description of the circumstances. At a minimum, the following information must be recorded:

- Vessel name and call sign;
- PSO names and affiliations;
- Date and participants of PSO briefings;
- Dates of departures and returns to port with port name;
- Dates and times (Greenwich Mean Time) of survey effort and times corresponding with PSO effort;
- Vessel location (latitude/longitude) when survey effort began and ended and vessel location at beginning and end of visual PSO duty shifts;
- Vessel heading and speed at beginning and end of visual PSO duty shifts and upon any line change;
- Environmental conditions while on visual survey (at beginning and end of PSO shift and whenever conditions changed significantly), including Beaufort sea state and any other relevant weather conditions including cloud cover, fog, sun glare, and overall visibility to the horizon;
- Factors that may have contributed to impaired observations during each PSO shift change or as needed as environmental conditions changed (e.g., vessel traffic, equipment malfunctions); and

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

The following information must be recorded upon visual observation of any marine mammal:

- Watch status (sighting made by PSO on/off effort, opportunistic, crew, alternate vessel/platform);
- PSO who sighted the animal;
- Time of sighting;
- Vessel location at time of sighting;
- Water depth;
- Direction of vessel's travel (compass direction);
- Direction of animal's travel relative to the vessel;
- Pace of the animal;
- Estimated distance to the animal and its heading relative to vessel at initial sighting;
- Identification of the animal (e.g., genus/species, lowest possible taxonomic level, or unidentified) and the composition of the group if there is a mix of species;
- Estimated number of animals (high/low/best);
- Estimated number of animals by cohort (adults, yearlings, juveniles, calves, group composition, etc.);
- Description (as many distinguishing features as possible of each individual seen, including length, shape, color, pattern, scars or markings, shape and size of dorsal fin, shape of head, and blow characteristics);
- Detailed behavior observations (e.g., number of blows/breaths, number of surfaces, breaching, spyhopping, diving, feeding, traveling; as explicit and detailed as possible; note any observed changes in behavior);
- Animal's closest point of approach and/or closest distance from any element of the sound source;
- Platform activity at time of sighting (e.g., deploying, recovering, testing, shooting, data acquisition, other); and
- Description of any actions implemented in response to the sighting (e.g., delays, shutdown, ramp-up) and time and location of the action.

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

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

3.3.5 Passive Acoustic Monitoring

Passive acoustic monitoring means the use of trained personnel operators, herein referred to as acoustic PSOs, to operate passive acoustic monitoring equipment to acoustically detect the presence of vocalizing marine mammals. Passive acoustic monitoring involves acoustically detecting and identifying 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 vessel-based visual mitigation monitoring (during daylight hours) in maintaining an shutdown zone around the airgun array that is clear of marine mammals. In cases where vessel-based visual mitigation monitoring is not effective (e.g., due to weather, nighttime), passive acoustic monitoring may be used to allow certain seismic survey activities to occur, as further detailed below.

Passive acoustic monitoring would take place in addition to the vessel-based visual mitigation monitoring program. Vessel-based visual mitigation monitoring is typically 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 water's surface or beyond visual range. Passive acoustic monitoring can be used in addition to visual observations to improve detection, identification, and localization of vocalizing marine mammals. The passive acoustic monitoring would serve to alert visual PSOs (if on duty) when vocalizing marine mammals are detected. It is only useful when marine mammals vocalize, 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 PSOs can be advised when marine mammals are detected. Passive acoustic monitoring must include a system that has been tested and verified by an experienced acoustic PSO that would be using it during the trip for which monitoring is required. Acoustic PSOs would be required to complete a specialized training for operating passive acoustic monitoring systems and are encouraged to have familiarity with the research vessel with which they would be working.

The passive acoustic monitoring system would consist of hardware (i.e., towed hydrophone streamer) and software (i.e., Pamguard). The "wet end" of the passive acoustic monitoring system consists of a towed hydrophone streamer that is connected to the research vessel by a tow cable. The steel reinforced tow cable is approximately 250 meters (820.2 feet) long and the detachable hydrophone array is approximately 25 meters (82 feet) long. The hydrophones are fitted in the last ten meters (32.8 feet) of towed hydrophone streamer. A depth gauge (with 100 meter [328.1 feet] capacity) is attached to the free end of the cable, and the cable is typically towed at a depth of less than 20 meters (65.6 feet). The towed hydrophone array would be deployed from a winch located on the stern deck; however, the deployment and connection to the research vessel may change depending upon weather conditions and configuration of the airgun array. The "dry end" of the passive acoustic monitoring system consists of a cable on deck that would connect the tow cable to the electronics unit in the main computer laboratory where the

passive acoustic monitoring station would be located. The acoustic signals received by the towed hydrophone streamer are amplified, conditioned, digitized, and processed by Pamguard software. The passive acoustic monitoring system can detect marine mammal vocalizations at frequencies from ten Hz to 250 kHz. The hydrophone array would consist of two low-frequency hydrophones (ten Hz to 24 kHz), two mid-frequency hydrophones (200 Hz to 200 kHz) and two high-frequency hydrophones (two kHz to 200 kHz).

The passive acoustic monitoring system would be monitored 24 hours per day during airgun array operations and most periods when the airgun array is not operating. If the passive acoustic monitoring system is damaged or malfunctions, it would be repaired and redeployed as soon as possible. The acoustic PSO would monitor the passive acoustic monitoring system by listening to the signals from two channels using headphones and/or speakers as well as watching the real-time spectrographic display on the computer monitors for frequency ranges produced by marine mammals. The passive acoustic monitoring system must be monitored by a minimum of one on-duty acoustic PSO beginning at least 30 minutes prior to ramp-up and at all times (day and night) during the use of the airgun array. When both acoustic and visual PSOs are on-duty, all detections must be immediately communicated to the remainder of the on-duty PSO team for potential verification of visual observations by the acoustic PSO or of acoustic detections by visual PSOs. An acoustic PSO may be on watch for a maximum of 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 of any individual PSO. Combined observational duties (acoustic and visual but not at the same time) may not exceed 12 hours of observation per 24-hour period for any individual PSO. All PSOs would be expected to rotate through the acoustic and visual positions, although the most experienced with acoustics would be on duty at the passive acoustic monitoring system more frequently.

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

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

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

- An acoustic encounter identification number, and whether the detection was linked with a visual sighting;
- Date and time when first and last heard;

- Types and nature of sounds heard (e.g., clicks, whistles, creaks, burst pulses, continuous, sporadic, strength of signal);
- Any additional information recorded such as water depth of the hydrophone array, bearing of the animal to the vessel (if determinable), species or taxonomic group (if determinable), spectrogram screenshot, and any other notable information.

Seismic survey activities may continue for 30 minutes when the passive acoustic monitoring system malfunctions or is damaged, while the passive acoustic monitoring operator diagnoses the issue. If the diagnoses indicates that the passive acoustic monitoring system must be repaired to solve the problem, operations may continue for an additional five 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 shutdown 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.

The passive acoustic monitoring system will be used to implement shutdown requirements if North Atlantic right whale vocalizations are detected, regardless of localization (i.e., distance).

3.3.6 Vessel Strike Avoidance Measures

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

- The vessel operator (R/V *Marcus G. Langseth*) and crew must maintain a vigilant watch for all marine mammals and slow down or stop or alter course of the vessel, as appropriate and regardless of vessel size, to avoid striking any marine mammal. A visual observer aboard the vessel must monitor a vessel strike avoidance zone around the vessel (specific distances detailed below). Visual observers monitoring the vessel strike avoidance zone may either be third-party PSOs or crew members, but crew members responsible for these duties would be provided sufficient training to distinguish marine mammals from other phenomena and broadly to identify a marine mammal to broad taxonomic group (i.e., as a North Atlantic right whale, large whale, or other marine mammal).
- Vessel speeds must be reduced to 18.5 kilometers per hour (ten knots) or less when mother/calf pairs, pods, or large assemblages of marine mammals are observed near the vessel.

- All vessels, regardless of size, must observe a 18.5 kilometers per hour (ten knots) speed restriction in specific areas designated by NMFS for the protection of North Atlantic right whales from vessel strikes. These include all seasonal management areas established under 50 C.F.R. §224.105 (when in effect), any dynamic management areas (when in effect), and slow zones. More information is available online at: www.fisheries.noaa.gov/national/endangered-species-conservation/reducing-ship-strikes-north-atlantic-right-whales for specific detail regarding these areas.
- The vessel (R/V *Marcus G. Langseth*) must maintain a minimum separation distance of 500 meters (1,640.4 feet) from North Atlantic right whales. If a whale is observed but cannot be confirmed as a species other than a North Atlantic right whale, the vessel operator must assume that it is a North Atlantic right whale and take appropriate action.
- The vessel (R/V *Marcus G. Langseth*) must maintain a minimum separation distance of 100 meters (1,640.2 feet) from large whales (i.e., all baleen whales and sperm whales).
- The vessel must, to the maximum extent practicable, maintain a minimum separation distance of 50 meters (164 feet) from all other marine mammals, with an understanding that at times this may not be possible (e.g., for animals that approach the vessel).
- When marine mammals are sighted while a vessel is underway, the vessel must take action as necessary to avoid violating the relevant separation distance (e.g., attempt to remain parallel to the animal's source, avoid excessive speed or abrupt changes in direction until the animal has left the area). If marine mammals are sighted within the relevant separation distance, the vessel must reduce speed and shift the engine to neutral, not engaging the engines until the animal(s) are clear of area. This does not apply to any vessel towing gear or any vessel that is navigationally constrained.

3.3.7 Seasonal Restrictions

NSF and L-DEO must limit use of the airgun array to May 1 through October 31. No use of the airgun array is allowed from November 1 through April 30 to protect North Atlantic right whales during their migration through the action area. The movement of the research vessel and other seismic survey activities that do not require the use of an airgun array may occur outside of these dates. If any activities (non-seismic) are conducted between November 1 through April 30, daily PSO logs must be sent to Kara Shervanick (kara.shervanick@noaa.gov) at NMFS Southeast Regional Office.

3.3.8 Additional Conservation Measures Considered

Additional conservation measures were considered by the NSF and L-DEO during the planning phase of the high-energy seismic survey to reduce the severity of the effects of the action on ESA-listed species. Additional detail is described below in this consultation.

3.3.8.1 Sound Source

The NSF and L-DEO considered and evaluated whether the research objectives could be met with a smaller sound source for the high-energy seismic survey. The NSF and L-DEO

determined that the 18 airgun array to be the lowest practical sound source to meet the scientific objectives for the high-energy seismic survey. The sound source would be half the size of the 36 airgun array that would be typically used by L-DEO. Based on experience, the principal investigators have found that this relatively large sound source (18 airgun array) is considered the minimum that would provide sufficient energy to penetrate the crustal depths that would address the project goals.

3.3.8.2 Speed or Course Alteration

The NSF would alter the R/V *Marcus G. Langseth*'s speed and course during seismic survey activities if a marine mammal, based on its position and relative motion, appears likely to enter the 100 meters (328.1 feet) shutdown zone. Speed and course alteration would be implemented if operationally practicable and meets safety requirements while minimizing the effect on the planned scientific objectives. The seismic survey activities and movements of the protected species (relative to the research vessel) would be closely monitored to determine whether the animal is approaching the applicable shutdown zone. If speed or course alteration is not safe or practical (e.g., without damaging deployed equipment) or, if after alteration, the marine mammal still appears likely to enter the shutdown zone (100 meters [328.1 feet]), further mitigation measures (such as shutdown procedures) would be taken. Typically, during seismic survey activities, the R/V *Marcus G. Langseth* is unable to change speed and course and one or more alternative mitigation measures would need to be implemented.

3.3.8.3 Location and Timing

The principal investigators worked with the NSF, L-DEO, and its contractors to consider and identify potential times to carry out the high-energy seismic survey, taking into consideration key factors such as environmental conditions (e.g., seasonal presence of marine mammals, sea turtles, and seabirds), weather conditions, equipment, and optimal timing for other research cruises using the R/V *Marcus G. Langseth*. Marine mammals (including baleen whales) and sea turtles are expected to occur in the seismic survey area throughout the year, and baleen whales appear to be most common off North Carolina during the winter. The occurrence of North Atlantic right whales appears to peak during February through March off North Carolina, but they are unlikely to occur in the deep waters of the offshore seismic survey area. The calving season for North Atlantic right whales is conventionally considered to be November through April. Due to concern about seismic survey activities during the months close to the calving season, NSF and L-DEO plan to avoid seismic survey activities from November through April. Hurricane season typically occurs during June through November. The late spring or summer schedule (May through September or October) is proposed as it is the most practical season based on the occurrence of marine mammals, weather conditions, other operational requirements (e.g., availability of the research vessel and equipment) and data quality concerns, and availability of researchers.

The seismic survey locations were chosen as the Cape Fear region is an ideal location for a study of submarine landslide history on the Eastern North American Margin through the Neogene

during passive margin evolution due to existing evidence of a long history of slope failure that is intricately linked with margin building processes. The unknowns in the history and dynamics of buried mass transport deposits on the mid-Atlantic margin clearly merit more study, particularly since future landslides and landslide-generated tsunamis pose a risk to seafloor infrastructure and coastal populations. Despite their prevalence on the mid-Atlantic margin, very little is understood about their causes, mechanical and kinetic behavior, and frequency in the context of passive margins. The newly acquired densely-spaced, high-resolution seismic grid can be integrated with the sparse existing seismic and International Ocean Discovery Program drilling data to allow for the identification of source regions for the mass transport deposits material, date key horizons, and constrain rock physical properties. The research proposal for the high-energy seismic survey underwent the NSF merit review process, and the science, including the site location, was determined to be meritorious.

3.3.9 Reporting

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

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

- Occurrence of marine mammal species or stocks in the area in which take is anticipated (e.g., presence, abundance, distribution, density).
- Nature, scope, or context of likely marine mammal exposure to potential stressors/impacts (individual or cumulative, acute or chronic), through better understanding of (1) action or environment (e.g., source characterization, propagation, ambient noise); (2) affected species (life history, diver patterns); (3) co-occurrence of marine mammal species with the action; or (4) biological or behavioral context of exposure (e.g., age, calving, or feeding areas).
- Individual marine mammal responses (behavioral or physiological) to acoustic stressors (acute, chronic, or cumulative), other stressors, or cumulative impacts from multiple stressors.
- How anticipated responses to stressors impact either (1) long-term fitness and survival of individual marine mammals; or (2) populations, species, or stocks.
- Effects on marine mammal habitat (e.g., marine mammal prey species, acoustic habitat, or other important physical components of marine mammal habitat).

- Mitigation and monitoring effectiveness.

To support NMFS' goal of improving our understanding of occurrence of marine mammal species or stocks in the action area (e.g., presence, abundance, distribution, density), NSF and L-DEO would immediately report observations of North Atlantic right whales to NMFS Office of Protected Resources. Although the likelihood of encountering either species is considered to be rare and unexpected.

NSF and L-DEO must submit a draft comprehensive report to NMFS Permits Division on all seismic survey activities and monitoring results within 90 days of the completion of the high-energy seismic survey or expiration of the IHA, whichever comes sooner. A final report must be submitted within 30 days following resolution of any comments on the draft report. The report would describe a summary of all the seismic survey activities that were conducted and sightings of marine mammals near the proposed actions. The report would provide a summary of all data required to be collected. The report would provide full documentation of methods, results, and interpretation pertaining to all monitoring and would summarize the dates and locations of seismic survey activities (including the number of days on which the airgun array was active, and the percentage of time and total time the airgun array was active during daylight versus nighttime hours [including dawn and dusk]), and all marine mammal sightings (dates, times, locations, activities, associated seismic survey activities). The report would also include estimates of the number and nature of exposures that occurred within estimated harassment zones based on PSO observations and including an estimate of those that were not detected, in consideration of both the characteristics and behaviors of the species of marine mammals that affect detectability as well as the environmental factors that affect detectability.

The draft report must also include geo-referenced time-stamped vessel tracklines for all time periods during which the airgun array were operating. Tracklines should include points recording any change in the airgun array status (e.g., when the airgun array began operating, when they were turned off, or when they changed from full airgun array to single airgun or vice versa). Geographic information system (GIS) files shall be provided in Environmental Systems Research Institute (ESRI, a GIS company) shapefile format and include the coordinated universal time (Dodge et al.) date and time, latitude in decimal degrees, and longitude in decimal degrees. All coordinates shall be referenced to the WGS84 geographic coordinate system. In addition to the report, all raw observational data shall be made available to NMFS Permits Division.

L-DEO must notify the NOAA Southeast Regional Office on the start and end date of seismic survey activities in the action area via email (nmfs.ser.research.notification@noaa.gov).

More details on reporting (e.g., reporting injured or dead marine mammals and reporting species of concern) and actions to minimize additional harm to live-stranded (or milling) marine mammals and additional information requests can be found in Appendix A, which contains NMFS Permits Division's proposed IHA and possible renewal (Section 18), of this consultation.

4 POTENTIAL STRESSORS

The proposed actions involve multiple activities, each of which can create stressors. Stressors are any physical, chemical, or biological entity that may induce an adverse response either in an ESA-listed species or their designated critical habitat. During consultation, we deconstructed the proposed actions to identify stressors that are reasonably certain to occur from the proposed actions. These can be categorized as pollution (e.g., exhaust, fuel, oil, and trash), vessel strikes, acoustic noise and visual disturbance (research vessel, seismic airgun array, sub-bottom profiler, multi-beam echosounder, split-beam echosounder, and acoustic Doppler current profiler), and entanglement and interaction in towed seismic equipment (airgun array and hydrophone streamer), and coring equipment and heat flow measurement probe.

Below we provide detailed information on the effects of these potential stressors. Furthermore, the proposed actions includes several conservation (monitoring and mitigation) measures described in Section 3.3 that are designed to minimize effects that may result from these potential stressors. While we consider all of these conservation measures important and expect them to be effective in minimizing the effects of potential stressors, they do not completely eliminate the identified stressors. Nevertheless, we treat them as part of the proposed actions and fully consider them when evaluating the effects of the proposed actions (Section 10).

4.1 Pollution

The operation of the R/V *Marcus G. Langseth* 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 include carbon dioxide, methane, nitrous oxide, and other fluorinated gases that can deplete the ozone, affect natural earth cycles, and ultimately contribute to climate change (see https://www.epa.gov/ghgemissions/overview-greenhouse-gases for additional information). Pollutants in discharges of gray water and wastewater from the research vessel can degrade habitat for marine life.

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

4.2 Vessel Strike

The transit of any research vessel in waters inhabited by ESA-listed species carries the risk of a vessel strike. If an animal is struck by a research vessel, it may experience minor, non-lethal injuries, serious injuries, or death (Brown and Murphy 2010; Laist et al. 2001; NMFS and USFWS 2008b; Work et al. 2010a).

The probability of a vessel collision and the associated response depends on the number, size, and speed of the vessel, as well as the distribution, abundance, and behavior of the species (Conn and Silber 2013a; Hazel et al. 2007; Jensen and Silber 2004; Laist et al. 2001; Vanderlaan and Taggart 2007). The R/V *Marcus G. Langseth* has a length of 72 meters (235 feet) and the operating speed during seismic data acquisition is typically 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 maximum speed is approximately 24.1 kilometers per hour (13 knots). Faster travel, especially of large vessels of 80 meters (262.5 feet) or greater, are more likely to cause serious injury or death (Conn and Silber 2013a; Jensen and Silber 2004; Laist et al. 2001; Vanderlaan and Taggart 2007) at speeds greater than approximately 18.5 kilometers per hour (10 knots). Thus, vessel strikes are more likely to occur when the vessel is transiting than when seismic survey activities are underway.

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. 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 (two 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 2013b; Jensen and Silber 2004; Laist et al. 2001; Vanderlaan and Taggart 2007).

Each of the ESA-listed fish species considered in this consultation 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 consultation 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 of the conservation measures (e.g., vessel strike avoidance measures) proposed by the NMFS Permits Division and/or NSF and L-DEO would minimize the risk of vessel strike (e.g., use of PSOs, vessel strike avoidance measures). In addition, the overall level of research vessel activity associated with the proposed actions is low relative to the large size of the action area, further reducing the likelihood of a vessel strike of an ESA-listed species. Nevertheless, vessel strike remains a potential stressor associated with the proposed actions.

4.3 Acoustic Noise from the Research Vessel Noise and Visual Disturbance

The proposed actions would produce a variety of different sounds including those associated with vessel operations, sub-bottom profilers, multi-beam echosounders, split-beam echosounders, acoustic Doppler current profilers, and airgun arrays that may produce an acoustic disturbance or otherwise affect ESA-listed species. It would 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 acoustic noise from the airgun array, sub-bottom profilers, multi-beam echosounders, split-beam echosounders, and acoustic Doppler current profilers, would be discussed further in Section 4.4.

The research vessel associated with the proposed actions may cause visual or auditory disturbances to ESA-listed species that spend time near the water surface. 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. 2008a). 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). At close distances animals may not even differentiate between visual and acoustic disturbances created by vessels and simply respond to the combined disturbance. Nonetheless, it is generally not possible to distinguish responses to the visual presences of vessels from those to the sounds associated with those vessels.

In addition, while not specifically designed to do so, several aspects of the vessel strike avoidance measures would minimize effects associated with vessel disturbance. However, even with these conservation measures, visual and acoustic disturbances are considered a potential stressor.

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

Sounds emitted by large vessels can be characterized as low-frequency, continuous, or tonal, and sound pressure levels at a source would vary according to speed, burden, capacity, and length (Kipple and Gabriele 2007; McKenna et al. 2012; Richardson et al. 1995a). Source levels for 593 container ships transits were estimated from long-term acoustic recording received levels in the Santa Barbara shipping channel, and a simple transmission loss model using Automatic Identification System data for source-receiver range (McKenna et al. 2013a). Vessel noise levels could vary five to ten dB depending on transit conditions. Given the sound propagation of low frequency sounds, a large vessel in this sound range can be heard 139 to 463 kilometers (75.1 to 250 nautical miles) away (Polefka 2004). Hatch et al. (2008) measured commercial ship underwater noise levels and reported average source level estimates (71 to 141 Hz, re: one µPa [rms] ± standard error) for individual vessels ranged from 158 ± two dB (research vessel) to 186 ± two dB (oil tanker). McKenna et al. (2012) documented different acoustic levels and spectral shapes observed from different modern vessel-types in a study off Southern California.

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

ESA-listed sea turtles 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. 2014b). 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 turtles suggests that sea turtles may habituate to vessel sound and may be more likely to respond to the sight of a vessel rather than the sound of a vessel, although both may play a role in prompting reactions (Hazel et al. 2007). Regardless of the specific stressor associated with vessels to which sea turtles are responding, they only appear to show responses (i.e., avoidance behavior) at approximately ten 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 nearfield, 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. 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 (Section 10).

4.4 Acoustic Noise from the Airgun Array

Unlike vessels, which produce sound as a byproduct of their operations, sub-bottom profilers, multi-beam echosounders, split-beam echosounders, acoustic Doppler current profilers, and airgun arrays are designed to actively produce sound, and as such, the characteristics of these sound sources are deliberate and under control. Assessing whether these sounds may adversely affect ESA-listed species involves understanding the characteristics of the acoustic sources, the species that may be present in the vicinity of the sound, and the effects that sound may have on the physiology and behavior of those species. Although it is known that sound is important for marine mammal communication, navigation, and foraging (NRC 2003b; NRC 2005), there are many unknowns in assessing impacts of sound, such as the potential interaction of different effects and the significance of responses by marine mammals to sound exposures (Nowacek et al. 2007; Southall et al. 2007a). 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. 2014c). 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 (Section 10).

Several of the conservation measures (e.g., ramp-up and shutdown procedures, vessel-based visual mitigation monitoring, and passive acoustic monitoring) proposed by the NMFS Permits Division and/or NSF and L-DEO would minimize the risk of acoustic noise from the airgun array. Nevertheless, acoustic noise from the airgun array remains a potential stressor associated with the proposed actions.

4.5 Acoustic Noise from the Sub-Bottom Profiler, Multi-Beam Echosounder, Split-Beam Echosounder, and Acoustic Doppler Current Profiler

The sub-bottom profiler, multi-beam echosounder, split-beam echosounder, and acoustic Doppler current profiler are four active acoustic systems that would operate during the high-

energy seismic survey on the R/V *Marcus G. Langseth*. As described above in Section 3.1.4, a sub-bottom profiler, multi-beam echosounder, split-beam echosounder, and acoustic Doppler current profiler would be operated continuously during the seismic survey activities and transits or when the airgun array is not operating.

The sub-bottom profiler, multi-beam echosounder, split-beam echosounder, and acoustic Doppler current profiler, (in addition to the airgun array) have the potential to expose ESA-listed marine mammal species to sound levels above the 160 dB re: one µPa (rms) threshold for ESA harassment. The sub-bottom profiler, multi-beam echosounder, split-beam echosounder, and acoustic Doppler current profiler operate at a frequency of 3.5 kHz, 10.5 to 13 (usually 12) kHz, 75 kHz, and 19 to 34 kHz, respectively. These frequencies are generally higher frequencies than airgun array operations (six to 20 Hz for the 18 airgun array). These frequencies are within the functional hearing range of baleen whales (seven Hz to 35 kHz), such as blue whales, fin whales, North Atlantic right whales, and sei whales, sperm whales (150 Hz to 160 kHz) (NOAA 2018). We expect that these mapping systems would 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 kHz within the 80 to 90 dB re: one 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 four kHz mid-frequency sonar at received levels below 90 dB re: one µPa (rms). Responses included cessation of foraging, increased swimming speed, and directed travel away from the sound source (Goldbogen 2013). Hearing is poorly understood for ESA-listed baleen whales, but it is assumed that they are most sensitive to frequencies over which they vocalize, which are much lower than frequencies emitted by the sub-bottom profiler, multi-beam echosounder, split-beam echosounder, and acoustic Doppler current profiler (Ketten 1997b; Richardson et al. 1995c).

The frequencies from these devices would attenuate more rapidly than those from airgun array sound sources. For these reasons, ESA-listed species would likely experience higher levels of sound from the airgun array well before sounds of equal amplitude from the sub-bottom profiler, multi-beam echosounder, split-beam echosounder, and acoustic Doppler current profiler since these other sound sources would drop off faster than the airgun arrays. In addition, the sub-bottom profiler, multi-beam echosounder, split-beam echosounder, and acoustic Doppler current profiler are expected to affect a smaller ensonified area within the larger sound field produced by the airgun array and are not expected to be of sufficient duration that would lead to the onset of a temporary threshold shift (Fritts et al.) in hearing or PTS for an animal. Therefore, sounds from the airgun array are expected to effectively cancel out sounds produced by the sub-bottom profiler, multi-beam echosounder, split-beam echosounder, and acoustic Doppler current profiler.

For the sub-bottom profiler, the instrument emits energy in a 27 degree beam (cone) downward from the bottom of the research vessel with ping duration 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. For the multi-beam echosounder, the transmitting beamwidth is very narrow, zero or two degrees fore-aft and 150 degrees (maximum) athwartship, and emits a series of 0.7 to 200 millisecond pulses. For the split-beam echosounder, the transmitting beamwidth is seven degrees or 11 degrees and emits eight millisecond pulse duration and the ping repetition rate would be one second. For the acoustic Doppler current profiler, the instrument would have a 30 degree conically-shaped beam, and emits a series of 11 to 37 millisecond pulses and has a ping rate of 0.7 seconds. Given the movement and speed of the research vessel, the intermittent and narrow downward-directed nature of the sounds emitted by the sub-bottom profiler, multi-beam echosounder, split-beam echosounder, and acoustic Doppler current profiler, would result in no more than one or two brief ping exposures of any individual marine mammal, sea turtle, or fish, if any exposure were to occur.

The response of a blue whale to 3.5 kHz sonar supports this species' ability to hear the signal from the sonar (Goldbogen 2013). Maybaum (1990; 1993) observed that Hawaiian humpback whales moved away and/or increased swimming speed upon exposure to 3.1 to 3.6 kHz 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 would have to pass at close range and be swimming at speeds similar to the vessel. The animal would 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. Assumptions for sperm whale hearing are much different than for ESA-listed baleen whales. Sperm whales vocalize between 3.5 to 12.6 kHz and an audiogram of a juvenile sperm whale provides direct support for hearing over this entire range (Au 2000; Au et al. 2006; Carder and Ridgway 1990; Erbe 2002a; Frazer and Mercado 2000; Goold and Jones 1995a; Levenson 1974; Payne and Payne 1985; Payne 1970; Richardson et al. 1995c; Silber 1986; Thompson et al. 1986; Tyack 1983; Tyack and Whitehead 1983; Weilgart and Whitehead 1993; Weilgart and Whitehead 1997a; Weir et al. 2007b; Winn et al. 1970). Sperm whales have stopped vocalizing in response to 6 to 13 kHz pingers, but did not respond to 12 kHz echosounders (Backus and Schevill 1966; Watkins 1977b; Watkins and Schevill 1975b). Sperm whales exhibited a startle response to 10 kHz 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 kHz 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 a the mass stranding of a large group of melon-headed whales (*Peponocephala electra*) (Southall 2013). Although pathological data suggesting a direct physical effect are lacking and the authors acknowledge that while the use of this type of sonar is widespread and common place globally without noted incidents (like the Madagascar stranding), all other possibilities were either ruled out or believed to be of much lower likelihood as a cause or contributor to stranding compared to the use of the multi-beam echosounder (Southall 2013). This incident highlights the caution needed when interpreting effects that may or may not stem from anthropogenic sound sources, such as the R/V

Marcus G. Langseth's sub-bottom profiler, multi-beam echosounder, split-beam echosounder, and acoustic Doppler current profiler. Although effects such as this have not been documented for ESA-listed species, the combination of exposure of this stressor with other factors, such as behavioral and reproductive state, oceanographic and bathymetric conditions, movement of the source, previous experience of individuals with the stressor, and other factors may combine to produce a response that is greater than would 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 non-ESA-listed marine mammals (e.g., beaked whales). The sonars proposed for use by the R/V *Marcus G. Langseth* differs from sonars used during naval operations, which generally have a longer pulse duration and more horizontal orientation than the more downward-directed sub-bottom profiler, multi-beam echosounder, split-beam echosounder, and acoustic Doppler current profiler. The sound energy received by any individuals exposed to the sub-bottom profiler, multi-beam echosounder, and acoustic Doppler current profiler, and pinger during the seismic survey activities is lower relative to naval sonars, as is the duration of exposure. The area of possible influence for the sub-bottom profiler, multi-beam echosounder, split-beam echosounder, acoustic Doppler current profiler is also much smaller, consisting of a narrow zone close to and below the source vessel. Because of these differences, we do not expect these systems to contribute to a stranding event.

The sub-bottom profiler, multi-beam echosounder, split-beam echosounder, and acoustic Doppler current profiler have the potential to expose ESA-listed sea turtles to sound levels above 175 dB re: one µPa (rms) threshold. However, as described previously, current data indicates sea turtles hear in the low-frequency range. The sub-bottom profiler operates at frequencies of 3.5 kHz, the multi-beam echosounder operates at frequencies of 10.5 to 13 (usually 12) kHz, the split-beam echosounder operates at frequencies of 38 kHz and 18 kHz, and the acoustic Doppler current profiler operates at frequencies of 75 kHz, all which emit sounds outside the hearing frequency of sea turtles (typically 30 Hz to two kHz), with a range of maximum sensitivity between 100 to 800 Hz). Sea turtles are not expected to detect and therefore not respond to sounds emitted by the sub-bottom profiler, multi-beach echosounder, split-beam echosounder, and acoustic Doppler current profiler.

4.6 Gear Entanglement and Interaction

There is a variety of gear that would be used during the proposed actions that might entangle, strike, or otherwise interact with ESA-listed species in the action area. The towed seismic equipment (e.g., airgun array and towed hydrophone streamer) and wire cables used during coring activities and heat flow measurements associated with the seismic survey activities as well as the coring equipment for sediment sampling may pose a risk of entanglement to ESA-listed species. The gear used in the proposed actions may also strike ESA-listed species while in

use, or during deployment or recovery, resulting in injury. This is a possibility for the coring activities and heat flow measurements in particular, as they would be lowered into the water from the research vessel, weighted down, and would penetrate the seafloor. 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. 2013a; Van der Hoop et al. 2013b). 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, death is usually quick, due to drowning. However, large whales, like North Atlantic 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 poses a risk of entanglement to ESA-listed marine mammals, sea turtles, and fishes. The towed hydrophone streamer could come in direct contact with ESA-listed species and sea turtle entanglement have occurred in towed gear from seismic survey vessels. For example, a NSF-funded seismic survey off the coast of Costa Rica during 2011 recovered a dead olive ridley turtle (*Lepidochelys olivacea*) in the deflector foil of towed seismic equipment; it is unclear whether the sea turtle became lodged in the deflector 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. 2005a; Holst et al. 2005b). 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 would not encircle, wrap around, or in any other way entangle any of the large whales, sea turtles, or fishes considered during this consultation. We expect the taut cables would prevent entanglement. The towed hydrophone streamer does not include any floatation that contains subsurface crossbars or frames that would entrap sea turtles; therefore, no sea turtle "guards" are necessary. Furthermore, mysticetes (baleen whales) and sperm whales are expected to avoid areas where the airgun array is actively being used, meaning they would also avoid towed gear. Instances of such entanglement events with ESA-listed marine mammals are unknown to us. The coring equipment for sediment sampling and heat flow measurement probe will result in very minor, temporary disturbances to the water column and seafloor sediments and are not expected to significantly impact ESA-listed species.

In addition to marine mammals and sea turtles, some of the ESA-listed fish species (e.g., Carolina DPS, Chesapeake DPS, Gulf of Maine DPS, New York Bight DPS, and South Atlantic DPS of Atlantic sturgeon, giant manta ray, oceanic whitetip shark, and shortnose sturgeon) could be entangled or stuck by equipment during the seismic survey activities. ESA-listed giant manta ray and oceanic whitetip shark are distributed throughout the water column, while Atlantic sturgeon and shortnose sturgeon occur at the ocean bottom. The coring activities and heat flow

measurements would operate at or near the seafloor. The towed hydrophone array and towed airgun array pose similar risk to ESA-listed fish. However, we consider the possibility of equipment entanglement or strike to be remote because of fishes' ability to detect the equipment moving through the water and move out of the way. The shape of the streamlined bodies of ESA-listed fish and the ability to avoid materials that could entangle, strike, or interact with them in the water column make it extremely unlikely.

The coring activities and heat flow measurements would result in very minor, temporary disturbances to seafloor sediments. The coring activities and heat flow measurements are not expected to significantly impact geologic resources or ESA-listed species.

5 ACTION AREA

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

The proposed NSF action will take place between approximately 31 to 35 degrees North, 72 to 75 degrees West off the coastline of North Carolina in the Northwest Atlantic Ocean. The high-energy seismic survey will take place in the U.S. Exclusive Economic Zone and International Waters in water depths from approximately 200 to 5,500 meters (656.2 to 18,044.6 feet). Approximately 90 percent will take place in the Exclusive Economic Zone of the U.S. and approximately ten percent will take place in International Waters. Representative tracklines are shown in Figure 1. Approximately ten percent (629 kilometers [339.6 nautical miles]) will take place in intermediate water depths and 90 percent (5,454 kilometers [2,944.9 nautical miles]) will take place in deep water depths. Some deviation in actual tracklines and order of seismic survey operations are dependent on data collected in situ and weather. The tracklines shown in Figure 1 have a total length of approximately 6,083 kilometers (3,284.6 nautical miles). The closest approach of the high-energy seismic survey to the 100 meter (328.1 feet) isobaths will be approximately five kilometers (2.7 nautical miles), to state waters (5.6 kilometers [three nautical miles]) will be approximately 35 kilometers (18.9 nautical miles), and to the coast of Cape Hatteras, North Carolina would be approximately 40 kilometers (21.6 nautical miles). The order of the seismic survey activities in the various survey regions will be determined when airgun array operations commence and will depend on a variety of 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 of the survey regions noted in Figure 1. The action area also includes 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 high-energy seismic survey. The R/V *Marcus G. Langseth* is expected to leave from and return to the port of Norfolk, Virginia. The port locations may be subject to change. The action area also includes all areas where stressors from the high-energy seismic survey could occur (including all areas ensonified by sound from the seismic survey activities and transit routes from ports). The action area (the study area and the transit to/from Norfolk, Virginia) would not extend beyond the area

shown in Figure 1. We do not anticipate any effects (Sections 4, 7, and 10) outside the area shown on the maps in Figure 1 and the transit to and from Norfolk, Virginia.

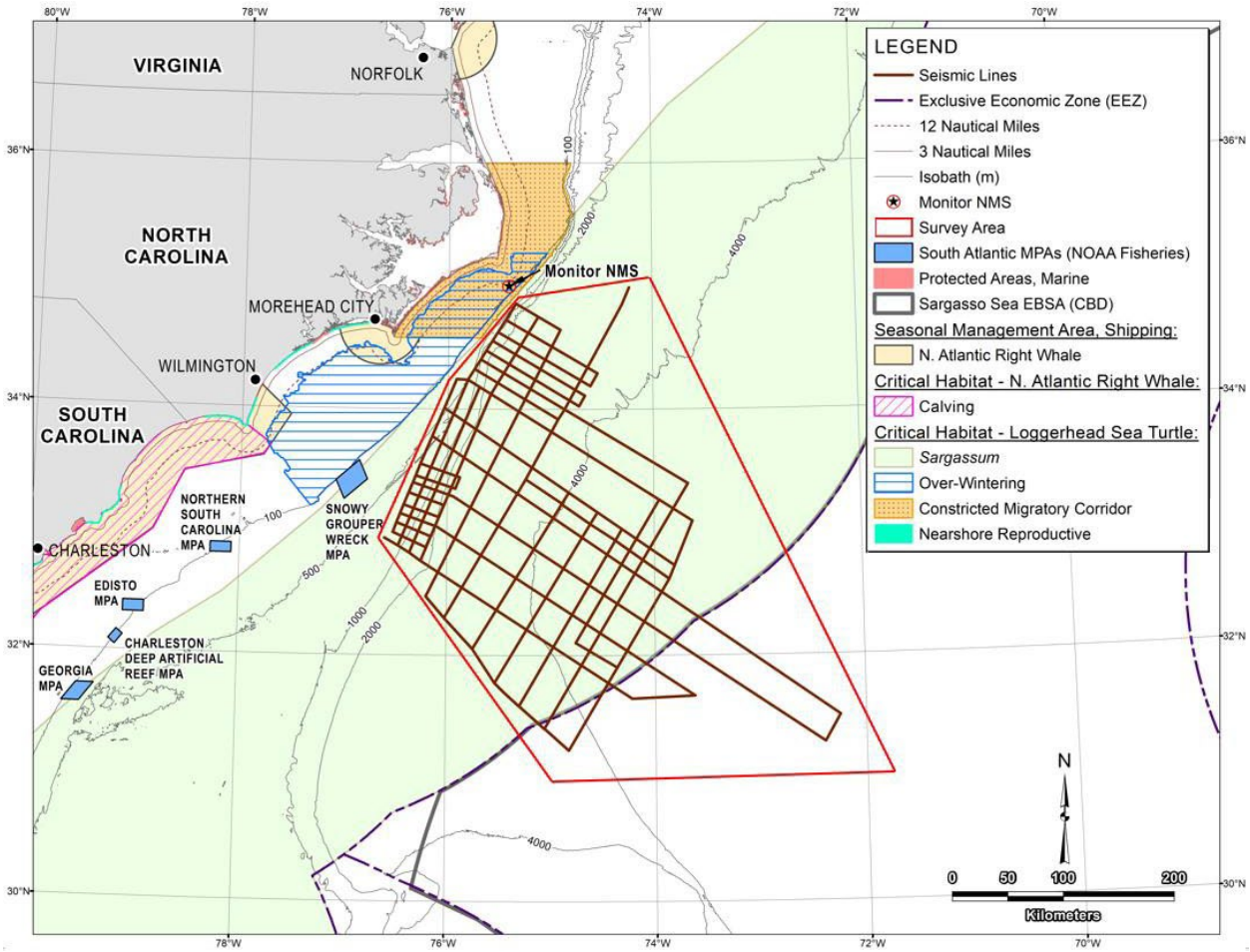

Figure 1. Map of the National Science Foundation and Lamont-Doherty Earth Observatory's high-energy seismic survey in the Northwest Atlantic Ocean off North Carolina and National Marine Fisheries Service Permits and Conservation Division's proposed issuance of an incidental harassment authorization and possible renewal for this consultation.

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

This section identifies the ESA-listed species and designated critical habitat that occur within the action area (Table 7) and may be affected by the proposed actions. These ESA-listed species and designated critical habitat co-occur with the potential stressors produced by the proposed actions in space and time.

Table 7. Endangered Species Act-listed threatened and endangered species and designated critical habitat potentially occurring in the action area that may be affected by the National Science Foundation and Lamont-Doherty Earth Observatory's high-energy seismic survey in the Northwest Atlantic Ocean off North Carolina and National Marine Fisheries Service Permits and Conservation Division's proposed issuance of an incidental harassment authorization and possible renewal.

Species	ESA Status	Critical Habitat	Recovery Plan
Marine Mammals – Cetaceans			
Blue Whale (*Balaenoptera musculus*)	E – 35 FR 18319	-- --	07/1998 11/2020
Fin Whale (*Balaenoptera physalus*)	E – 35 FR 18319	-- --	75 FR 47538 07/2010
North Atlantic Right Whale (*Eubalaena glacialis*)	E – 73 FR 12024	81 FR 4837	70 FR 32293 08/2004
Sei Whale (*Balaenoptera borealis*)	E – 35 FR 18319	-- --	12/2011
Sperm Whale (*Physeter macrocephalus*)	E – 35 FR 18319	-- --	75 FR 81584 12/2010
Marine Reptiles			
Green Turtle (*Chelonia mydas*) – North Atlantic DPS	T – 81 FR 20057	63 FR 46693*	10/1991 – U.S. Atlantic
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
Kemp's Ridley Turtle (*Lepidochelys kempii*)	E – 35 FR 18319	-- --	03/2010 – U.S. Caribbean, Atlantic, and Gulf of Mexico 09/2011

Species	ESA Status	Critical Habitat	Recovery Plan
Leatherback Turtle (*Dermochelys coriacea*)	E – 35 FR 8491	44 FR 17710 and 77 FR 4170*	10/1991 – U.S. Caribbean, Atlantic, and Gulf of Mexico 63 FR 28359 05/1998 – U.S. Pacific
Loggerhead Turtle (*Caretta caretta*) – Northwest Atlantic Ocean DPS	T – 76 FR 58868	79 FR 39855	74 FR 2995 10/1991 – U.S. Caribbean, Atlantic, and Gulf of Mexico 05/1998 – U.S. Pacific 01/2009 – Northwest Atlantic
Fishes			
Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*) – Carolina DPS	E – 77 FR 5913	82 FR 39160*	02/2012 (Outline)
Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*) – Chesapeake DPS	E – 77 FR 5913	82 FR 39160*	02/2012 (Outline)
Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*) – Gulf of Maine DPS	T – 77 FR 5879	82 FR 39160*	02/2012 (Outline)
Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*) – New York Bight DPS	E – 77 FR 5879	82 FR 39160*	02/2012 (Outline)
Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*) – South Atlantic DPS	E – 77 FR 5913	82 FR 39160*	02/2012 (Outline)
Giant Manta Ray (*Manta birostris*)	T – 83 FR 2916	-- --	-- --
Oceanic Whitetip Shark (*Carcharhinus longimanus*)	T – 83 FR 4153	-- --	9/2018 (Outline)
Shortnose Sturgeon (*Acipenser brevirostrum*)	E – 32 FR 4001	-- --	63 FR 69613 12/1998

ESA= Endangered Species Act, T=Threatened, E=Endangered, FR=*Federal Register*, DPS=Distinct Population Segment, *=not in action area.

7 SPECIES AND CRITICAL HABITAT NOT LIKELY TO BE ADVERSELY AFFECTED

This section identifies potential stressors associated with the proposed actions that may affect, but are not likely to adversely affect ESA-listed species and designated critical habitat under NMFS jurisdiction that may occur within the action area (as described in Table 7), then discusses those ESA-listed species and designated critical habitat that are not likely to be exposed to potential stressors associated with the proposed actions that may cause adverse effects.

NMFS uses two criteria to identify the ESA-listed or critical habitat that are not likely to be adversely affected by the proposed actions, as well as the effects of activities that are consequences of the Federal agency's proposed actions. 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. An ESA-listed species or designated critical habitat that co-occurs with a stressor of the action but is not likely to respond to the stressor is also not likely to be adversely affected by the proposed actions. We applied these criteria to the ESA-listed species and designated critical habitats in Table 7 and we summarize our results below.

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

Insignificant effects relate to the response of the individual or critical habitat and include those effects that are undetectable, not measurable, or so minor that they cannot be meaningfully evaluated. Insignificant is the appropriate effect conclusion when a species or critical habitat is likely to be exposed to a stressor, but the response would not rise to the level of constituting an adverse effect.

Discountable effects relate to the exposure of species or critical habitat to a stressor. For an effect to be discountable, we must conclude that the likelihood of exposure is extremely unlikely to occur.

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

In this section, we evaluate effects to ESA-listed species and critical habitat that may be affected, but are not likely to be adversely affected, by the proposed actions. For these ESA-listed species and critical habitat, we focus specifically on stressors associated with the NSF and L-DEO's high-energy seismic survey and their effects on these ESA-listed species. The effects of other stressors associated with the proposed actions, which are not likely to adversely affect ESA-listed species and critical habitat, are evaluated in Section 7.1. The ESA-listed species and designated critical habitat (along with their regulatory status and recovery plan) potentially occurring within the action area that may be affected, but are not likely to be adversely affected, are listed in Table 9 (overall determination shown as 'NLAA').

7.1 Potential Stressors Not Likely to Adversely Affect Endangered Species Act-Listed Marine Mammals, Sea Turtles, and Fishes or Designated Critical Habitat

Stressors that may affect, but are not likely to adversely affect the ESA-listed marine mammals (cetaceans), sea turtles, fishes, and designated critical habitat considered in this consultation (Section 4) include pollution, vessel strike, vessel noise and visual disturbance, acoustic noise from the airgun array (for fish), acoustic noise from sub-bottom profiler, multi-beam echosounder, split-beam echosounder, acoustic Doppler current profiler, and gear entanglement and interaction. The following sections describe how we reached these determinations for these stressors.

7.1.1 Pollution

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

Exhaust (i.e., air pollution) from the research vessel would occur during the entirety of the proposed actions, during all transit and operations, and could affect air-breathing ESA-listed species such as marine mammals and sea turtles. It is unlikely that exhaust resulting from the operation of the R/V *Marcus G. Langseth* would have a measurable impact on ESA-listed marine mammals or sea turtles given the relatively short duration of the proposed actions (approximately 33 days), the brief amount of time that marine mammals and sea turtles spend at the water's surface, and the various regulations to minimize air pollution from exhaust, such as NSF and L-DEO's compliance with the Act to Prevent Pollution from Ships. The amount of exhaust from a single research vessel operating globally would be a negligible addition to the amount of carbon dioxide in the atmosphere. For these reasons, the effects that may result from exhaust on ESA-listed marine mammals and sea turtles are considered insignificant.

Discharges into the water from the research vessel in the form of wastewater or leakages of fuel or oil are possible, though effects of any spills to ESA-listed marine mammals, sea turtles, fishes, and designated critical habitat considered in this consultation would be minimal, if they occur at all. Wastewater from the research vessel would be treated in accordance with U.S. Coast Guard standards. The potential for fuel or oil leakages is extremely unlikely. As stated in Section 4.1,

the NSF and L-DEO proposes to include guidance on the handling and disposal of marine trash and debris during the high-energy seismic survey. The research vessel used during the NSF-funded high-energy seismic survey has spill-prevention plans, which would allow a rapid response to a spill in the event one occurs. In addition to this, the potential for an oil or fuel spill to emanate from the R/V *Marcus G. Langseth* during the seismic survey activities is extremely small. An oil or fuel leak would 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 would impact ESA-listed species directly or pose hazards to their food sources that may be part of designated critical habitat in the action area. Because the potential for oil or fuel leakage is extremely unlikely to occur, we find that the risk from this potential stressor on ESA-listed marine mammals, sea turtles, fishes, and designated critical habitat is discountable.

Trash or other debris resulting from the proposed actions may affect ESA-listed marine mammals, sea turtles, and fishes. Any marine debris (e.g., plastic, paper, wood, metal, glass) that might be released would be accidental. The NSF and L-DEO follows standard, established guidance on the handling and disposal of marine trash and debris during the high-energy seismic survey. The gear used in the proposed actions may also result in marine debris. Because the potential for accidental release of trash is extremely unlikely to occur, we find that the effects from this potential stressor on ESA-listed marine mammals, sea turtles, and fishes are discountable. Therefore, we conclude that pollution by vessel exhaust, wastewater, fuel or spills or leaks, and trash or other debris may affect, but is not likely to adversely affect ESA-listed species and designated critical habitat.

7.1.2 Vessel Strike

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 research vessel associated with seismic surveys. The R/V *Marcus G. Langseth* would 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). Vessel strikes are rare events offshore and the risk of a vessel strike resulting from the proposed actions is considered extremely low. Our expectation of vessel strike for a marine mammal, sea turtle, and fish is extremely small due to the hundreds of thousands of kilometers the R/V *Marcus G. Langseth* has traveled without a vessel strike, the general expected movement of marine mammals, sea turtles, and fish 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). The R/V *Marcus G. Langseth* would have an operating speed of typically 9.3 kilometers per hour (5 knots) during airgun array operations (seismic data acquisition). When not towing seismic survey gear, the R/V

Marcus G. Langseth typically transits at 18.5 kilometers per hour (10 knots). Vessel strike is a less pronounced threat for fishes, as fish are mostly expected to be able to sense and maneuver away from vessels. Sturgeon have been known to be struck and killed by vessels or by the blades of vessel propellers, but we are not aware of reports of vessel strike for Carolina DPS, Chesapeake DPS, Gulf of Maine DPS, New York Bight DPS, and South Atlantic DPS of Atlantic sturgeon in the action area. They have been struck and killed by large commercial vessels as well as smaller recreational vessels. The risk of injury and mortality could be high in areas with high vessel traffic navigating channels dredged to the depth of the vessels including the Hudson River, Delaware River, and James River and is an emerging threat in the Savannah River, Cooper River, and Cape Fear River. It is not known how many sturgeon are struck by vessels and survive their injuries. Balazik et al. (2012) states that Atlantic sturgeon spend the majority of the time in deeper, cooler waters within one meter (3.3 feet) of the bottom. Vessel strike is generally considered as a low-risk threat to Carolina DPS, Chesapeake DPS, Gulf of Maine DPS, New York Bight DPS, and South Atlantic DPS of Atlantic sturgeon and shortnose sturgeon (NMFS 2018), as they generally are not at the water's surface. In addition, adherence to observation and avoidance procedures is also expected to avoid vessel strikes of marine mammals, sea turtles, and fishes. All factors considered, we have concluded that the risk of vessel strike affecting ESA-listed marine mammals, sea turtles, and fishes in the action area is extremely unlikely to occur, and is therefore discountable. Therefore, we conclude that vessel strike may affect, but is not likely to adversely affect ESA-listed species.

7.1.3 Vessel Noise and Visual Disturbance

Numerous studies of interactions between surface vessels and cetaceans have demonstrated that free-ranging cetaceans engage in avoidance behavior when surface vessels move toward them. It is not clear whether these responses are caused by the physical presence of a surface vessel, the underwater noise generated by the vessel or an interaction between the two (Amaral and Carlson 2005; Au and Green 2000; Bain et al. 2006; Bauer 1986; Bejder et al. 1999; Bejder and Lusseau. 2008; Bejder et al. 2009; Bryant et al. 1984; Corkeron 1995; Erbe 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 2005b; Watkins 1986a; Williams et al. 2002; Wursig et al. 1998). However, several authors suggest that the noise generated during motion is probably an important factor (Blane and Jaakson 1994b; Evans et al. 1992; Evans et al. 1994). These studies suggest that the behavioral responses of cetaceans to surface vessels are similar to their behavioral responses to predators. With this said, the overall contribution of vessel noise by the R/V *Marcus G. Langseth* is likely small in the overall regional sound field of the action area. The R/V *Marcus G. Langseth*'s passage past ESA-listed marine mammals, sea turtles, or fish would be brief, at a distance of at least 100 meters (328.1 feet), and not likely to be significant in impacting any individual's ability to feed, reproduce, or avoid predators. Brief interruptions in communication via masking are possible, but unlikely given the habits of marine mammals to move away from vessels, either as a result of engine noise, the physical presence of the vessel, or both (Lusseau 2006; Mitson and Knudsen 2003).

Also, sea turtles are most likely to habituate and are shown to be less effected by vessel noise at distances greater than ten meters (32.8 feet) (Hazel et al. 2007). In addition, the R/V *Marcus G. Langseth* would travel at slow speeds, reducing the amount of noise produced by the propulsion system (Kite-Powell et al. 2007; Vanderlaan and Taggart 2007). The distance between the research vessel and observed marine mammals, per vessel avoidance measures, would also minimize the potential for acoustic disturbance from engine noise.

In addition to effects to ESA-listed species, important species for *Sagassum* (i.e., copepods that make up PBFs for Northwest Atlantic Ocean DPS of loggerhead turtle designated critical habitat may also be affected by vessel noise. Impacts of vessel noise on prey species such as copepods is less known, but some studies have shown a reduction in egg production and size with exposure to vessel noise (Aspirault 2019). Additionally, an important zooplankton predator (*Chaoborus flavicans*) increased anti-predatory defense behavior when exposed to short-term vessel noise (Rojas et al. 2021). These works highlight that noise could affect both fitness and behavior or zooplankton species; however, the results from these studies are contrasted by other research showing a lack of response in zooplankton from chronic noise (Prosnier et al. 2022; Sabet et al. 2019).

Because the potential acoustic interference from engine noise is expected to be nearly undetectable or so minor that it cannot be meaningfully evaluated, we find that the risk from this potential stressor on ESA-listed marine mammals, sea turtles, fish, and designated critical habitat is insignificant. Therefore, we conclude that vessel noise may affect, but is not likely to adversely affect ESA-listed species.

7.1.4 Acoustic Noise from the Airgun Array

ESA-listed fishes may be exposed to and detect noise generated by the high-energy seismic survey. Effects to ESA-listed sturgeon and elasmobranchs from acoustic noise from the airgun array are discussed below.

7.1.4.1 Endangered Species Act-Listed Sturgeon

ESA-listed sturgeon (which include Carolina DPS, Chesapeake DPS, Gulf of Maine DPS, New York Bight DPS, and South Atlantic DPS of Atlantic sturgeon, and shortnose sturgeon) may be exposed to and detect noise generated by the high-energy seismic survey.

There is no available information on the hearing capabilities of Atlantic sturgeon or shortnose sturgeon specifically, although the hearing of five closely related species from the sturgeon family Acipenseriformes have been studied. While sturgeon have swim bladders, they are not known to be used for hearing, and thus sturgeon appear to only rely directly on their ears for hearing. Popper (2005) reported that studies measuring responses of the ear of European sturgeon (*Acipenser sturio*) using physiological methods suggest sturgeon are likely capable of detecting sounds from below 100 Hz to about one kHz, indicating that sturgeon should be able to localize or determine the direction of origin of sound. Meyer and Popper (2002) recorded auditory evoked potentials of varying frequencies and intensities for lake sturgeon (*Acipenser*

fulvescens) and found that lake sturgeon can detect pure tones from 100 Hz to two kHz, with best hearing sensitivity from 100 to 400 Hz. They also compared these sturgeon data with comparable data for oscar (*Astronotus ocellatus*) and goldfish (*Carassius auratus*) and reported that the auditory brainstem responses for lake sturgeon were more similar to goldfish (which is considered hearing specialist that can hear up to five kHz) than to the oscar (which is a non-specialist that can only detect sound up to 400 Hz); these authors, however, felt additional data were necessary before lake sturgeon could be considered specialized for hearing (Meyer and Popper 2002). Lovell et al. (2005) also studies sound reception and the hearing abilities of paddlefish (*Polyodon spathula*; in the family Acipenseriformes) and lake sturgeon. Using a combination of morphological and physiological techniques, they determined that paddlefish and lake sturgeon were responsive to sounds ranging in frequency from 100 to 500 Hz, with the lowest hearing thresholds from frequencies in a bandwidth of between 200 and 300 Hz and higher thresholds at 100 and 500 Hz; lake sturgeon were not sensitive to sound pressure. We assume that the hearing sensitivities reported for these other species of sturgeon are representative of the hearing sensitivities of all DPSs of Atlantic sturgeon and shortnose sturgeon.

Sturgeon are known to produce sounds, especially during spawning. Lake sturgeon produce low frequency sounds during spawning bouts, principally consisting of drumming sounds that range from five to eight Hz, but low frequency rumbles and hydrodynamic sounds as well as high frequency sounds have also been reported (Bocast et al. 2014). The pallid sturgeon (*Scaphirhynchus albus*) and shovelnose sturgeon (*Scaphirhynchus platorhynchus*) are known to produce at least four types of sounds during the breeding season, ranging from squeaks and chirps from one to two kHz, with low frequency moans ranging in frequency between 90 and 400 Hz (Johnston and Phillips 2003).

Based on the review above, it is likely that the seismic survey activities would be audible to ESA-listed sturgeon, and as such, may elicit a behavioral response. However, Popper et al. (2014c) concluded that the relative risk of a fish eliciting a behavioral response to low-frequency sonar was low, regardless of the distance from the sound source. The authors did not find any data on masking by sonar on fishes, but concluded that if it were to occur, masking would only occur in a narrow range of frequencies being masked by sonar transmissions (Popper et al. 2014c).

The precise expected response of ESA-listed sturgeon 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 and the fact that most sturgeon are found in nearshore coastal areas, we do not expect frequent exposure or measurable responses from any exposures. The most likely response of ESA-listed sturgeon exposed to acoustic noise, if any, would 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 of take.

Therefore, the potential effect of the seismic survey activities on ESA-listed sturgeon is considered insignificant. Therefore, we conclude that acoustic noise from the airguns may affect, but is not likely to adversely affect Carolina DPS, Chesapeake DPS, Gulf of Maine DPS, New York Bight DPS, and South Atlantic DPS of Atlantic sturgeon, and shortnose sturgeon.

7.1.4.2 Endangered Species Act-Listed Elasmobranchs

ESA-listed elasmobranchs (which include giant manta rays and oceanic whitetip sharks) may be exposed to and detect noise generated by the high-energy seismic survey. Elasmobranchs, like all fish, have an inner ear capable of detecting sound and a lateral line capable of detecting water motion caused by sound (Hastings and Popper 2005; Popper and Schilt 2009). Data for elasmobranch fishes suggest they are capable of detecting sounds from approximately 20 Hz to one kHz with the highest sensitivity to sounds at lower ranges (Casper et al. 2012b; Casper and Mann 2009; Casper 2006; Ladich and Fay 2013; Myrberg Jr. 2001; Yan 2003). However, unlike most teleost fish, elasmobranchs do not have swim bladders (or any other air-filled cavity), and thus are unable to detect sound pressure (Casper et al. 2012a). Particle motion is presumably the only sound stimulus that can be detected by elasmobranchs (Casper et al. 2012a). Given their assumed hearing range, elasmobranchs are anticipated to be able to detect the low frequency sound from the airgun array if exposed. However, the duration and intensity of low-frequency acoustic stressors and the implementation of conservation measures will likely minimize the effect this stressor has on elasmobranchs. Furthermore, although some elasmobranchs have been known to respond to anthropogenic sound, in general elasmobranchs are not considered particularly sensitive to sound (Casper et al. 2012a).

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

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

These signals, some “pulsed,” are not substantially different from the airgun array signals. Myrberg et al. (1978) reported that silky shark withdrew ten meters (33 feet) from a speaker

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

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

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

The precise expected response of ESA-listed elasmobranchs to low-frequency acoustic energy is not completely understood due to a lack of sufficient experiment and observational data for these species. However, given the signal type and level of exposure to the low-frequency signals used in the seismic survey activities, we do not expect a measurable response. The most likely response of ESA-listed elasmobranchs exposed to seismic survey activities, if any, would be minor temporary changes in their behavior including increased swimming rate, avoidance of the sound source, or changes in orientation to the sound source, none of which rise to the level of take. Therefore, the potential effect of the seismic survey activities on ESA-listed elasmobranchs is considered insignificant. Therefore, we conclude that acoustic noise from the airguns may affect, but is not likely to adversely affect ESA-listed elasmobranchs (giant manta ray and oceanic whitetip shark).

The effects of acoustic noise from the airgun array on ESA-listed marine mammals and sea turtles in the action area are discussed in Section 10.

7.1.5 Acoustic Noise from Sub-Bottom Profiler, Multi-Beam Echosounder, Split-Beam Echosounder, and Acoustic Doppler Current Profiler

A description of the acoustic noise from the sub-bottom profiler, multi-beam echosounder, split-beam echosounder, and acoustic Doppler current profiler and how these instruments work can be found in Section 3.1.4. We do not expect masking of communication would occur to an appreciable extent in marine mammals, sea turtles, fish and designated critical habitat (available prey and other material in *Sargassum* habitat, which include populations of macroinvertebrates [e.g., copepods]) due to the sub-bottom profiler, multi-beam echosounder, split-beam echosounder, and acoustic Doppler current profiler's signal directionality, low duty cycle, and brief period when an individual could be within their beam. These factors were considered when Burkhardt et al. (2013) estimated the risk of injury from multi-beam echosounder was less than three percent that of vessel strike. Behavioral responses to the sub-bottom profiler, multi-beam echosounder, split-beam echosounder, and acoustic Doppler current profiler may be similar to the other pulsed sources discussed earlier if received at the same sound source levels and duration; however, this is unlikely to occur. Boebel et al. (2006) and Lurton and DeRuiter (2011) concluded that sub-bottom profilers, multi-beam echosounders, and acoustic Doppler current profilers similar to those to be used during the seismic survey activities presented a low risk for auditory damage or any other injury. In order for there to be a measurable response from exposure to these sound sources, the animal would have to pass the transducers at close range and match the research vessel's speed and direction. Because this behavior is extremely unlikely, exposure to sound levels sufficient to cause a response is extremely unlikely. Sea turtles generally do not possess a hearing range that includes frequencies emitted by the sub-bottom profiler, multi-beam echosounder, split-beam echosounder, and acoustic Doppler current profiler; 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. We find the probability of adverse impacts to ESA-listed marine mammals, sea turtles, and fish from this potential stressor to be discountable. We are unable to quantify the level of exposure from secondary sound sources, but do not expect any exposure at levels sufficient to cause more than imperceptible behavioral responses (e.g., avoidance of the sound source) in some species capable of hearing frequencies produced by the sub-bottom profiler, multi-beam echosounder, split-beam echosounder, and acoustic Doppler current profiler. We find that the risk from this potential stressor on ESA-listed marine mammals, sea turtles, fish, and designated critical habitat is insignificant. Therefore, we conclude that the sub-bottom profiler, multi-beam echosounder, split-beam echosounder, and acoustic Doppler current profiler may affect, but are not likely to adversely affect ESA-listed species and designated critical habitat.

7.1.6 Gear Entanglement and Interaction

There is a variety of gear proposed for use during the proposed actions that might entangle, strike, or otherwise interact with ESA-listed species in the action area. Towed seismic equipment (airgun array and towed hydrophone streamers) associated with the seismic survey activities as

well as the coring equipment for sediment sampling and heat flow measurements may pose a risk of entanglement and interaction to ESA-listed species. Although the airgun array, towed hydrophone streamers, and coring equipment could come in direct contact with an ESA-listed species, entanglements and interactions are extremely unlikely. The airgun array, towed hydrophone streamer, and coring equipment are rigid and as such are not expected to encircle, wrap around, or in any other way entangle any of the ESA-listed marine mammals, sea turtles, and fishes considered during this consultation. The weight of the coring equipment and heat flow measurement probe would keep the wire taught as well as the very slow speed of the research vessel would prevent gear entanglement and interactions with ESA-listed species. For these reasons, we expect the taut cables would prevent entanglement and interaction of ESA-listed species. Furthermore, mysticetes and possibly sperm whales (the only cetaceans considered in this consultation) are expected to avoid areas where the airgun array is actively being used, meaning they would also likely avoid towed seismic equipment. Instances of such entanglement and interaction events in the towed hydrophone streamers, other seismic survey equipment, and coring equipment, with ESA-listed species are unknown to us. Based upon extensive deployments of this type of equipment and gear, with no reported entanglement or interaction and the nature of the gear that is likely to prevent it from occurring, we find the probability of adverse impacts to ESA-listed marine mammals, sea turtles, and fish from this stressor to be extremely unlikely to occur, and any effects are discountable. Therefore, we conclude that gear entanglement and interaction may affect, but is not likely to adversely affect ESA-listed species.

7.2 Species Not Likely to be Adversely Affected by Potential Stressors Considered Further

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

7.2.1 Marine Mammals – Cetaceans

The North Atlantic right whale may occur in the action area and may be affected by the proposed actions. In addition to the potential stressors that are not likely to adversely affect ESA-listed cetaceans discussed above in Section 7.1, other stressors resulting from the proposed actions may affect, but are not likely to adversely affect specific species and designated critical habitat as discussed in the following subsections.

7.2.1.1 North Atlantic Right Whale

The ESA-listed North Atlantic right whale may occur in the action area and may be affected by the stressors associated with the NSF and L-DEO's high-energy seismic survey (Section 4). While the North Atlantic right whale could be found in coastal and pelagic habitats within the action area, it is unlikely that North Atlantic right whales would be adversely affected by

stressors associated with the proposed actions as they are not expected to occur in the portion of the action area where airgun array operations are expected to occur.

The North Atlantic right whale is a narrowly distributed baleen whale found in temperate and subpolar waters of the North Atlantic Ocean. Today they are mainly found in the Western North Atlantic Ocean, but have been historically recorded south of Greenland and in the Denmark Strait, as well as in the Eastern North Atlantic Ocean waters (Kraus and Rolland 2007) with possible historic calving grounds being located in the Mediterranean Sea (Rodrigues et al. 2018).

There are currently two recognized populations of North Atlantic right whales, an eastern and a western population. Today, North Atlantic right whales are primarily found in the western North Atlantic Ocean, from their calving grounds in lower latitudes off the coast of the southeastern U.S. to their feeding grounds in higher latitudes off the coast of New England and Nova Scotia (Hayes et al. 2018b). In recent years, there has been a shift in distribution in their feeding grounds, with fewer animals being seen in the Great South Channel and the Bay of Fundy and more animals being observed in the Gulf of St. Lawrence and mid-Atlantic region (Daoust et al. 2017; Davis et al. 2017; Hayes et al. 2018a; Hayes et al. 2018b; Meyer-Gutbrod et al. 2018; Pace et al. 2017). In the eastern North Atlantic Ocean, sightings of North Atlantic right whales are rare. Very few individuals likely make up the population in the eastern Atlantic Ocean and the population is thought to be functionally extinct (Best et al. 2001). However, in recent years, a few known individuals from the western population have been seen in the eastern Atlantic Ocean, suggesting some individuals may have wider ranges than previously thought (Kenney 2009).

Pregnant North Atlantic right whales migrate south through the mid-Atlantic Ocean region of the U.S., to low latitudes during late fall where they overwinter and give birth in shallow, coastal waters (Kenney 2009; Krzystan et al. 2018). During spring, these females migrate back north with their new calves to high latitude foraging grounds where they feed on large concentrations of copepods, primarily *Calanus finmarchicus* (Mayo et al. 2018; NMFS 2017b). Some non-reproductive North Atlantic right whales (males, juveniles, non-reproducing females) also migrate south along the mid-Atlantic region, although at more variable times throughout the winter, while others appear to not migrate south, and instead remain in the northern feeding grounds year round or go elsewhere (Bort et al. 2015; Mayo et al. 2018; Morano et al. 2012a; NMFS 2017b; Stone et al. 2017b). Nonetheless, calving females arrive to the southern calving grounds earlier and stay in the area more than twice as long as other demographics (Krzystan et al. 2018). Little is known about North Atlantic right whale habitat use in the mid-Atlantic region, but recent acoustic data indicate near year round presence of at least some animals off the coasts of New Jersey, Virginia, and North Carolina (Davis et al. 2017; Hodge et al. 2015a; Salisbury et al. 2016a; Whitt et al. 2013). While it is generally not known where North Atlantic right whales mate, some evidence suggests that mating may occur in the northern feeding grounds (Cole et al. 2013; Matthews et al. 2014).

The waters offshore of North Carolina, including waters adjacent to the seismic survey area, are used as part of the migration corridor for North Atlantic right whales. North Atlantic right whales occur here during seasonal movements north or south between their foraging and breeding grounds (Firestone et al. 2008; Knowlton et al. 2002). North Atlantic right whales have been observed in or near the waters off North Carolina from October through December, as well as in February and March, which coincides with their migratory timeframe (Knowlton et al. 2002). They have been acoustically detected off Georgia and North Carolina in seven of eleven months monitored (Hodge et al. 2015b) and other recent passive acoustic monitoring studies of North Atlantic right whales off the coast of Virginia demonstrate their year-round presence in waters off Virginia (Salisbury et al. 2016b)), with increased detections in fall and late winter to early spring. They are typically most common in the spring (late March) when they are migrating north and in the fall (October and November) when they are migrating south. During their migration, North Atlantic right whales prefer shallower waters, with the majority of sightings occurring within 56 kilometers (30.2 nautical miles) of the coast and in water depths shallower than 45 meters (147.6 feet). Comparatively, the seismic survey activities would occur at a minimum of 40 kilometers (21.6 nautical miles) off the coast of North Carolina in water depths of 200 to 5,500 meters (656.2 to 18,044.6 feet).

On WhaleMap, there are 56 definite sightings and 29 definite acoustic detection records of North Atlantic right whales off North Carolina from 2010 through 2022. All sightings were made from January through March (Johnson et al. 2021).There were no sightings or detections in the seismic survey area, although there were some records in the shallower water adjacent to it (Johnson et al. 2021). Similarly, (Hayes et al. 2022) showed several sightings on the continental shelf off North Carolina for 2015 through 2019, but no sightings within the seismic survey area. In contrast, Department of the Navy (DoN 2008b; DoN 2008c) reported single sightings within or near the seismic survey area during fall, winter, and spring. North Atlantic right whales had the greatest occurrence off North Carolina during the winter (December through April), with fewer sightings during spring and fall, and no sightings during summer. There are no records of North Atlantic right whales for the seismic survey area off North Carolina in the OBIS database. However, there are 47 records in the OBIS database for coastal waters of North Carolina, including sightings made during the 1978 through 1982 Cetacean and Turtle Assessment Program (CETAP) surveys; most records occurred during March. The North Atlantic right whale is expected to be rare in the seismic survey area at the time of the high-energy seismic survey, and it spends most of its time in nearshore areas.

From this overview, the North Atlantic right whales may be found within the action area. However, the North Atlantic right whale is not expected to occur in the area of the seismic survey activities as the tracklines to the high-energy seismic survey are further offshore than in the nearshore and shallower waters which they normally occur as well as during May through September when they are further north in the summer feeding grounds. Given the lack of 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 during the seismic survey activities. Therefore, we do not expect the animals to be exposed to the potential stressors of acoustic noise from the airgun array, as it is extremely unlikely to occur. Due to the rare nature of North Atlantic right whales in the action area, the potential adverse impacts from the acoustic noise from the airgun array is discountable.

As discussed in Section 7.1, exposure is discountable or response is insignificant for North Atlantic right whales from the stressors of pollution, vessel strike, vessel noise during the transit and port stops of the R/V *Marcus G. Langseth*, acoustic noise from the airgun array, acoustic noise from the sub-bottom profiler, multi-beam echosounder, split-beam echosounder, and acoustic Doppler current profiler, and gear entanglement and interaction. Therefore, we conclude that the NSF and L-DEO's high-energy seismic survey may affect, but is not likely to adversely affect ESA-listed North Atlantic right whales.

7.2.2 Marine Reptiles

The hawksbill turtle may occur in the action area and may be affected by the proposed actions. In addition to the potential stressors that are not likely to adversely affect ESA-listed sea turtles discussed above in Section 7.1, other stressors resulting from the proposed actions may affect, but are not likely to adversely affect specific species and designated critical habitat as discussed in the following subsections.

7.2.2.1 Hawksbill Turtles

The ESA-listed hawksbill turtle may occur in the action area and may be affected by stressors associated with the NSF and L-DEO's high-energy seismic survey (Section 4). While the hawksbill turtle can be found in coastal and pelagic habitats within the action area, it is unlikely that hawksbill turtles will be adversely affected by stressors associated with the proposed actions as they are not expected to occur in the portion of the action area where airgun array operations are expected to occur. Each of the stressors associated with the proposed actions, along with our determination of their impacts to ESA-listed sea turtles within the action area, are discussed above.

Hawksbill turtles are circumtropical, and found in the Atlantic Ocean, Indian Ocean, and Pacific Ocean from about 30 degrees North to 30 degrees South. The proposed actions would take place in the Northwest Atlantic Ocean off North Carolina, between approximately 31 to 35 degrees North, and 72 to 75 degrees West, which is north of where we would expect hawksbill turtles to occur.

Hawksbill turtles are rare in the mid-Atlantic Ocean, with only occasional sightings (Witherington et al. 2012a; Witzell 1983). The lack of sighting or bycatch data, as well as the rarity of strandings, lead us to believe that hawksbill turtles are unlikely to be in the action area during the high-energy seismic survey (Epperly et al. 2002; Epperly et al. 1996; NMFS 2010a; NMFS 2011a; NMFS 2012a; NMFS 2013; NMFS 2014; NMFS 2015a; NMFS 2016).

Several sightings have been reported off the coasts of Virginia and North Carolina throughout the year, with the fewest sightings in the fall; most sightings occurred on the shelf (DoN 2008b)(DoN 2008c)(Palka et al. 2021). There are no records in the seismic survey area off North Carolina in the OBIS database.

From this overview, the hawksbill turtle may be found within the action area. However, the hawksbill turtle is not expected to occur in the area of the seismic survey activities. Given the lack of sightings, this species is considered extremely rare and not expected to be present in the action area. Therefore, we do not expect the animals to be exposed to the potential stressors of acoustic noise from the airgun array, as it is extremely unlikely to occur. Due to the rare nature of hawksbill turtles in the action area, the potential adverse impacts from the acoustic noise from the airgun array is discountable.

As discussed in Section 7.1, exposure is discountable or response is insignificant for hawksbill turtles from the stressors of pollution, vessel strike, vessel noise, acoustic noise from the airgun array, acoustic noise from the sub-bottom profiler, multi-beam echosounder, split-beam echosounder, acoustic Doppler current profiler or gear entanglement and interaction. Therefore, we conclude that the NSF and L-DEO's high-energy seismic survey may affect, but is not likely to adversely affect ESA-listed hawksbill turtles.

7.2.3 Fishes

The Carolina DPS of Atlantic sturgeon, Chesapeake DPS of Atlantic sturgeon, Gulf of Maine DPS of Atlantic sturgeon, New York Bight DPS of Atlantic sturgeon, South Atlantic DPS of Atlantic sturgeon, giant manta ray, oceanic whitetip shark, and shortnose sturgeon may occur in the action area and may be affected by the proposed actions. In addition to the potential stressors discussed in Section 7.1, other stressors resulting from the proposed actions may affect, but are not likely to adversely affect specific species and designated critical habitat as discussed in the following subsections.

7.2.3.1 Atlantic Sturgeon – Carolina Distinct Population Segment, Chesapeake Distinct Population Segment, Gulf of Maine Distinct Population Segment, New York Bight Distinct Population Segment, and South Atlantic Distinct Population Segment

The ESA-listed Carolina DPS, Chesapeake DPS, Gulf of Maine DPS, New York Bight DPS, and South Atlantic DPS of Atlantic sturgeon may occur in the action area and may be affected by the stressors associated with the NSF and L-DEO's high-energy seismic survey (Section 4). While the Carolina DPS, Chesapeake DPS, Gulf of Maine DPS, New York Bight DPS, and South Atlantic DPS of Atlantic sturgeon can be found in coastal and pelagic habitats within the action area, it is unlikely that Carolina DPS, Chesapeake DPS, Gulf of Maine DPS, New York Bight DPS, and South Atlantic DPS of Atlantic sturgeon will be adversely affected by stressors associated with the proposed actions because they are not expected to occur in the portion of the action area where airgun array operations are expected to occur. Each of the stressors associated

with the proposed actions, along with our determination on their impacts to ESA-listed fish within the action area, are discussed above.

Atlantic sturgeon occupy ocean waters and associated bays, estuaries, and coastal river systems from Hamilton Inlet, Labrador, Canada to Cape Canaveral, Florida (ASMFC 2006; Stein et al. 2004). Atlantic sturgeon spawn in freshwater, but spend most of their adult life in the marine environment. Spawning adults generally migrate upriver in May through July in Canadian systems (Bain 1997; Caron et al. 2002; Murawski and Pacheco 1977; Smith 1985; Smith and Clugston 1997).

Sub-adult and adult Atlantic sturgeon from all five DPSs (Carolina DPS, Chesapeake DPS, Gulf of Maine DPS, New York Bight DPS, and South Atlantic DPS) of Atlantic sturgeon occur in the marine environment. There are gaps in our understanding about the offshore marine distribution of Atlantic sturgeon. Much of the available data point to Atlantic sturgeon using relatively nearshore, shallow water habitats, less than 20 meters (65.6 feet) in the marine environment, but there are reports of Atlantic sturgeon being captured in waters 75 meters (246 feet) deep (Sokolowski et al. 2012). The proposed actions would take place in water depths from 200 to 5,500 meters (656.2 to 18,044.6 feet).

Bycatch data offer insight into the marine distribution of Atlantic sturgeon. During observed fishing trips using trawls, the majority of Atlantic sturgeon captures occurred in waters 20 meters (65.6 feet) deep or less (ASMFC 2017). Studies focusing on Atlantic sturgeon in the New York Bight have found that Atlantic sturgeon appear to prefer waters 20 meters (65.6 feet) or less (Dunton et al. 2010), with no captures occurring in waters greater than 20 meters (65.6 feet) (Dunton et al. 2015). Other observations have found Atlantic sturgeon in deeper waters (up to 50 meters [164 feet]) (ASMFC 2017; Stein et al. 2004), and even as deep as 75 meters (246 feet) (Colette and Klein-MacPhee 2002). In South Carolina, tagged Atlantic sturgeon were detected up to 24 kilometers (13 nautical miles) from shore, placing them in waters ten to 20 meters (32.8 to 65.6 feet) deep.

There is also evidence that Atlantic sturgeon habitat in the marine environment use changes with season. Erickson et al. (2011) found that Atlantic sturgeon occupied deeper waters in the fall and winter (October through March) than in the spring and summer. From April through June (spring), Atlantic sturgeon occupied a mean water depth of 12.9 meters (42.3 feet) (3.8 to 37.7 meters [12.5 to 123.7 feet]) and 9.9 meters (32.5 feet) (4.5 to 25 meters [14.8 to 82 feet]) from July through September (summer). From October through December (Pfaller et al.) and January through March (winter), Atlantic sturgeon occupied deeper waters with a mean water depth of 16.1 meters (52.8 feet) (two to 33.9 meters [6.6 to 111.2 feet]) and 24.4 meters (80.1 feet) (6.5 to 37.6 meters [21.3 to 123.4 feet]) (Erickson et al. 2011). In addition, aggregations of Atlantic sturgeon have been detected by telemetry arrays off the coast of Virginia, with groups of 40 or more individuals found at stations 53 kilometers (28.6 nautical miles) from shore (20 to 30 meters [65.6 to 98.4 feet] deep) in January through April (C. Watterson personal communication to C. Cairns on December 5, 2017; Watterson 2017). Groups of six to 20 Atlantic sturgeon were

found as far as 83 kilometers (44.8 nautical miles) from shore (30 to 40 meters [98.4 to 131.2 feet] deep) during that same period. In summer, there were no Atlantic sturgeon detections that far offshore; the few Atlantic sturgeon that were detected were close to shore (28 kilometers [15.1 nautical miles] or less, in waters less than 20 meters [65.6 feet] deep). Similarly, reports of Atlantic sturgeon habitat use in and near the Bureau of Ocean Energy Management's Maryland Wind Energy Area off the coast of Maryland indicate individuals prefer inshore, shallow water during warmer months, with an increase in detection in deeper waters, further offshore during winter months (Secor and Bailey 2017). It is possible that the movement of adult Atlantic sturgeon in the marine environment is driven by physical conditions; other life stages of Atlantic sturgeon also make seasonal movements in rivers and estuaries, likely driven by water temperature or prey availability (ASMFC 2017).

Based on what we understand about Atlantic sturgeon distribution in the marine environment, it seems likely that they would mostly be prevented from exposure due to the offshore area of the high-energy seismic survey. However, it is possible that some Atlantic sturgeon could be exposed to the proposed actions. In the even that an Atlantic sturgeon is exposed to seismic survey activities, we provide a discussion on sturgeon hearing and a description of the sound sources used in the proposed actions above to consider potential effects to Atlantic sturgeon.

From this overview, the Carolina DPS, Chesapeake DPS, Gulf of Maine DPS, New York Bight DPS, and South Atlantic DPS of Atlantic sturgeon may be found within the action area. However, the Carolina DPS, Chesapeake DPS, Gulf of Maine DPS, New York Bight DPS, and South Atlantic DPS of Atlantic sturgeon are not expected to occur in the area of the seismic survey activities as the tracklines of the high-energy seismic survey are further offshore than in the nearshore and shallow waters which they normally occur. Given the lack of detections, this species is considered extremely rare and not expected to be present in the action area. Therefore, we do not expect the animals to be exposed to the potential stressor of acoustic noise from the airgun array. Due to the rarity of the Carolina DPS, Chesapeake DPS, Gulf of Maine DPS, New York Bight DPS, and South Atlantic DPS of Atlantic sturgeon in the action area, the potential adverse effects from the acoustic noise from the airgun array is discountable.

As discussed in Section 7.1, exposure is discountable or response is insignificant for Carolina DPS, Chesapeake DPS, Gulf of Maine DPS, New York Bight DPS, and South Atlantic DPS of Atlantic sturgeon from the stressors of pollution, vessel strike, vessel noise, acoustic noise from the airgun array, acoustic noise from the sub-bottom profiler, multi-beam echosounder, split-beam echosounder, acoustic Doppler current profiler, or gear entanglement and interaction. Therefore, we conclude that the NSF and L-DEO's high-energy seismic survey may affect, but is not likely to adversely affect ESA-listed Carolina DPS, Chesapeake DPS, Gulf of Maine DPS, New York Bight DPS, and South Atlantic DPS of Atlantic sturgeon.

7.2.3.2 Giant Manta Ray

The ESA-listed giant manta ray may occur in the action area and may be affected by the stressors associated with the NSF and L-DEO's high-energy seismic survey (Section 4). While the giant

manta ray can be found in coastal and pelagic habitats within the action area, it is unlikely that giant manta rays will be adversely affected by stressors associated with the proposed actions.

Giant manta rays occupy tropical, subtropical, and temperate oceanic waters and productive coastlines. Manta rays are commonly detected at productive nearshore and shelf-edge upwelling zones at surface thermal frontal boundaries within a temperature range of approximately 20 to 30 degrees Celsius (68 to 86 degrees Fahrenheit) (Farmer et al. 2022). Some individual manta rays may be occasionally observed in coastal areas, though we consider sightings rare, and the status review says that this larger of the two manta ray species be more oceanic than the other. In the Atlantic Ocean, giant manta rays have been observed as far north as New Jersey and are widespread in the Gulf of Mexico. Giant manta rays are commonly found offshore in oceanic waters, but are sometimes found feeding in shallow waters (less than ten meters [32.8 feet]) during the day (Miller 2016). Giant manta rays may be found in shallow water, but tagged individuals have been shown to dive up to 200 to 450 meters (656.2 to 1,476.4 feet) and may make dives greater than 1,000 meters (3,280.8 feet), possibly depending on prey distribution (NMFS 2020b). A study using satellite tags by Graham et al. (2012) tracked movements of tagged giant manta rays off the Yucatán Peninsula, in which most observations (92 percent) occurred over 20 kilometers (10.8 nautical miles) offshore in waters five to 100 meters (16.4 to 328.1 feet) deep near the tip of the peninsula.

Giant manta rays are migratory, capable of undertaking migrations up to 1,500 kilometers (809.9 nautical miles) (Graham et al. 2012; Hearn et al. 2014), although some tagged individuals have been observed staying in the same location (Stewart et al. 2016). Giant manta rays tend to be solitary except for feeding and breeding periods in which individuals congregate. Giant manta rays have been observed in aggregations of 100 to 1,000 individuals (Miller 2016; Notarbartolo-di-Sciara and Hillyer 1989), at particular sites. These sites are thought to be feeding or cleaning locations, or where courtships take place.

There is not a great deal of information on the population structure of giant manta rays. Some evidence suggests that there are isolated subpopulations (Stewart et al. 2016), and possibly a subspecies resident to the Yucatán Peninsula (Hinojosa-Alvarez et al. 2016). There are not current or historical estimates of rangewide abundance, although there are some rough estimates of subpopulation size based on anecdotal accounts from fishermen and divers. It is difficult to obtain reliable abundance estimates as the species is only sporadically observed. There are about 11 subpopulations worldwide (perhaps more), and these subpopulation estimates range from 100 to 1,500 individuals each (FAO 2012; Miller 2016). The only abundance data for giant manta rays in the Atlantic Ocean comes from two sources; the Flower Garden Banks National Marine Sanctuary in the Gulf of Mexico, with more than 70 individuals, and in the waters off Brazil, with about 60 individuals (Miller 2016).

From this overview, giant manta rays may be found within the action area. As discussed in Section 7.1, response is insignificant for giant manta rays from the stressors of pollution, vessel strike, vessel noise, acoustic noise from the airgun array, acoustic noise from the sub-bottom

profiler, multi-beam echosounder, split-beam echosounder, acoustic Doppler current profiler, or gear entanglement and interaction. Therefore, we conclude that the NSF and L-DEO's high-energy seismic survey may affect, but is not likely to adversely affect ESA-listed giant manta rays.

7.2.3.3 Oceanic Whitetip Shark

The ESA-listed oceanic whitetip shark may occur in the action area and may be affected by the stressors associated with the NSF and L-DEO's high-energy seismic survey (Section 4). While the oceanic whitetip shark can be found in pelagic habitats within the action area, it is unlikely that oceanic whitetip sharks will be adversely affected by stressors associated with the proposed actions.

The oceanic whitetip shark is distributed worldwide in tropical and subtropical waters between ten degrees North and ten degrees South, usually found in open ocean and near the outer continental shelf (Young 2016). They can be found as far as 30 degrees North and 35 degrees South latitude. Oceanic whitetip sharks can be found at the water's surface, but most frequently stay between 25.5 to 50 meters (83.7 to 164 feet) (Carlson and Gulak 2012; Young 2016). Oceanic whitetip sharks occur from the water's surface to at least 152 meters (498.7 feet) deep, and display a preference for water temperatures above 20 degrees Celsius (68 degrees Fahrenheit. They can be found in waters between 15 and 28 degrees Celsius (59 to 82.4 degrees Fahrenheit, and can briefly tolerate waters as cold as 7.75 degrees Celsius (45.9 degrees Fahrenheit) during dives to the mesopelagic zone (Howey-Jordan et al. 2013; Howey et al. 2016). In the Western Atlantic Ocean, oceanic whitetip sharks occur from Maine to Argentina, including the Caribbean Sea and Gulf of Mexico. Essential Fish Habitat for the oceanic whitetip shark includes localized areas in the central Gulf of Mexico and Florida Keys, and depths greater than 200 meters (656.2 feet) in the Atlantic Ocean (from southern New England to Florida, Puerto Rico, and the U.S. Virgin Islands).

Little is known about the movement or possible migration paths of the oceanic whitetip shark. Although the species is considered highly migratory and capable of making long distance movements, tagging data provides evidence that this species also exhibits a high degree of philopatry (i.e., site fidelity) in some locations. To date, there have been three tagging studies conducted on oceanic whitetip sharks in the Atlantic Ocean. In the Atlantic Ocean, young oceanic whitetip sharks have been found well offshore along the Southeastern coast of the U.S., suggesting that there may be a nursery in oceanic waters over this continental shelf (Bonfil et al. 2008; Compagno 1984). In the Southwestern Atlantic Ocean, the prevalence of immature sharks, both female and male, in fisheries catch data suggests that this area may serve as potential nursery habitat for the oceanic whitetip shark (Coelho et al. 2009; Frédou et al. 2015; Tambourgi et al. 2013; Tolotti et al. 2015). Juveniles seem to be concentrated in equatorial latitudes, while specimens in other maturational stages are more widespread (Tambourgi et al. 2013). Pregnant females are often found close to shore, particularly around the islands in the Caribbean Sea.

There is no rangewide abundance estimate available for oceanic whitetip sharks. However, the species was once one of the most abundant sharks in the ocean; catch data from individual ocean basins indicate that the populations have undergone significant declines (Young 2016). There is no population growth rate available for the oceanic whitetip shark. In the Northwest Atlantic Ocean and Gulf of Mexico, declines are estimated to be between 57 and 88 percent (Young 2016). Although oceanic whitetip sharks are highly migratory, they appear to display a high degree of philopatry to certain sites, with females giving birth on one side of a basin or the other, and may not mix with individuals of other regions (Howey-Jordan et al. 2013; Tolotti et al. 2015; Young 2016). Thermal barriers (i.e., water temperatures less than 15 degrees Celsius [59 degrees Fahrenheit]) may prevent inter-ocean basin movements. In the Northwest Atlantic Ocean, the oceanic whitetip shark was described historically as widespread, abundant, and the most common pelagic shark in the warm parts of the North Atlantic Ocean (Backus et al. 1956). Recent information, however, suggest the species is relatively rare in this region.

From this overview, oceanic whitetip sharks may be found in the action area. The oceanic whitetip shark has been reported in the Northwest Atlantic Ocean off North Carolina. As discussed in Section 7.1, response is insignificant for oceanic whitetip shark from the stressors of pollution, vessel strike, vessel noise, acoustic noise from the airgun array, acoustic noise from the sub-bottom profiler, multi-beam echosounder, split-beam echosounder, and acoustic Doppler current profiler, or gear entanglement and interaction. Therefore, we conclude that the NSF and L-DEO's high-energy seismic survey may affect, but is not likely to adversely affect ESA-listed oceanic whitetip sharks.

7.2.3.4 Shortnose Sturgeon

The ESA-listed shortnose sturgeon may occur in the action area and may be affected by the stressors associated with the NSF and L-DEO's high-energy seismic survey (Section 4). While the shortnose sturgeon can be found in coastal habitats within the action area, it is unlikely that shortnose sturgeon will be adversely affected by stressors associated with the proposed actions because the species is not expected to occur in the portion of the action area where airgun array operations and the majority of stressors are expected to occur.

Shortnose sturgeon occur in the rivers, estuaries, and seas along the east coast of North America (Vladykov and Greeley 1963). They were once present in most major river systems along the coast of the Atlantic Ocean (Kynard 1997). Their northerly distribution extends to the St. John River, New Brunswick, Canada, and their southerly distribution historically extended to the Indian River, Florida (Evermann and Bean 1898; Scott and Scott 1988). Currently, the distribution of shortnose sturgeon across their range is disjunct, with northern populations separated from southern populations by a distance of about 400 kilometers (248.5 miles) near their geographic center in North Carolina and Virginia. Some river systems host populations which barely leave freshwater while in other areas coastal migrations between river systems are common. Spawning locations have been identified within a number of river systems (NMFS 2010f).

Shortnose sturgeon overwinter in the lower portion of rivers and migrate upriver to spawn in the spring. After spawning, adult shortnose sturgeon move rapidly to downstream feeding areas where they forage on benthic insects, crustaceans, mollusks, and polychaetes (Buckley and Kynard 1985; Dadswell 1984; Kieffer and Kynard 1993; O'Herron et al. 1993).

The general pattern of coastal migration of shortnose sturgeon indicates movement between groups of rivers proximal to each other across the geographic range (Altenritter et al. 2015; Dionne et al. 2013; Quattro et al. 2002; Wirgin et al. 2005). However, migration/straying is not necessarily resulting in effective gene exchange as indicated by high degree of genetic differentiation among riverine populations. Currently, shortnose sturgeon occur in 41 bays and rivers along the U.S. east coast and reproduce in 19 of them. The 1998 Final Recovery Plan for shortnose sturgeon recommended that 19 separate river populations of shortnose sturgeon be managed as DPSs (NMFS 1998b). Upon further analysis, five regional population clusters of shortnose sturgeon have been determined for abundance estimates for populations within each of these population clusters. The regional population clusters include the Gulf of Maine (Penobscot River, Kennebec Complex, and Merrimack River), Connecticut River and Housatonic River (Lower and Upper Connecticut River), Hudson River (Hudson River), Delaware River and Chesapeake Bay (Delaware River), and Southeast Rivers (Cape Fear River, Winyah Bay System, Cooper River, Lake Marion, Savannah River, Ogeechee River, and Altamaha River). The shortnose sturgeon status review team recommends, however, that recovery and management actions consider each rivering population as a management/recovery unit (NMFS 2010f).

From this overview, the shortnose sturgeon may be found within the action area. However, the shortnose sturgeon is not expected to occur in the area of the seismic survey activities as the tracklines to the high-energy seismic survey are deeper and further offshore than in the shallower and nearshore waters which they normally occur. Given the lack of detections, this species is considered extremely rare and not expected to be present in the main portion of the action area. Therefore, we do not expect the animals to be exposed to the potential stressors of acoustic noise from the airgun array, as it is extremely unlikely to occur. Due to the rare nature of shortnose sturgeon in the action area, the potential adverse impacts from the acoustic noise from the airgun array is discountable.

As discussed in Section 7.1, exposure is discountable or response is insignificant for shortnose sturgeon from the stressors of pollution, vessel strike, vessel noise, acoustic noise from the airgun array, acoustic noise from the sub-bottom profiler, multi-beam echosounder, split-beam echosounder, and acoustic Doppler current profiler, or gear entanglement and interaction. Therefore, we conclude that the NSF and L-DEO's high-energy seismic survey may affect, but is not likely to adversely affect ESA-listed shortnose sturgeon.

7.3 Designated Critical Habitat

The designated critical habitat of Northwest Atlantic Ocean DPS of loggerhead turtle occur in the action area and may be affected by the proposed actions.

7.3.1 Loggerhead Turtle – Northwest Atlantic Ocean Distinct Population Segment Critical Habitat

In 2014, NMFS and the U.S. Fish and Wildlife Service designated critical habitat for the Northwest Atlantic Ocean DPS of loggerhead turtle along the U.S. Atlantic and Gulf of Mexico coasts, from North Carolina to Mississippi (79 FR 39856) (Figure 2). The final rule designated five different units of critical habitat, each supporting an essential biological function of loggerhead turtles. These units include nearshore reproductive habitat, winter area, *Sargassum*, breeding areas, and migratory corridors. In total, the critical habitat is composed of 38 occupied marine areas and 1,102.4 kilometers (685 miles) of nesting beaches. Loggerhead designated critical habitat occurs within the action area and the potential effects to each unit and its physical and biological features are discussed below (Table 8).

Table 8. Essential physical and biological features for loggerhead turtle designated critical habitat units.

Loggerhead Turtle Designated Critical Habitat Unit	Essential Physical or Biological Features
Nearshore Reproductive Habitat	1. Nearshore waters directly off the highest density nesting beaches and their adjacent beaches as identified in 50 C.F.R. 17.95(c) to 1.6 kilometers (0.9 nautical miles) offshore. 2. Waters sufficiently free of obstructions or artificial lighting to allow transit through the surf zone and outward toward open water. 3. Waters with minimal manmade structures that could promote predators (i.e., nearshore predator concentration caused by submerged and emergent offshore structures), disrupt wave patterns necessary for orientation, and/or create excessive longshore currents.
Winter Habitat	1. Water temperatures above 10 degrees Celsius from November through April. 2. Continental shelf waters in proximity to the western boundary of the Gulf Stream. 3. Water depths between 20 and 100 meters (65.6 to 328.1 feet).
Breeding Habitat	1. High densities of reproductive male and female loggerheads. 2. Proximity to primary Florida migratory corridor.

Loggerhead Turtle Designated Critical Habitat Unit	Essential Physical or Biological Features
	3. Proximity to Florida nesting grounds.
Constricted Migratory Habitat	1. Constricted continental shelf area relative to nearby continental shelf waters but concentrate migratory pathways. 2. Passage conditions to allow for migration to and from nesting, breeding, and/or foraging areas.
Sargassum Habitat	1. Convergence zones, surface-water downwelling areas, the margins of major boundary currents (Gulf Stream), and other locations where there are concentrated components of the *Sargassum* community in water temperatures suitable for the optimal growth of *Sargassum* and inhabitance of loggerhead turtles. 2. *Sargassum* in concentrations that support adequate prey abundance and cover. 3. Available prey and other material associated with *Sargassum* habitat including, but not limited to, plants and cyanobacteria and animals native to the *Sargassum* community such as hydroids and copepods. 4. Sufficient water depth and proximity to available currents to ensure offshore transport (out of the surf zone), and foraging and cover requirements by *Sargassum* for post-hatchling loggerhead turtles, i.e., greater than 10 meters (32.8 feet) depth.

Nearshore Reproductive Habitat

Nearshore reproductive habitat is a portion of the nearshore waters adjacent to nesting beaches that are used by hatchlings to egress to the open-water environment as well as by nesting females to transit between beach and open water during nesting season. Nearshore reproductive habitat units occur in 35 areas from North Carolina to Mississippi. These units extend from the shore to 1.6 kilometer (0.9 nautical mile) seaward. The physical and biological features for nearshore reproductive habitat are shown in Table 8.

Winter Habitat

Winter habitat is designated off North Carolina from the 20 to 100 meter (65.6 to 328.1 feet) depth contour. Winter habitat is warm water habitat south of Cape Hatteras near the western edge of the Gulf Stream used by a high concentration of juveniles and adults during the winter months. The purpose in the designated winter habitat was to maintain habitat with suitable water temperatures and depths, and continental shelf waters in proximity to the Gulf Stream to support a loggerhead turtle foraging area (Table 8). The physical and biological features for winter habitat are shown in Table 8.

Breeding Habitat

Breeding habitat is sites with high densities of both male and female adult individuals during the breeding season. Loggerhead turtle breeding critical habitat includes two areas along the Atlantic Ocean coast of Florida, and into the Florida Keys. The southern unit starts at the Martin County/Palm Beach County line and extends south to the Marquesas Keys. The northern portion of the breeding habitat unit is located from near Titusville, Florida, south to Floridana Beach, from the shoreline to depths less than 60 meters (196.9 feet). The physical and biological features for breeding habitat are shown in Table 8.

Constricted Migratory Habitat

Constricted migratory habitat is high use migratory corridors that are constricted (limited in width) by land on one side and the edge of the continental shelf and Gulf Stream on the other side. Loggerhead turtles migrate through this area northward in the spring (to foraging areas in the Mid-Atlantic Bight) and southward in the fall (south of Cape Hatteras) to be in warmer waters (78 FR 43005). The physical and biological features for constricted migratory habitat are shown in Table 8.

Sargassum Habitat

Sargassum habitat is developmental and foraging habitat for young loggerhead turtles where surface waters form accumulations of floating material, especially *Sargassum*. The physical and biological features for *Sargassum* habitat are shown in Table 8.

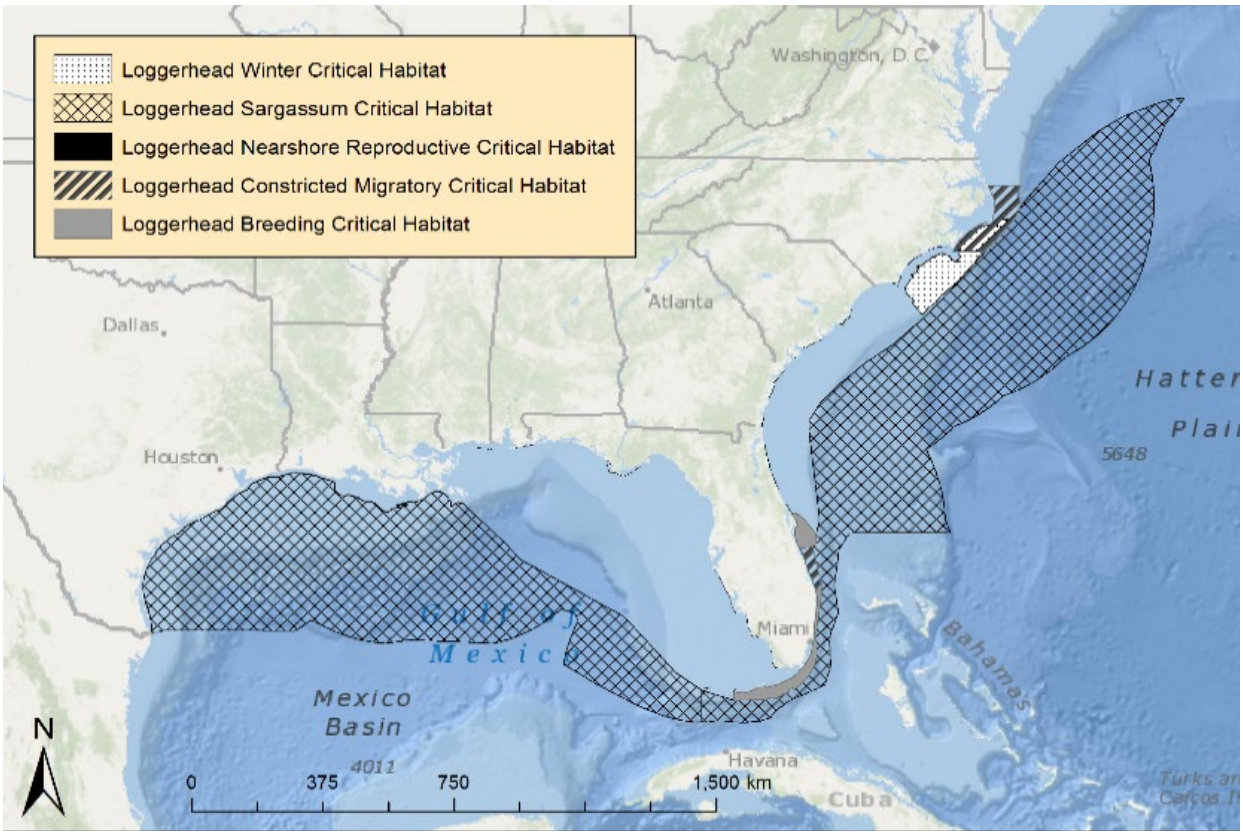

Figure 2. Map identifying designated critical habitat (nearshore reproductive habitat, winter habitat, breeding habitat, constricted migratory habitat, and *Sargassum* habitat) for the threatened Northwest Atlantic Ocean distinct population segment of loggerhead turtle.

7.3.2 Effects to Designated Critical Habitat

The seismic survey activities overlap with portions of the designated critical habitat for the Northwest Atlantic Ocean DPS of loggerhead turtle. Four habitat types (nearshore reproductive habitat, winter habitat, constricted migratory habitat, and *Sargassum* habitat) types occur near or within the seismic survey area. Breeding habitat does not occur within the seismic survey area. Nearshore reproductive habitat occurs approximately 50 kilometers (27 nautical miles) from the seismic survey area near Morehead City and Wilmington, North Carolina. Winter habitat occurs approximately five kilometers (2.7 nautical miles) west of the seismic survey area and includes warm waters on the continental shelf south of Cape Hatteras, North Carolina that hosts a high abundance of juveniles and adults during the winter. Constricted migratory habitat occurs approximately one kilometer (0.5 nautical miles) from the seismic survey area. *Sargassum* habitat overlaps much of the seismic survey area. The research vessel's transit to and from the port of Norfolk, Virginia overlaps with these four habitat types of designated critical habitat of the Northwest Atlantic Ocean DPS of loggerhead turtle. Very few effects to this habitat are expected for the reasons detailed below.

Given the nature of the survey activities, none of the physical and biological features essential to the conservation of Northwest Atlantic Ocean DPS of loggerhead turtle would be significantly

altered. We do not expect there to be substantial effects to water quality as a result of the proposed actions. Pollution would effect water quality and was discussed in Section 7.1.1. Vessel transit would not significantly alter nearshore and open waters, water temperature, continental shelf waters, water depths, migratory pathways and passage conditions, *Sargassum* concentrations, available prey and other material associated with *Sargassum* habitat, and water depth and proximity to available currents to ensure offshore transport, foraging, and cover requirements by *Sargassum*. Based on the size of the action area as well as research vessel and gear relative to the designated critical habitat, Northwest Atlantic DPS of loggerhead turtles should be able to maneuver away from the research vessel and associated gear and transit in open water. Furthermore, the proposed actions are an overall short duration in areas where we expect Northwest Atlantic Ocean DPS of loggerhead turtles most likely to occur (e.g., off the coasts of North Carolina and Virginia). No impediment of migration pathways to continental shelf waters or to and from nesting, breeding, and/or foraging areas would be expected to occur for Northwest Atlantic Ocean DPS of loggerhead turtles as the amount of time that the proposed actions would overlap with designated critical habitat during transits is a couple days (approximately two days), and most of that transit time would be further offshore in open water. The research vessel could come into close proximity with, or even in contact with, prey species found within these designated critical habitats. We expect that any such interactions would only result in a temporary, slight displacement of prey. If larger prey were to come into contact with the research vessel's propellers, it is possible that individual prey can be killed. However, even if this unlikely event were to occur, the removal of several individual prey would have a limited impact on the overall abundance of prey resources in the area of the designated critical habitat. Because the operations of the research vessel are temporary (i.e., not a permanent manmade structure), the seismic survey activities would not prevent animals from accessing critical habitats on land or in the water. Also, the equipment would not alter, damage, or destroy physical habitat (e.g., water temperature and water depths).

The acoustic sound sources from the seismic survey activities would not significantly alter the primary prey or food resources available given the short duration of the high-energy seismic survey within the designated critical habitat for the Northwest Atlantic Ocean DPS of loggerhead turtle. We expect impacts to prey fish (e.g., small pelagic schooling fish) to be in the form of behavioral disturbance, TTS, and injury, but no mortality. After the research vessel has moved away from their prey species may occur, we expect prey species to return to normal behavior in the action area. If prey fish, euphausiids, shrimp, amphipods, jellyfish (if at all), and benthic organisms avoid the area of the active airgun array operations due to aversions from the sound source, it is expected to be temporary with no long-term significant effects. Prey species are mobile and are broadly distributed throughout the action area; therefore, sea turtles that may be temporarily displaced during seismic survey activities are expected to be able to resume foraging once they have moved away from areas with disturbing levels of underwater noise. Conditions are expected to return to normal within a few days at the most after the seismic survey activities have ceased in the action area. Because the seismic survey activities are relatively short in

duration (approximately 28 days of airgun array operations, approximately three days of coring activities and heat flow measurements, and approximately two days of transit), the disturbance would be temporary in nature, and similar habitat and prey resources are available in the surrounding area, the impacts to sea turtles and their prey resources that they utilize for food are not expected to cause significant or long-term consequences for individuals or their populations. The coring activities and heat flow measurements may also temporarily disperse sea turtles and other prey.

The use of active acoustics during the seismic survey activities would be temporary and relatively short in duration, and are not expected to significantly impact available prey and other material associated with *Sargassum* habitat. For example, evidence indicates that airguns may lead to a significant reduction in zooplankton, including copepods. McCauley et al. (2017) found that the use of a single airgun (approximately 2,458.1 cubic centimeters [150 cubic inches]) led to a decrease in zooplankton abundance by over 50 percent and a two- to three-fold increase in dead adult and larval zooplankton when compared to control scenarios. In addition, effects were found out to 1.2 kilometers (0.6 nautical miles), the maximum distance to which the sonar equipment used in the study was able to detect changes in abundance. McCauley et al. (2017) noted that for seismic survey activities to have a significant impact on zooplankton at an ecological scale, the spatial or temporal scale of the seismic survey activities must be large in comparison to the ecosystem in question. In particular, three-dimensional seismic surveys, which involve the use of multiple overlapping tracklines to extensively and intensively survey a particular area, are of concern (McCauley et al. 2017). This is in part because for such seismic survey activities to have a measurable effect, they need to outweigh the naturally fast turnover rate of zooplankton (McCauley et al. 2017).

In contrast to McCauley et al. (2017), Fields et al. (2019b) observed lower rates of mortality to zooplankton in an experiment using two airguns each with a chamber of 4,260.6 cubic centimeters (260 cubic inches). Fields et al. (2019b) noted that immediate mortality of copepods was significantly different from controls at distances of five meters (16.4 feet) or less from the airguns. Mortality one week after the seismic shot from the airgun was nine percent higher than controls in copepods placed ten meters (32.8 feet) from the airgun blast, but was not significantly different from the controls at a distance of 20 meters (65.6 feet) from the seismic shot from the airgun. The increase in mortality relative to controls did not exceed 30 percent at any distance from the seismic shot from the airgun.

Given the results from each of these studies, it is difficult to assess the exact impact airgun arrays may have on the instantaneous or long-term survivability of zooplankton that are exposed. The majority of copepod prey available to loggerhead turtles in *Sargassum* habitat are expected to be near the water's surface (Witherington et al. 2012b), but results of McCauley et al. (2017) provide little information on the effects to copepods at the water's surface since their analyses excluded zooplankton at the surface bubble layer. Nonetheless, given that airguns primarily transmit sound downward, and that those associated with the proposed actions would be towed at

a depth of six meters (19.7 feet), we expect that sounds from the airgun array would be relatively low at the water's surface and as such, would affect copepod prey in *Sargassum* habitat less than that reported in McCauley et al. (2017). We also anticipate that seismic survey activities would actively avoid *Sargassum* patches within the action area, as coming near or in contact with any *Sargassum* may interfere with towed equipment. Nevertheless, since effects to zooplankton have been observed out to 1.2 kilometers (0.6 nautical miles), the avoidance of *Sargassum* patches may not entirely prevent effects to copepods in nearby *Sargassum* patches. However, in contrast to the intensive three-dimensional seismic surveys discussed in McCauley et al. (2017), the two-dimensional seismic survey and designed as exploratory and covering a large area in a relatively short amount of time. The seismic survey activities are less likely to have significant effects on zooplankton given the high turnover rate of zooplankton and the currents in the North Atlantic Ocean gyre and the Gulf Stream, which would circulate *Sargassum* within the action area (see Richardson et al. 2017 for simulations based on the results of McCauley et al. 2017 that suggest ocean circulation greatly reduce the impact of seismic surveys on zooplankton at the population level). Also, the research vessel would be conducting a two-dimensional, high-energy seismic survey with some overlapping tracklines and continuously moving during the entire proposed action, but will remain on station during coring activities.

When considering the limit of potential exposure, we conclude that any disturbance to the physical and biological features would be insignificant. Therefore, the seismic survey activities may affect, but are not likely to adversely affect any of the physical and biological features of the designated critical habitat for the Northwest Atlantic Ocean DPS of loggerhead turtle.

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

Table 9 depicts our effects analysis by potential stressor for each ESA-listed species and designated critical habitat considered in this consultation.

Table 9. Summary of Endangered Species Act-listed species effects determination by potential stressor associated with the proposed actions.

Endangered Species Act-listed Species in the Action Area	Overall Determination	Potential Stressors					
		Pollution	Vessel Strike	Vessel Noise, Visual Disturbance	Acoustic Sources		Gear Entanglement Interaction
					SBP MBES SBES ADCP	Seismic Airgun Array	
Marine Mammals – Cetaceans							
Blue Whale	LAA	NLAA	NLAA	NLAA	NLAA	LAA	NLAA
Fin Whale	LAA	NLAA	NLAA	NLAA	NLAA	LAA	NLAA
North Atlantic Right Whale	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Sei Whale	LAA	NLAA	NLAA	NLAA	NLAA	LAA	NLAA
Sperm Whale	LAA	NLAA	NLAA	NLAA	NLAA	LAA	NLAA
Marine Reptiles							
Green Turtle – North Atlantic DPS	LAA	NLAA	NLAA	NLAA	NLAA	LAA	NLAA
Hawksbill Turtle	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Kemp's Ridley Turtle	LAA	NLAA	NLAA	NLAA	NLAA	LAA	NLAA
Leatherback Turtle	LAA	NLAA	NLAA	NLAA	NLAA	LAA	NLAA
Loggerhead Turtle – Northwest Atlantic Ocean DPS	LAA	NLAA	NLAA	NLAA	NLAA	LAA	NLAA

Endangered Species Act-listed Species in the Action Area	Overall Determination	Potential Stressors					
		Pollution	Vessel Strike	Vessel Noise, Visual Disturbance	Acoustic Sources		Gear Entanglement Interaction
					SBP MBES SBES ADCP	Seismic Airgun Array	
Fish							
Atlantic Sturgeon – Carolina DPS	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Atlantic Sturgeon – Chesapeake DPS	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Atlantic Sturgeon – Gulf of Maine DPS	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Atlantic Sturgeon – New York Bight DPS	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Atlantic Sturgeon – South Atlantic DPS	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Giant Manta Ray	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Oceanic Whitetip Shark	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Shortnose Sturgeon	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA
Critical Habitat							
Loggerhead Turtle – Northwest Atlantic Ocean DPS	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA	NLAA

ESA=Endangered Species Act, SBP=sub-bottom profiler, MBES=multi-beam echosounder, SBES=split-beam echosounder, ADCP=acoustic Doppler current profiler, DPS=distinct population segment, NLAA=not likely to adversely affect, LAA=- likely to adversely affect.

8 SPECIES LIKELY TO BE ADVERSELY AFFECTED

This section identifies the ESA-listed species that occur within the action area (Figure 1) that are likely to be affected by the proposed actions. The ESA-listed marine mammal and sea turtle species that are likely to be adversely affected by the proposed actions are the blue whale, fin whale, sei whale, sperm whale, North Atlantic DPS of green turtle, Kemp's ridley turtle, leatherback turtle, and Northwest Atlantic Ocean DPS of loggerhead turtle. The determinations for the effects of stressors that are not likely to adversely affect any ESA-listed species during the high-energy seismic survey are discussed in Section 7.1. Other potential stressors (i.e., acoustic noise from the airgun array) are discussed in more detail in Section 10.

This section identifies and examines the status of each species that is expected to be adversely affected by the proposed actions. The status includes the existing level of risk that the ESA-listed species face, based on parameters considered in documents such as recovery plans, status reviews, and ESA-listing decisions. The species' status section helps to inform the description of the species' current "reproduction, numbers, or distribution," which is part of the jeopardy determination as described in 50 C.F.R. §402.02. More detailed information on the status and trends of these ESA-listed species, and their biology and ecology can be found in the listing regulations and critical habitat designations published in the *Federal Register*, status reviews, recovery plans, and on these NMFS websites: https://www.fisheries.noaa.gov/species-directory/threatened-endangered. Because there are not likely to be adverse affects to designated critical habitat (Section 7.3.2), only the status of the species likely to be adversely affected would be discussed in this section. One factor affecting the rangewide status of marine mammals, and aquatic habitat at large is climate change. The localized effects of climate change in the action area would be discussed in the Environmental Baseline (Section 9).

8.1 Blue Whale

The blue whale is a widely distributed baleen whale found in all major oceans (Figure 3).

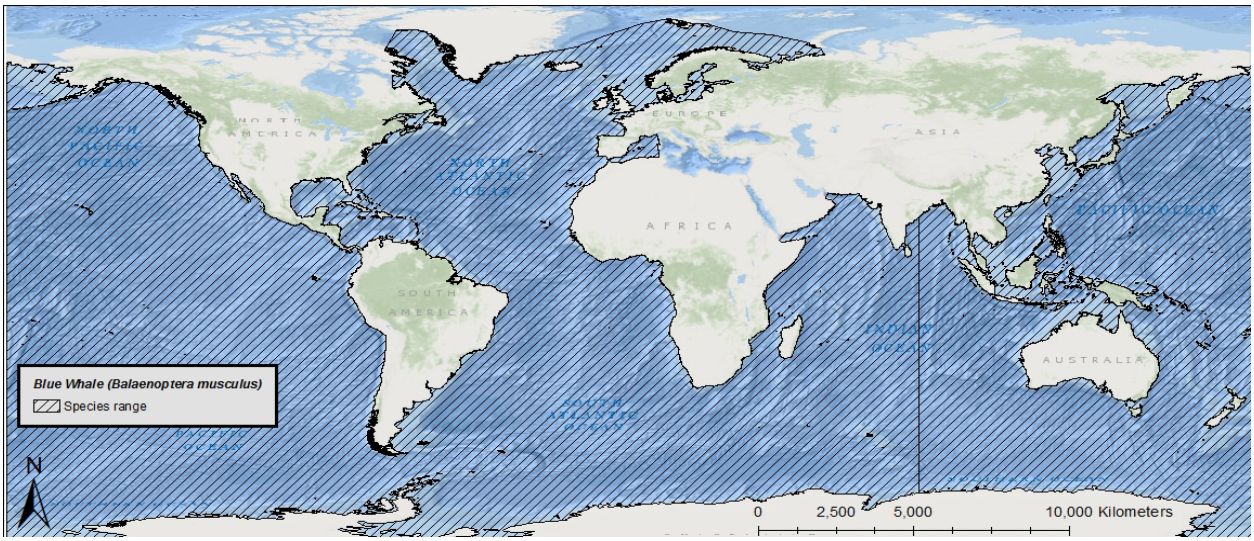

Figure 3. Map identifying the range of the endangered blue whale.

There are currently four accepted subspecies of blue whale, *B. m. musculus*, which occurs in the Northern Hemisphere, *B. m. intermedia*, which occurs in the Southern Ocean, *B. m. indica* which occurs in the Northern Indian Ocean, and *B. m. brevicauda*, a pygmy species found in the Indian Ocean and South Pacific Ocean. A recently recognized unnamed subspecies also occurs off Chile and migrates annually to waters off Peru, Ecuador, and the Galapagos Islands (Branch et al. 2007) (Hucke-Gaete et al. 2018). The blue whale was originally listed as endangered on December 2, 1970.

8.1.1 Life History

The average life span of blue whales is 80 to 90 years. They have a gestation period of ten to 12 months, and calves nurse for six to seven months. Blue whales reach sexual maturity at about ten (between five and 15) years of age with an average calving interval of two to three years. Blue whales generally undertake annual migrations; wintering at low latitudes, where they mate, calve and nurse, and summering at high latitudes, where they feed. However, in the Northern Indian Ocean, *B. m. indica* are resident, and remain in the Bay of Bengal and off the east coast of Sri Lanka (NMFS 2020b). Blue whales forage almost exclusively on krill and can eat approximately 3,600 kilograms (7,936.6 pounds) daily. Feeding aggregations are often found at the continental shelf edge, where upwelling produces concentrations of krill at depths of 90 to 120 meters (295.3 to 393.7 feet).

8.1.2 Population Dynamics

The 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). The International Whaling Commission (IWC) recognizes three blue whale stocks that correspond to the three major ocean basins (North Atlantic Ocean, North Pacific Ocean, and Southern Hemisphere). In the Southern Hemisphere, where blue whales feed, there are six recognized management areas. In U.S. waters, NMFS recognizes three stocks: the eastern North Pacific Ocean, central North Pacific Ocean, and western North Atlantic Ocean. Blue whale abundance for the eastern North Pacific stock is estimated at 1,898 individuals (lower [N_{min}] and upper 20th percentile: 1,767 to 2,038 individuals) (Calambokidis and Barlow 2020). Abundance estimates for the central North Pacific stock (around the Hawaiian Islands) is 137 individuals (95 percent CI=23 to 796 individuals) (Bradford et al. 2021). There is much uncertainty when estimating abundance for the western North Atlantic stock due to low numbers of encountered and photographed individuals; however, researchers believe there may be between 400 to 600 individuals based on the Gulf of St. Lawrence photographic-identification catalog (N_{min}= 402 individuals; (Hayes et al. 2020). In the Southern Hemisphere, the abundance estimate for Antarctic blue whales is 2,280 individuals based on surveys from 1991/1992 through 2003/2004 (95 percent CI=1,160 to 4,500 individuals; (Branch 2007). While no range-wide estimate for pygmy blue whales exists (Thomas et al. 2016), the latest estimate for pygmy blue whales off the west coast of Australia is 662 to 1,559 individuals based on passive acoustic monitoring

(McCauley and Jenner 2010), or 712 to 1,754 individuals based on photographic mark-recapture (Jenner 2008). The abundance estimate for pygmy blue whales off New Zealand based on a closed capture-recapture model is 718 individuals (95 percent CI=279 to 1,926 individuals) (Barlow et al. 2018). There are no current abundance estimates for the Chilean (unnamed subspecies) blue whale across its entire range; however, based on line transect surveys conducted off central Chile December 1997 through January 1998, estimated abundance is 303 individuals (95 percent CI=176 to 625 individuals) (Williams et al. 2011). Estimated abundance based on capture-recapture for central and southern Chile from 2004 through 2011 is between 570 to 760 individuals (95 percent CI for right and left flank photographs: 475 to 705 individuals and 638 to 933 individuals, respectively) (Galletti Vernazzani et al. 2017).

Current estimates indicate the Eastern North Pacific stock shows no signs of population growth since the early 1990s, perhaps because the population is nearly at carry capacity (Carretta et al. 2018). An overall population growth rate for the species or growth rates for the two other U.S. stocks (central North Pacific Ocean and western North Atlantic Ocean) are not available at this time. In the Southern Hemisphere, it is estimated that whaling reduced the population from 239,000 individuals (95 percent CI=202,000 to 311,000 individuals) in 1904 to just 360 individuals (95 percent CI=150 to 840 individuals) in the early 1970's. Currently, the Antarctic population appears to be increasing at a rate of 8.2 percent per year (95 percent CI=1.6 to 14.8 percent; (95 percent confidence interval 1.6 to 14.8 percent, Branch 2007). Population trends are largely unknown for the pygmy blue whale, though it is estimated that the current population represents less than 23 percent of the historical pre-whaling population (NMFS 2020b).

Little genetic data exist on blue whales globally. Data from Australia and Antarctica indicate that at least populations in these regions experienced a genetic bottleneck, likely the result of commercial whaling. However, in Australia, genetic diversity levels appear to be similar to other, non-threatened mammal species (Attard et al. 2010). In Antarctica, blue whale mtDNA haplotype diversity is relatively high, though haplotype richness is lower relative to other Antarctic marine mammal species, likely due to the bottleneck and blue whales long lifespan; (Sremba et al. 2012). Data on genetic diversity of blue whales in the Northern Hemisphere are currently unavailable. However, genetic diversity information for similar cetacean population sizes can be applied. Stocks that have a total population size of 2,000 to 2,500 individuals or greater provide for maintenance of genetic diversity resulting in long-term persistence and protection from substantial environmental variance and catastrophes. Stocks that have a total population 500 individuals or less may be at a greater risk of extinction due to genetic risks resulting from inbreeding. Stock populations at low densities (less than 100) are more likely to suffer from the 'Allee' effect, where inbreeding and the heightened difficulty of finding mates reduces the population growth rate in proportion with reducing density. There is little genetic data to differentiate breeding populations for pygmy blue whales. However, based on acoustic and genetic data, there appear to be three distinct populations: Indo-Australian, New Zealand, and Madagascar (Möller et al. 2020). Pygmy blue whales off Australia have relatively low genetic diversity compared to other blue whale populations, likely due to historical climate

change (Attard et al. 2015). For Chilean blue whales, though the population estimate is small, (Torres-Florez et al. 2014) found that the genetic diversity (mtDNA and nDNA) off southern Chile feeding grounds was similar to that of other Southern Hemisphere blue whale feeding grounds. Blue whale and fin whale genetic hybrids have also been documented in the North Pacific Ocean, North Atlantic Ocean, and Mediterranean Sea.

Off North Carolina, blue whales appear to be transiting through the area. A satellite telemetry study tracked a blue whale transiting along the continental shelf from Virginia down to an area offshore of Charlestown, South Carolina and back (Lesage et al. 2017). Passive acoustic monitoring studies recorded short periods of blue whale acoustic presence in late summer through early fall in 2010–2018 (Debich et al. 2016; Hodge et al. 2015c; Hodge et al. 2016; Rafter et al. 2018a; Rafter et al. 2018b). These short periods of acoustic presence may indicate that blue whales are transiting through the area (Engelhaupt et al. 2020).

8.1.3 Vocalization and Hearing

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

Calls are short-duration sounds (two to five seconds) that are transient and frequency-modulated, having a higher frequency range and shorter duration than song units and often sweeping down in frequency (80 to 20 Hz), with seasonally variable occurrence. Blue whale calls have high acoustic energy, with reports of source levels ranging from 180 to 195 dB re: one µPa at one meter (Aburto et al. 1997; Berchok et al. 2006; Clark and Gagnon 2004a; 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 whales (less than 30 meters [98.4 feet]), while deeper diving whales (greater than 50 meters [164 feet]) were likely feeding and calling less.

Although general characteristics of blue whale calls are shared in distinct regions (McDonald et al. 2001; Mellinger and Clark 2003; Rankin et al. 2005; Thompson et al. 1996), some variability appears to exist among different geographic areas (Rivers 1997). Sounds in the North Atlantic Ocean have been confirmed to have different characteristics (i.e., frequency, duration, and repetition) than those recorded in other parts of the world (Berchok et al. 2006; Mellinger and Clark 2003; Samaran et al. 2010). Clear differences in call structure suggestive of separate populations for the western and eastern regions of the North Pacific Ocean have also been reported (Stafford et al. 2001); however, some overlap in calls from the geographically distinct

regions have been observed, indicating that the whales may have the ability to mimic calls (Stafford and Moore 2005). In Southern California, blue whales produce three known call types: Type A, B, and D. B calls are stereotypic of blue whale population found in the eastern North Pacific Ocean (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 (ten to 100 Hz); 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). Off California, blue whale song B calls have decreased in frequency and are now sung at a frequency 31 percent lower than calls recorded in the 1960's (McDonald et al. 2009). Further, there has been a document decrease in call frequency in blue whale populations worldwide. Recently, this decrease in frequency has also been observed in Northeast Pacific Ocean (in the Southern California Bight) A calls (Rice et al. 2022). Between 2006 and 2019, A calls decreased at a rate of 0.32 Hz a year, and B calls decreased further at a rate of 0.27 Hz a year. A call pulse rate has also declined in this Southern California and other blue whale populations. There are many theories for this observed frequency decline in blue whale populations (e.g., sexual selection, increasing ocean noise, increasing whale body size, population density); however, none of the current theories account for all aspects of this frequency shift. Recently, a new blue whale song type have been documented in the Arabian Sea and western Indian Ocean, suggesting a distinct population, and potential separate subspecies, that has previously been conflated with other more widespread populations in the area (Cerchio et al. 2020). In the Northeast Pacific Ocean, at least two geographically distinct song variants have been observed, suggesting that there are vocally distinct subpopulation within the Northeast Pacific Ocean (currently managed as a single stock) and possible finer-scale population structure (Carbaugh-Rutland et al. 2021). In the Indian Ocean, pygmy blue whale song off the Chagos Islands are likely produced by a distinct pygmy blue whale population that migrates from the Chagos Islands to Western Australia and possibly up to Sri Lanka (Leroy et al. 2021).

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. 1992b). Because blue whale song has only been documented as being produced by males, it is thought that song functions in a

reproductive context (i.e., sexual selection, breeding display, competition for mates). Intense bouts of long, patterned sounds are common from fall through spring in low latitudes (i.e., during the winter breeding season), but these also occur less frequently while in summer high-latitude feeding areas. Singular calls are thought to be produced when feeding, resting or in social contexts, and both males and females produce D calls. 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 1997a; Richardson et al. 1995a). Based on vocalizations and anatomy, blue whales are assumed to predominantly hear low-frequency sounds below 400 Hz (Croll et al. 2001a; 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 seven Hz to 35 kHz (NOAA 2018). Recently, (Southall et al. 2019) revised their marine mammal hearing groups, and there is evidence that blue whales, along with a few other mysticete species, are sensitive to very low frequencies and should be treated separately, as a very low-frequency, from the low frequency group.

8.1.4 Status

The blue whale is endangered because of past commercial whaling. In the North Atlantic Ocean, at least 11,000 blue whales were harvested from the late 19th to mid-20th centuries. In the North Pacific Ocean, at least 9,500 blue whales were killed between 1910 and 1965. In the Southern Hemisphere, it is estimated that about 360,000 blue whales were killed in the last century, reducing the population of Antarctic blue whales from 239,000 individuals (95 percent CI=202,000 to 311,000 individuals) in 1904 to just 360 individuals (95 percent CI=150 to 840 individuals) in the early 1970's. Currently, the Antarctic blue whale population estimate is 2,280 individuals (CV=0.36) (NMFS 2020b). Commercial whaling no longer occurs, but blue whales are threatened by vessel strikes, marine debris and fishing gear ingestion and/or entanglement, anthropogenic noise, and loss of prey base due to climate and ecosystem change. Because populations appear to be increasing in size, the species appears to be somewhat resilient to current threats; however, most population trends are unknown and the species has not recovered to pre-exploitation levels.

8.1.5 Status in the Action Area

In the western North Atlantic Ocean, higher densities of blue whales are typically found north of 40 degrees of North especially during summer, with lower densities south of 40 degrees North (DoN 2008b; DoN 2008c). Several sightings were reported during summer surveys by the NMFS Northeast Fisheries Science Center and Southeast Fisheries Science Center off the northeastern

U.S. coast and in particular Canada, but none were reported off Virginia or North Carolina (Hayes et al. 2020). Hayes et al. (2020) suggested that the blue whale is an occasional visitor in the U.S. Exclusive Economic Zone of the Atlantic Ocean. However, blue whales have been detected acoustically off Virginia and North Carolina during all seasons, with the greatest number of detections during fall and winter (Davis et al. 2020; Palka et al. 2021). At least one satellite-tagged female blue whale was recorded transiting off Virginia and North Carolina in January and February 2015 (Lesage et al. 2017). While there are no records of blue whales in the OBIS database for the seismic survey area off North Carolina, there are only four records ever of blue whales off Norfolk, Virginia between February and April (the proposed port for departure and return). Two sightings of blue whale (one during a vessel survey and one during an aerial survey) were also recorded off Virginia in April 2018 and February 2019 (Engelhaupt et al. 2020).

8.1.6 Critical Habitat

No critical habitat has been designated for the blue whale.

8.1.7 Recovery Goals

In response to the current threats facing the species, NMFS developed goals to recover blue whale populations. These threats are discussed in further detail in the Environmental Baseline of this consultation. NMFS defines nine blue whale management units in the Revised Recovery Plan (NMFS 2020b). The two main objectives for the blue whale for complete downlisting/delisting criteria are:

1. Increase blue whale resiliency and ensure geographic and ecological representation by achieving sufficient and viable populations in all ocean basins and in each recognized subspecies.
2. Increase blue whale resiliency by managing or eliminating significant anthropogenic threats.

8.2 Fin Whale

The fin whale is a large, widely distributed baleen whale found in all major oceans (North Pacific Ocean, North Atlantic Ocean, and Southern Hemisphere) and is currently comprised of three recognized subspecies (recognized by the Society for Marine Mammalogy's Committee on Taxonomy): *B. p. physalus* in the North Atlantic Ocean, *B. p. velifera* in the North Pacific Ocean, and *B. p. quoyi* in the Southern Hemisphere. Previously, another subspecies, *B. p. patachonica* (a pygmy form), was identified in the Southern Hemisphere; however, a recent genetic study found no support for this differentiation between fin whales in the Southern Hemisphere (further discussed in Section 8.3.2) (Figure 4).

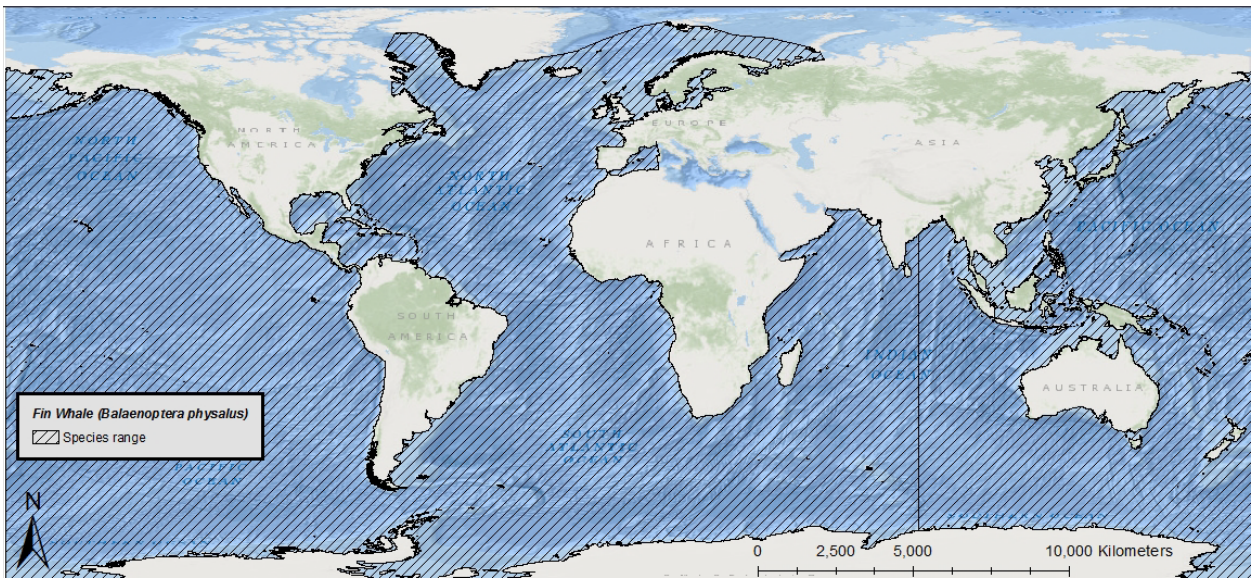

Figure 4. Map identifying the range of the endangered fin whale.

The fin whale was listed as endangered on December 2, 1970.

8.2.1 Life History

Fin whales can live, on average, 80 to 90 years. They have a gestation period of less than one year, and calves nurse for six to seven months. Sexual maturity is reached between six and ten years of age with an average calving interval of two to three years. They mostly inhabit deep, offshore waters of all major oceans. They winter at low latitudes, where they calve and nurse, and summer at high latitudes, where they feed, although some fin whales appear to be residential to certain areas (e.g., potentially in the Mediterranean Sea, East China Sea/Sea of Japan, and Gulf of California; (Geijer et al. 2016); (Mizroch et al. 2009); (Bérubé et al. 2002); (Rivera-León et al. 2019). Fin whales eat pelagic crustaceans (mainly euphausiids or krill) and schooling fish such as capelin, herring, and sand lance (NMFS 2010b).

8.2.2 Population Dynamics

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 pre-exploitation estimate for the fin whale population in the North Pacific Ocean was 42,000 to 45,000 (Ohsumi and Wada 1974). In the North Atlantic Ocean, at least 55,000 fin whales were killed between 1910 and 1989. Approximately 704,000 fin whales were killed in the Southern Hemisphere from 1904 through 1975. Of the three to seven stocks thought to occur in the North Atlantic Ocean (approximately 50,000 individuals), NMFS currently manages four stocks: Western North Atlantic, Northeast Pacific, California/Oregon/Washington, and Hawaii. The current population abundance estimate for the Western North Atlantic stock is 6,802 individuals (CV=0.24), and minimum population estimate (N_{min}) is 5,573 individuals (Hayes et al. 2022). While there are no reliable estimates of abundance (current or historical) for the entire Northeast Pacific stock, studies have estimated abundance for specific surveyed areas: eastern Bering Sea

(in 2002: 419 individuals [CV=0.33]; in 2008: 1,368 individuals [CV=0.34]; in 2010: 1,061 individuals [CV=0.38]); western Alaska and the eastern and central Aleutian Islands (between 2001 and 2003: 1,652 individuals (95 percent CI=1,142 to 2,389 individuals); offshore waters of the Gulf of Alaska (in 2013: 3,168 individuals [CV=0.26] and in 2015: 916 individuals [CV=0.39]). The minimum population estimate for the Northeast Pacific stock is 2,554 individuals (Muto et al. 2021). For the California/Oregon/Washington and Hawaii stocks, the current population estimate is 11,065 individuals (CV=0.405) in 2018 (N_{min}=7,970 individuals) and 203 individuals (CV=0.99) in 2017 (N_{min}=101 individuals), respectively (Carretta et al. 2022). 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). The most current population estimate for fin whales in the Antarctic south of 60 degrees South is 5,445 individuals (95 percent CI=2,000 to 14,500 individuals) between 1991 and 2004 (Leaper and Miller 2011). The International Whaling Commission (IWC) also recognizes the China Sea stock of fin whales, found in the Northwest Pacific Ocean, which currently lacks an abundance estimate (Reilly et al. 2013). For apparent resident populations (Mediterranean Sea and East China Sea), population estimates for the western Mediterranean, Corsican-Ligurian-Provençal Basin, and Pelagos Sanctuary are 3,583 individuals (95 percent CI=2,130 to 6,027 individuals) in 1991, 901 individuals (95 percent CI=591 to 1,374 individuals) in 1992, and 539 individuals (95 percent CI=345 to 732 individuals), respectively (NMFS 2019).

Population trends for the Western North Atlantic, Hawaii, Southern Hemisphere, Mediterranean, and East China Sea stocks are not currently available. For the Northeast Pacific stock, there was an increasing trend by 4.8 percent (95 percent CI=4.1 to 5.4 percent) between 1987 and 2003 (Carretta et al. 2022). For the California/Oregon/Washington stock, there is strong evidence that population abundance is increasing; from 1991 through 2014, abundance increased 7.5 percent annually (Nadeem et al. 2016), though it is unknown how much of that rate could be attributed to immigration rather than birth and death processes (Carretta 2019b). An overall population trend in U.S. Pacific Ocean waters has not been established, but there is evidence that there has been increasing rates in the recent past in different parts of the region. 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. 2019) recently re-examined d the genetic structure and diversity of fin whales globally (with the exception of East China Sea/Sea of Japan fin whales). In Archer et al. (2013), full sequencing of the mitochondrial deoxyribonucleic acid (mtDNA) 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. This more recent study conducted analyses on a larger mtDNA control region dataset and on 23 single nucleotide polymorphisms from 144 of the 154 samples. (Archer et al. 2019) concluded with 99 percent accuracy that North Pacific Ocean and North Atlantic Ocean fin whales are distinct, with very low rates of gene flow between ocean basins (thus separating North Pacific fin whales as subspecies *B. p. velifera*). Pygmy fin whales were

thought to be a separate subspecies occurring in the low- to mid-latitudes of the Southern Hemisphere since 2004 based on morphological features (Clarke 2004). However, scientists in 2021 determined that there was an absence of genetic structure within the Southern Hemisphere, suggesting that all fin whales in the Southern Hemisphere are of the *B. p. quoyi* subspecies (Pérez-Alvarez et al. 2021). Haplotype diversity was high in all ocean basins (North Pacific Ocean, North Atlantic Ocean, Southern Hemisphere [southeastern Pacific Ocean and Southern Ocean]) except in the Gulf of California, where haplotype diversity was nearly three times lower (Pérez-Alvarez et al. 2021). High genetic 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.

Fin whales generally undertake annual migrations from low-latitude wintering grounds to high-latitude feeding grounds, except for apparent resident populations in the Mediterranean Sea, East China Sea/Sea of Japan, and Gulf of California, as mentioned previously. Off the U.S. East Coast, distribution and movements is largely driven by prey availability, particularly of sand lance (NMFS 2010b). On feeding grounds in the Antarctic, fin whale 'hot spots' were observed where there were currents and eddys associated with krill aggregations. In the North Atlantic Ocean, fin whales may temporarily suspend their migration and forage in 'hot spots' around the Mid-Atlantic Bight (NMFS 2019).

8.2.3 Vocalization and Hearing

Fin whales produce a variety of low frequency sounds in the 10 to 200 Hz range (Edds 1988; Thompson et al. 1992a; Thompson et al. 1992b; Watkins 1981; Watkins et al. 1987a; Watkins et al. 1987b). Fin whales primarily produce two types of calls: a 20 Hz call and a 40 Hz call.

The most common fin whale vocalization is what is called a 20 Hz pulse (or 20 Hz note), which is a downswept pulse (30 to 15 Hz) that lasts about one second, and can reach source levels of 189 ± 4 dB re: one µPa at one meter and can be detected tens of kilometers away (Charif et al. 2002b; Charif et al. 2002a; Clark et al. 2002b; Clark et al. 2002a; Edds 1988; Garcia et al. 2018; Richardson et al. 1995a; Richardson et al. 1995b; Sirovic et al. 2007b; Sirovic et al. 2007a; Watkins 1981; Watkins et al. 1987a; Watkins et al. 1987b). The 20 Hz pulses can occur as a single pulse, in a doublet, or a triplet, and frequently occur in long sequenced patterns known as 'song', which can be repeated over the course of many hours to days (Watkins et al. 1987b). Fin whale song is produced by males, and singing generally peaks during the breeding season; thus, songs are thought to have a reproductive function (Croll et al. 2002). Geographic variations in fin whale song may indicate some level of population structure, though variations may also change within a single region seasonally. Variations in fin whale song can be identified by the presence of a higher frequency component after the 20 Hz pulse, by the presence of doublets or triplets, or by the internote interval (also called the interpulse interval), or time between 20 Hz pulses. For example, in Massachusetts Bay and the New York Bight, internote interval varies throughout the year: a "short internote interval " season between September and January, and a "long internote interval " season between March and May, where months in between these seasons are

transitional- internote interval months (Morano et al. 2012b). Because these internote interval patterns are not different between Massachusetts Bay and the New York Bight, it is thought that these changes in internote interval, which may be associated with changes in behavioral contexts, are occurring within the same population of fin whales (Morano et al. 2012b). However, when comparing fin whale song from the Gulf of St. Lawrence and the Gulf of Maine, (Delarue et al. 2009) found that song internote interval s were significantly different, indicating two subpopulations. Recordings of fin whale song off Southern California and in the Gulf of California revealed four song types based on the total internote interval durations of the song and patterns of internote intervals within the repeated series (Širović et al. 2017). (Širović et al. 2017) found that different song types were dominant in Southern California and the Gulf of California, suggesting that each song type is unique to a population and that any change or overlap in song indicated a change in the primary population in the area or some exchange among populations, respectively.

Another less common fin whale vocalization is the 40 Hz pulse (75 to 40 Hz), which is also a downsweep lasting less than one second. Fin whale 40 Hz pulses has a similar, but slightly lower, source level as 20 Hz pulses (Wiggins and Hildebrand 2020). (Croll et al. 2001b) and (Charif et al. 2002b; Charif et al. 2002a; Clark et al. 2002b; Clark et al. 2002a; Edds 1988; Garcia et al. 2018; Richardson et al. 1995a; Richardson et al. 1995b; Sirovic et al. 2007b; Sirovic et al. 2007a; Watkins 1981; Watkins et al. 1987a; Watkins et al. 1987b) noted that fin whale 40 Hz pulses were generally produced by animals in groups, in foraging contexts such as surface feeding or foraging dives. In the eastern North Pacific Ocean (Bering Sea, Southern California, and northern Gulf of California), the presence of 40 Hz pulses peaked in early summer (Širović et al. 2013). This is similar to blue whale D calls off Southern California (Oleson et al. (2007c) which is associated with feeding whales ((Edds-Walton 1997; Oleson et al. 2007b; Payne and Webb 1971; Thompson et al. 1992b)). Additionally, fin whale 40 Hz pulses were strongly influenced by prey biomass (unlike season for the reproductive-context 20 Hz pulses) (Romagosa et al. 2021). Thus, fin whale 40 Hz pulses are thought to be produced in a foraging context.

Some researchers have also recorded moans of 14 to 118 Hz, with a dominant frequency of 20 Hz, tonal and upsweep vocalizations of 34 to 150 Hz, and songs of 17 to 25 Hz (Cummings and Thompson 1994; Edds 1988; Garcia et al. 2018; Watkins 1981). In general, sound source levels for fin whale vocalizations are 140 to 200 dB re: one µPa at one meter (see also Clark and Gagnon 2004a; see also Clark and Gagnon 2004b; as compiled by Erbe 2002b; as compiled by Erbe 2002c). The source depth of calling fin whales has been reported to be about 50 meters (164 feet) (Watkins et al. 1987b).

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 1997a; Richardson et al. 1995a). 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 1997a). In a study using computer tomography scans of a fin whale calf skull, Cranford and Krysl (2015) identified a 'best hearing' range between ten Hz and 12 kHz. In the examined fin whale calf skull, a maximum sensitivity to sounds in the one to two kHz range was observed; however, it is likely that an adult fin whale's frequency with the best sensitivity would be lower given the increase in skull size. In terms of functional hearing capability, fin whales belong to the low-frequency group, which have a hearing range of seven Hz to 35 kHz (NOAA 2018). Recently, (Southall et al. 2019) revised their marine mammal hearing groups, and there is evidence that fin whales, along with a few other mysticete species, are sensitive to very low frequencies and should be treated separately, as a very low-frequency, from the low frequency group.

8.2.4 Status

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

8.2.5 Status in the Action Area

Fin whales are most frequently sighted off North Carolina during winter, with some sightings also reported for spring (Conley et al. 2017). There is a single sighting record for the U.S. Navy's Cherry Point Operating Area, which was reported during winter, and numerous strandings have been reported during the winter (DoN 2008b; DoN 2008c). One sighting has been made during NMFS Northeast Fisheries Science Center and Southeast Fisheries Science Center summer surveys off North Carolina (Hayes et al. 2022). Fin whales have been detected acoustically off North Carolina during all seasons, with the greatest number of detections during winter; there were no detections south of Cape Hatteras, North Carolina during summer (May through July) (Davis et al. 2020; Palka et al. 2021). Fin whales were also acoustically detected year-round off Virginia (Davis et al. 2020). There are numerous records of fin whales off Norfolk, Virginia to the seismic survey area. There are three records in the OBIS database for the seismic survey area, all of which were reported for April (OBIS 2022).

8.2.6 Critical Habitat

No critical habitat has been designated for the fin whale.

8.2.7 Recovery Goals

In response to the current threats facing the species, NMFS developed goals to recover fin whale populations. These threats are discussed in further detail in the Environmental Baseline of this

consultation. See the 2010 Final Recovery Plan for the fin whale (NMFS 2010d) for complete downlisting/delisting criteria for both of the following recovery goals:

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

8.3 Sei Whale

The sei whale is a widely distributed baleen whale found in all major oceans (Figure 5).

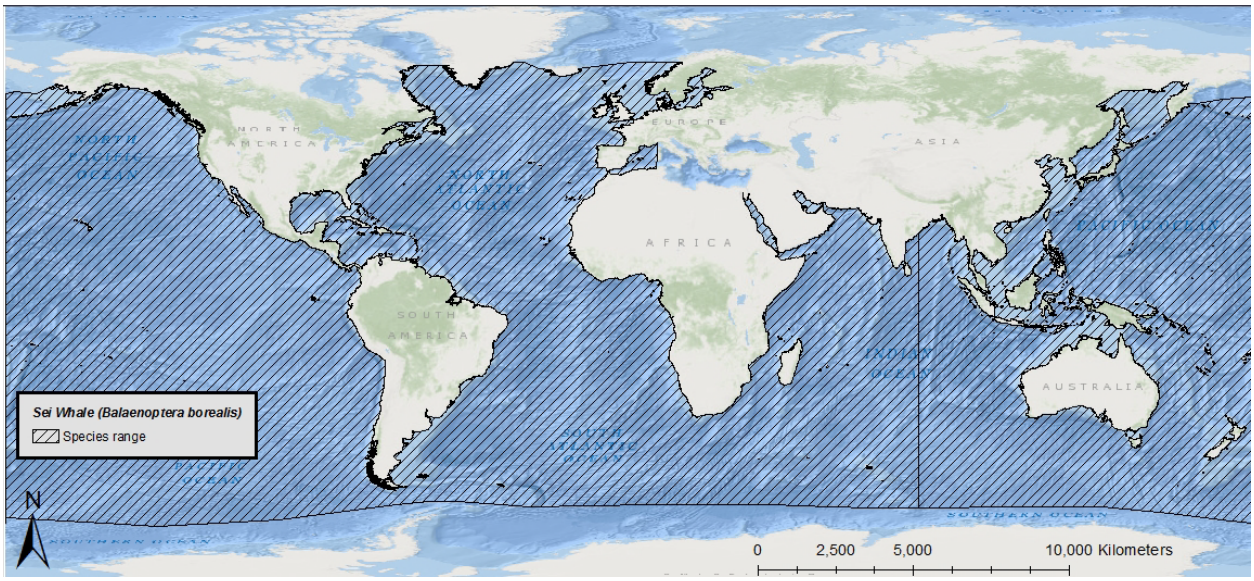

Figure 5. Map identifying the range of the endangered sei whale.

The sei whale was originally listed as endangered on December 2, 1970.

8.3.1 Life History

Sei whales life span is about 60 years (Wiles 2017). They have a gestation period of approximately 10.5 months, calves nurse for six to nine months, and the average calving interval is two to three years. Sexual maturity is thought to be reached between eight and ten years of age; however, a more recent study on age determination, based on growth layers in earplugs, of sei whales in the western North Pacific Ocean found that age at sexual maturity was 6.7 for males, and 6.9 for females (Bando and Maeda 2020).

Sei whales are distributed worldwide, occurring in the North Atlantic Ocean, North Pacific Ocean, and Southern Hemisphere. Sei whales generally undertake seasonal migrations, from low-latitude winter breeding grounds, where they calve and nurse, to high-latitude summer foraging grounds, where they feed on a range of prey types including plankton (copepods and krill), small schooling fishes, and cephalopods. However, winter breeding areas are currently unknown and feeding areas can change substantially between years and seasons. Sei whales are mainly seen offshore, where they mostly inhabit waters in deep ocean basins or along the continental shelf and slope far from the coastline.

8.3.2 Population Dynamics

Two sub-species of sei whale are recognized, *B. b. borealis* in the Northern Hemisphere and *B. b. schlegellii* in the Southern Hemisphere. Though there are no current estimates of global abundance for sei whales, (Wiles 2017) provides a rough estimate of 250,000 sei whales pre-whaling to 32,000 sei whales during the 1970s and 1980s. 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 central and eastern North Pacific Ocean population was estimated to be 29,632 individuals (95 percent CI=18,576 to 47,267 individuals) between 2010 and 2012 (IWC 2016; Thomas et al. 2016). Surveys of the western North Pacific Ocean were estimated to be 5,086 individuals (CV=0.38) in 2008 (Hakamada and Matsuoka 2016). In the Southern Hemisphere, pre-exploitation abundance is estimated at 65,000 individuals, with recent abundance estimated at 9,800 to 12,000 individuals. Three relatively small stocks occur in U.S. waters: Nova Scotia, Hawaii, and Eastern North Pacific Ocean. The Nova Scotia stock (Halifax, Nova Scotia to Florida) population is estimated at 6,292 individuals (CV=1.02; N_{min}=3,098 individuals) from surveys conducted in the spring from 2010 through 2013 (March through May, when sei whale density is predicted to be highest; (Hayes et al. 2022). The population estimate for the Hawaii stock of sei whales is 391 individuals (CV=0.9) based on a survey of the Hawaiian Islands Exclusive Economic Zone from August through December 2010 (Bradford et al. 2017). This is the best estimate even though a majority of sei whales would be expected to be in higher-latitude feeding grounds during that time of the year (Carretta et al. 2022). The minimum number for the Hawaii stock of sei whales is 204 individuals. In the eastern North Pacific Ocean, the sei whale population is estimated at 311 individuals (CV=0.76) based on surveys in 2008 and 864 individuals (CV=0.4) based on surveys in 2014; the best estimate is the mean of these two estimates, or 519 individuals (CV=0.4; N_{min}=374 individuals; (Barlow 2016)). 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. The apparent increase in Eastern North Pacific stock of sei whales from 2008 through 2014 may be partially due to recovery from commercial whaling, but may also be due to distributional shifts (Barlow 2016).

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 Ocean 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 Ocean sei whales, though both appear to be genetically distinct from sei whales in the North Atlantic Ocean (Baker and Clapham 2004; Huijser et al. 2018a). (Taguchi et al. 2021) also found that Southern Hemisphere sei whales were genetically closer to North Pacific Ocean sei whales compared to North Atlantic Ocean sei whales based on microsatellite DNA. Though haplotype frequency in sei whales was significantly different among the three ocean basins (North Pacific Ocean, North Atlantic Ocean, and Southern Hemisphere), suggesting these populations are genetically distinct

(Taguchi et al. 2021). Within an ocean basin, there appears to be intermediate to high genetic diversity and little genetic differentiation despite there being different managed stocks (Danielsdottir et al. 1991a; Danielsdottir et al. 1991b; Huijser et al. 2018b; Huijser et al. 2018a; Kanda et al. 2011; Kanda et al. 2006b; Kanda et al. 2006a; Kanda et al. 2015; Kanda et al. 2013); (Pastene et al. 2016).

8.3.3 Vocalization and Hearing

Data on sei whale vocal behavior is limited compared to other baleen whale species and the extent of their vocal repertoire is not well understood. In general, documented sei whale calls include upsweeps, downsweeps, tonal, and broadband calls.

Upsweeps, tonal, and broadband calls have generally only been documented in the Southern Hemisphere, near or in the Southern Ocean. (McDonald et al. 2005) documented six categories: (1) multi-part frequency stepping tonals, (2) upsweep, (3) tonal, (4) downsweep, (5) upsweep stepping up, and (6) broadband calls. Tonal call components were on average 0.45 ± 0.3 seconds long and 433 ± 192 Hz, whereas the frequency swept calls (downsweeps and upsweeps) were on average 1.1 ± 0.6 seconds long and had an average frequency sweep of 178 ± 141 Hz. (Calderan et al. 2014) also documented downsweep and upsweep calls in the Southern Ocean: all calls were between 34 and 87 Hz and lasted on average 1.1 second. Off the Falkland Islands, five categories of calls were described including downsweeps (100 to 30 Hz or 160 to 30 Hz, some occurring in doublets or with a short initial upsweep "hook"), upsweeps (roughly 20 to 70 Hz over two seconds), and other frequency-modulated calls (Cerchio and Weir 2022). (Cerchio and Weir 2022) also documented mid-frequency sei whale song consisting of patterned broadband calls and low-frequency calls.

The most commonly documented sei whale call in the North Pacific Ocean and North Atlantic Ocean are downsweep calls. There are two types of downsweeps that have been recorded, one that is generally 100 to 30 Hz and are just over one second long, and one that is generally lower-frequency (40 or 50 Hz to 20 or 30 Hz) also around one second long (e.g., (Rankin and Barlow 2007); (Tremblay et al. 2019). There is also variation in the occurrence of downsweeps, as some downsweeps have been documented to occur as singles, doublets, or even triplets (e.g., (Tremblay et al. 2019); (Español-Jiménez et al. 2019)). These variations in frequencies and of downsweep calls are documented; for example, off Hawaii where (Rankin and Barlow 2007) recorded downsweeps 100 to 44 Hz over one second, and downsweeps 39 to 21 Hz over 1.3 seconds. In the south-eastern Pacific (downsweeps 93 to 42 Hz and 1.6 seconds long occurring mostly in pairs but also triplets and singlets (Español-Jiménez et al. 2019), in the mid-Atlantic Ocean (downsweeps 100 to 37 Hz and 1.2 seconds; (Romagosa et al. 2015), and in the western North Atlantic Ocean (downsweeps 82 to 34 Hz and 1.4 seconds long occurring mostly as a single call with some pairs and rare triplets; and downsweeps 50 to 30 Hz occurring as triplets and singlets (Baumgartner et al. 2008); (Tremblay et al. 2019). (Tremblay et al. 2019) also suggested the presence of sei whale song in the western North Atlantic Ocean based on the

repetition of certain patterns of calls. Source levels for downsweeps recorded in the mid-Atlantic Ocean were 177 dB re: one µPa at one meter (Romagosa et al. 2015).

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 1997a; Richardson et al. 1995a). 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 1997a). In terms of functional hearing capability, sei whales belong to the low-frequency group, which have a hearing range of seven Hz to 35 kHz (NOAA 2018). Recently, (Southall et al. 2019) revised their marine mammal hearing groups, and there is evidence that sei whales, along with a few other mysticete species, are sensitive to very low frequencies and should be treated separately, as a very low-frequency, from the low frequency group.

8.3.4 Status

The sei whale is endangered because of past commercial whaling. No estimates of pre-exploitation population size are available and the total number of sei whales in the North Atlantic Ocean is not known (Waring and et al. 2009). Now, only a few individuals are taken each year by Japan; however, Iceland has expressed an interest in targeting sei whales. Current threats include vessel strikes, fisheries interactions (including entanglement), climate change (habitat loss and reduced prey availability), and anthropogenic noise. Given the species' overall abundance, they may be somewhat resilient to current threats. However, trends are largely unknown, especially for individual stocks, many of which have relatively low abundance estimates.

8.3.5 Status in the Action Area

Sei whales have been detected acoustically off North Carolina and Virginia mainly during winter. A few detections were recorded off North Carolina and Virginia during summer and fall (Davis et al. 2020; Palka et al. 2021). Passive acoustic monitoring conducted along the U.S. East Coast in 2015 through 2016 reported acoustic detections of sei whales through the late fall and winter from Cape Hatteras, North Carolina, to the Blake Plateau (Cholewiak et al. 2018b). No sightings of sei whales have been made during summer surveys conducted by NMFS Northeast Fisheries Science Center and Southeast Fisheries Science Center (Hayes et al. 2022). In the OBIS database, there are less than ten sightings of sei whales from Norfolk, Virginia to the seismic survey area, and of those ten sightings, three sightings occur in the seismic survey area, which were recorded in January through February.

8.3.6 Critical Habitat

No critical habitat has been designated for the sei whale.

8.3.7 Recovery Goals

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

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

8.4 Sperm Whale

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

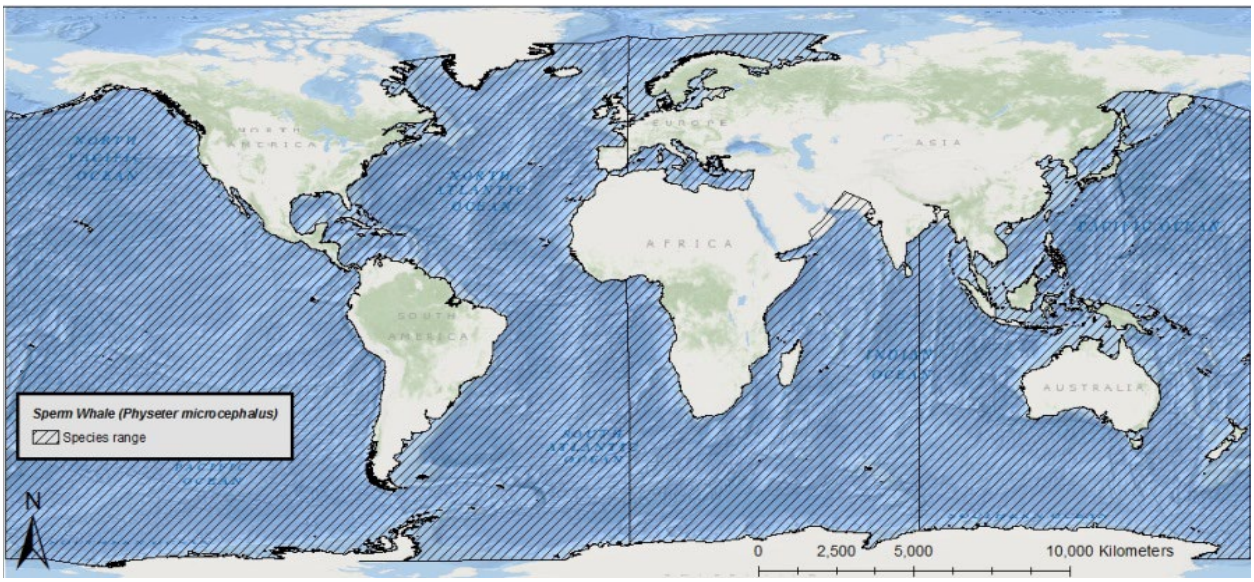

Figure 6. Map identifying the range of the endangered sperm whale.

The sperm whale was originally listed as endangered on December 2, 1970.

8.4.1 Life History

The average lifespan of sperm whales is estimated to be at least 50 years (Whitehead 2009). They have a gestation period ranging from 15 months to more than one and a half years, and calves nurse for approximately two years, though they may begin to forage for themselves within the first year of life (Tønnesen et al. 2018). Sexual maturity is reached between seven and 13 years of age for females with an average calving interval of four to six years, though females over 40 years of age rarely become pregnant. Male sperm whales reach full sexual maturity around age 20, after which they undergo a second growth spurt, reaching full physical maturity at around age 40 (Mizroch and Rice 2013). Sperm whale females and juveniles form stable social units while breeding males move among these units. Population structure is largely driven by female site fidelity. 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. However, if there are shelf breaks or submarine canyons close to land, sperm whales can occur there. They

winter at low latitudes, where they calve and nurse, and summer at high latitudes, where they feed primarily on squid; other prey includes octopus and demersal fish (including teleosts and elasmobranchs).

8.4.2 Population Dynamics

The 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, the reason for ESA-listing. It is estimated that well over 1,000,000 sperm whales were killed between the 1950's and 1999 (NMFS 2015b). There are six recognized sperm whale stocks in U.S. waters: Puerto Rico and U.S. Virgin Islands, Northern Gulf of Mexico, North Atlantic, North Pacific, California/Oregon/Washington, and Hawaii.

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

Ocean-wide genetic studies indicate sperm whales have low genetic diversity, suggesting a recent bottleneck/expansion or selective sweep, but strong differentiation between matrilinearly related groups (Lyrholm and Gyllensten 1998); (Alexander et al. 2016); (Morin et al. 2018). Consistent with this, two studies of sperm whales in the Pacific Ocean indicate low genetic diversity (Mesnick et al. 2011; Rendell et al. 2012a). 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. Despite low overall genetic diversity, there is strong differentiation between matrilinearly related groups and ocean basins, suggesting that both geographic and social philopatry influence sperm whale genetic structure (Lyrholm and Gyllensten 1998); (Alexander et al. 2016)). Sperm whales sampled off southeastern and southwestern Australia belong to the same population, but are distinct from sperm whales from other regions of the Pacific and Indian Oceans, based on nuclear and mtDNA (Day et al. 2021). Off New Zealand, a recent genetic study of stranded male sperm whales showed the presence of rare haplotypes suggesting genetic linkages within New Zealand and the Southwest Pacific (Palmer et al. 2022). Sperm whales in the Mediterranean appear to be genetically isolated from other eastern North Atlantic populations based on mtDNA analysis (Drouot et al. 2004). Similarly, genetic samples from sperm whales off the Azores show that individuals visiting the Azores are a single population (Pinela et al. 2009).

Sperm whales have a global distribution and can be found in relatively deep waters in all ocean basins. While both males and females can be found in latitudes less than 40 degrees, only adult males venture into the higher latitudes near the poles. Males appear to range more broadly than females (Mizroch and Rice 2013).

8.4.3 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 1999b). Sperm whales typically produce short duration repetitive broadband clicks with frequencies below 100 Hz to greater than 30 kHz (Watkins 1977a) and dominant frequencies between one to six kHz and 10 to 16 kHz. Another class of sound, "squeals," are produced with frequencies of 100 Hertz to 20 kHz (e.g., Weir et al. 2007a). The source levels of clicks can reach 236 dB re: one µPa at one meter, although lower source level energy has been suggested at around 171 dB re: one µPa at one meter (Goold and Jones 1995a; Goold and Jones 1995b; Mohl et al. 2003a; Mohl et al. 2003b; Weilgart and Whitehead 1993; Weilgart and Whitehead 1997c; Weilgart and Whitehead 1997b). Most of the energy in sperm whale clicks is concentrated at around two to four kHz and ten to 16 kHz (Goold and Jones 1995a; Goold and Jones 1995b; Weilgart and Whitehead 1993). The clicks of neonate sperm whales are very different from typical clicks of adults in that they are of low directionality, long duration, and low frequency (between 300 Hz and 1.7 kHz) with

estimated source levels between 140 to 162 dB re: one µPa at one meter (Madsen et al. 2003). The highly asymmetric head anatomy of sperm whales is likely an adaptation to produce the unique clicks recorded from these animals (Norris and Harvey 1972).

Long, repeated clicks are associated with feeding and echolocation (Goold and Jones 1995b; Miller et al. 2004b; Weilgart and Whitehead 1993; Weilgart and Whitehead 1997b; 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. 2005a; Miller et al. 2004b). (Laplanche et al. 2005b; Laplanche et al. 2005a; Miller et al. 2004a; Miller et al. 2004b). Maturing or mature male sperm whales are also thought to produce trumpet sounds on feeding grounds (Pace et al. 2021). 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 2004b; Rendell and Whitehead 2004a; Weilgart and Whitehead 1997c; Weilgart and Whitehead 1997b). 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 1997b). For example, significant differences in coda repertoire have been observed between sperm whales in the Caribbean Sea and those in the Pacific Ocean (Weilgart and Whitehead 1997b). In the South Pacific Ocean and Caribbean Sea, six acoustic "clans" were identified based on coda repertoires. These "clans" are likely an example of sympatric cultural variation in sperm whales, as smaller units of sperm whales are more likely to form groups with other units within their own clan (Rendell and Whitehead 2003). 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). A study analyzed mtDNA variation among sympatric vocal clans in the Pacific Ocean and found that variation in mtDNA cannot account for behavioral variation between vocal clans. This suggests that there is parent-offspring vocal transmission and that vocal clans may be more appropriate management units for the species (Rendell et al. 2012b).

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 potential tests were recorded (Carder and Ridgway 1990). From this sperm whale, responses support a hearing range of 2.5 to 60 kHz and highest sensitivity to frequencies between five to 20 kHz. Other hearing information consists of indirect data. For example, the anatomy of the sperm whale's inner and middle ear indicates an ability to best hear high-frequency to ultrasonic hearing (Ketten 1992). The sperm whale may also possess better low-frequency hearing than other odontocetes, although not as low as many baleen whales (Ketten 1992). Reactions to anthropogenic sounds can provide indirect evidence of hearing capability, and

several studies have made note of changes seen in sperm whale behavior in conjunction with these sounds. For example, sperm whales have been observed to frequently stop echolocating in the presence of underwater pulses made by echosounders and submarine sonar (Watkins et al. 1985a; Watkins and Schevill 1975c). In the Caribbean Sea, Watkins et al. (1985a) observed that sperm whales exposed to 3.25 to 8.4 kHz pulses (presumed to be from submarine sonar) interrupted their activities and left the area. Similar reactions were observed from artificial sound generated by banging on a boat hull (Watkins et al. 1985a). André et al. (1997) reported that foraging whales exposed to a ten kHz pulsed signal did not ultimately exhibit any general avoidance reactions: when resting at the surface in a compact group, sperm whales initially reacted strongly, and then ignored the signal completely (André et al. 1997). A recent study compared sperm whale reactions to continuous active sonar and traditional pulsed active sonar. Continuous active sonar may be used at a lower amplitude than traditional pulsed active sonar, but has a higher cumulative sound energy. Sperm whales reduced their time spent foraging during high sound exposure levels compared to high sound pressure levels (Isojunno et al. 2020). This suggests that cumulative sound energy may be an important driver of sperm whales behavioral responses to active sonar. Aaron et al. (2007); Thode et al. (2007) observed that the acoustic signal from the cavitation of a fishing vessel's propeller (110 dB re: one μPa^2-second between 250 Hz and one kHz) interrupted sperm whale acoustic activity and resulted in the animals converging on the vessel. Sperm whales have also been observed to stop vocalizing for brief periods when codas are being produced by other individuals, perhaps because they can hear better when not vocalizing themselves (Goold and Jones 1995b). Because they spend large amounts of time at depth and use low frequency sound, sperm whales are likely to be susceptible to low frequency sound in the ocean (Croll et al. 1999). Nonetheless, sperm whales are considered to be part of the mid-frequency marine mammal hearing group, with a hearing range between 150 Hz and 160 kHz (NOAA 2018). Recently, (Southall et al. 2019) revised their marine mammal hearing groups, and there is evidence that sperm whales, along with a few other odontocete species, are in the high-frequency group.

8.4.4 Status

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

8.4.5 Status in the Action Area

Sperm whales appear to have a well-defined seasonal cycle in the Northwest Atlantic Ocean (CETAP 1982);(Stanistreet et al. 2018). In winter, most historical records are in waters east and

northeast of Cape Hatteras, North Carolina, with few animals north of 40 degrees North; in spring, they shift the center of their distribution northward to areas east of Delaware and Virginia, but they are widespread throughout the central area of the Mid-Atlantic Bight and southern tip of Georges Bank (DoN 2005); (Hayes et al. 2020). During summer, they expand their spring distribution to include areas east and north of Georges Bank, the Northeast Channel, and the continental shelf south of New England (Hayes et al. 2020). By fall, sperm whales are most common south of New England on the continental shelf but also along the shelf edge in the Mid-Atlantic Bight (DoN 2005); (Hayes et al. 2020). Numerous sightings have been made off North Carolina, including in the action area, during NMFS Northeast Fisheries Science Center and Southeast Fisheries Science Center summer surveys (Hayes et al. 2020). (DoN 2008b); (DoN 2008c) also reported sperm whale sightings in the northern portion of the seismic survey area from winter through spring, and (Conley et al. 2017) reported sperm whales in the northern portion of the survey area during summer. Four sightings were made between September 16 through October 18, 2014 during an L-DEO seismic survey that overlapped the seismic survey area (RPS 2015). Acoustic detections have also been made off North Carolina and Virginia during most of the year; however, the months of May through July have not monitored (Stanistreet et al. 2018). There are 252 records in the OBIS database for the seismic survey area, which were reported throughout the year: most of these records (117) occurred for January and February; there were 14 records for May, 15 records for June, 22 for July, 18 for August, and three for September (OBIS 2022).

8.4.6 Critical Habitat

No critical habitat has been designated for the sperm whale.

8.4.7 Recovery Goals

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

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

8.5 Green Turtle – North Atlantic Distinct Population Segment

The green turtle has a circumglobal distribution and commonly inhabits nearshore and inshore waters, occurring throughout tropical, sub-tropical and, to a lesser extent, temperate waters. The North Atlantic DPS of green turtle is found in the North Atlantic Ocean and Gulf of Mexico (Figure 7).

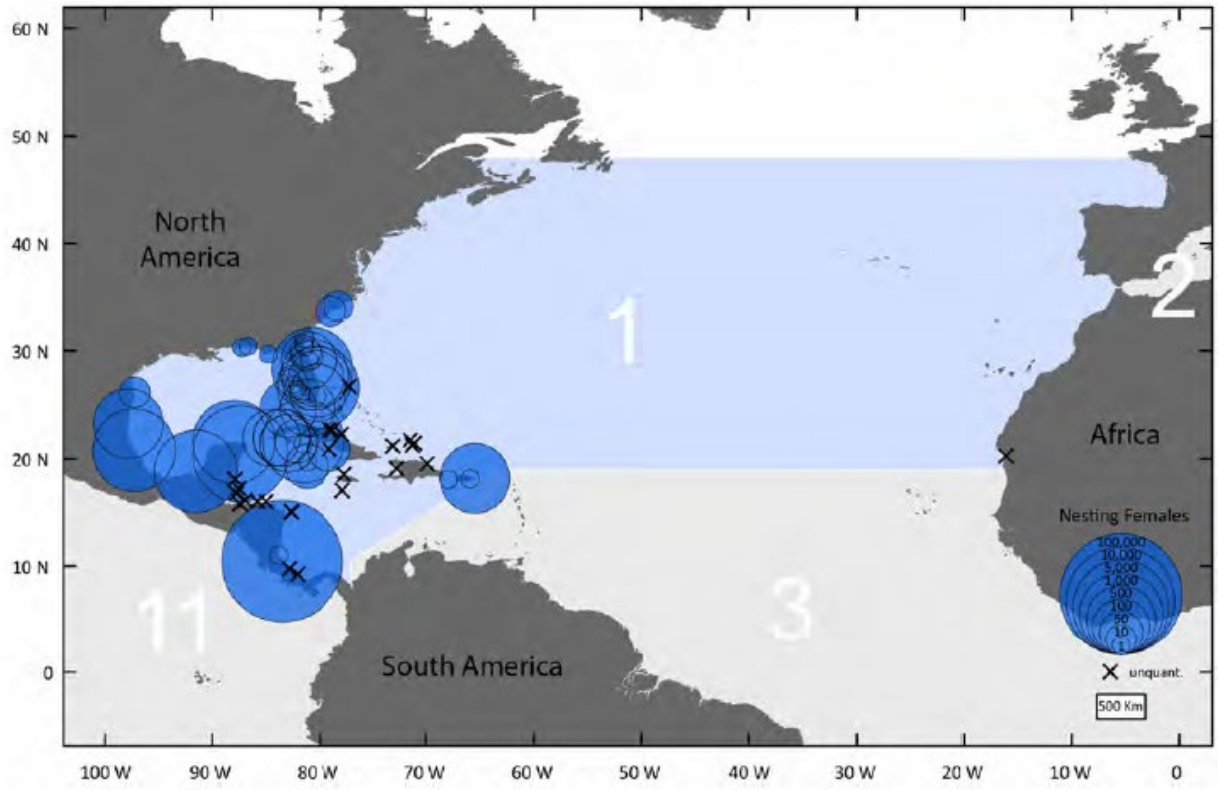

Figure 7. Map of geographic range of the threatened North Atlantic distinct population segment of green turtle, with location and abundance of nesting females (Seminoff et al. 2015).

The species was listed under the ESA on July 28, 1978 (43 FR 32800). The species was separated into two listing designations: endangered for breeding populations in Florida and the Pacific coast of Mexico and threatened in all other areas throughout its range. On April 6, 2016, NMFS listed eleven DPSs of green turtles as threatened or endangered under the ESA (81 FR 20057). The North Atlantic DPS of green turtle is listed as threatened.

8.5.1 Life History

Green turtles share a general life history pattern similar to other sea turtles. Females lay their eggs on coastal beaches where the eggs incubate in sandy nests. Mating occurs in waters off nesting beaches. Females are usually 20 to 40 years at first reproduction. Green turtles lay an average of three nests per season with an average of 100 eggs per nest. The remigration interval (i.e., return to natal beaches) is two to five years for females. Males are known to reproduce every year (Balazs 1983). In the southeastern U.S., females generally nest between June through September, and peak nesting occurs in June through July (Witherington and Ehrhart 1989). During the nesting season, females nest at approximately two week intervals, laying an average of three to four clutches (Johnson and Ehrhart 1996) of approximately 110 to 115 eggs. Eggs incubate for approximately two months before hatching. Nesting occurs primarily on beaches with intact dune structure, native vegetation and appropriate incubation temperatures during summer months.

After emerging from the nest, hatchlings swim to offshore areas and go through a post-hatchling pelagic stage where they are believed to live for several years. During this life stage, green turtles feed close to the surface on a variety of marine algae and other life associated with drift lines and debris. This early oceanic phase remains one of the mostly poorly understood aspects of the life history of green turtles (NMFS and USFWS 2007b). Green turtles exhibit particularly slow growth rates of about one to five centimeters (0.4 to two inches) per year (Green 1993; McDonald-Dutton and Dutton 1998), which may be attributed to their largely herbivorous, low-net energy diet (Bjorndal 1982). At approximately 20 to 25 centimeters (eight to ten inches) carapace length, juveniles leave the pelagic environment and enter nearshore developmental habitats such as protected lagoons and open coastal areas rich in seagrass and marine algae. Growth studies using skeletochronology indicate that green turtles in the western Atlantic Ocean shift from the oceanic phase to nearshore developmental habitats after approximately five to six years (Bresette et al. 2006; Zug and Glor 1998). Within the developmental habitats, juveniles begin the switch to a more herbivorous diet, and by adulthood feed almost exclusively on seagrasses and algae (Rebel 1974), although some populations are known to also feed heavily on invertebrates (Carballo et al. 2002). Adult green turtles exhibit site fidelity and migrate hundreds to thousands of kilometers from nesting beaches to foraging areas. Green turtles spend the majority of their lives in coastal foraging grounds, which include open coastlines and protected bays and lagoons. Adult green turtles feed primarily on seagrasses and algae, although they also eat jellyfish, sponges, and other invertebrate prey. Green turtles mature slowly, requiring 20 to 50 years to reach sexual maturity (Chaloupka and Musick 1997; Hirth and USFWS 1997).

With the exception of post-hatchlings, green turtles live in nearshore tropical and subtropical waters. Green turtles nest on sandy beaches of mainland shores, barrier islands, coral islands, and volcanic islands. While in coastal habitats, green turtles exhibit site fidelity to specific foraging and nesting grounds, and it is clear they are capable of "homing in" on these sites if displaced (Hart et al. 2013; McMichael et al. 2003).

8.5.2 Population Dynamics

The green turtle occupies the coastal waters of over 140 countries worldwide; nesting occurs in more than 80 countries (Hirth and USFWS 1997). Worldwide, nesting data at 464 sites indicate that 563,826 to 564,464 females nest each year (Seminoff et al. 2015). Compared to other DPSs, the North Atlantic DPS of green turtle exhibits the highest nester abundance, with approximately 167,424 females at 73 nesting sites (Figure 7), and available data indicate an increasing trend in nesting. The largest nesting site in the North Atlantic DPS of green turtle is in Tortuguero, Costa Rica (on the Caribbean Sea coast), which hosts 79 percent of nesting females for the North Atlantic DPS (Seminoff et al. 2015).

Many nesting sites worldwide suffer from a lack of consistent, standardized monitoring, making it difficult to characterize population growth rates from a DPS. For the North Atlantic DPS of green turtle, the available data indicate an increasing trend in nesting. There are no reliable estimates of population growth rate for the North Atlantic DPS as a whole, but estimates have

been developed at a localized level. Modeling by Chaloupka et al. (2008) using data sets of 25 years or more show the Florida nesting stock at the Archie Carr National Wildlife Refuge growing at an annual rate of 13.9 percent, and the Tortuguero, Costa Rica, population growing at 4.9 percent.

The North Atlantic DPS of green turtle has a globally unique haplotype, which was a factor in defining the discreteness of the population for the North Atlantic DPS. Evidence from mitochondrial DNA studies indicates that there are at least four independent nesting subpopulations in Florida, Cuba, Mexico, and Costa Rica (Seminoff et al. 2015). More recent genetic analysis indicates that designating a new western Gulf of Mexico management unit might be appropriate (Shamblin et al. 2016).

In the continental U.S., green turtle nesting occurs along the coast of the Atlantic Ocean, primarily along the central and southeast coast of Florida where an estimated 200 to 1,100 females nest each year (Meylan et al. 1994; Weishampel et al. 2003). Occasional nesting has also been documented along the Gulf Coast of Florida, Georgia, North Carolina, and Texas (Meylan et al. 1995).

Since 1989, the pattern of green turtle nesting has generally shown biennial peaks in abundance with a positive trend during the ten years of regular monitoring at index nesting beaches. From 1989 through 2016, green turtle nest counts across Florida have increased approximately 100-fold from a low of 267 in the early 1990s to a high of 27,975 in 2015. Green turtle nesting tends to follow a biennial pattern of fluctuation. Apparent increases in nester abundance for the North Atlantic DPS of green turtle in recent years are encouraging, but must be viewed cautiously, as the datasets represent a fraction of green turtle generation, up to 50 years.

Green turtles from the North Atlantic DPS range from the boundary of South and Central America (7.5 degrees North, 77 degrees West) in the south, throughout the Caribbean Sea, the Gulf of Mexico, and the U.S. Atlantic coast to New Brunswick, Canada (48 degrees North, 77 degrees West) in the north. The range of the North Atlantic DPS of green turtle then extends due east along latitudes 48 degrees North and 19 degrees North to the western coasts of Europe and Africa (Figure 7). Nesting occurs primarily in Costa Rica, Mexico, Florida, and Cuba.

In the waters of the Atlantic Ocean and Gulf of Mexico, green turtles are distributed throughout inshore and nearshore waters from Texas to Massachusetts. Principal benthic foraging areas in the southeastern U.S. include Aransas Bay, Matagorda Bay, Laguna Madre, and the Gulf inlets of Texas (Doughty 1984; Hildebrand 1982; Shaver 1994), the Gulf of Mexico off Florida from Yankeetown to Tarpon Springs (Caldwell and Carr 1957; Carr 1984), Florida Bay and the Florida Keys (Schroeder and Foley 1995), the Indian River Lagoon system in Florida (Ehrhart 1983), and the Atlantic Ocean off Florida from Brevard through Broward Counties (Guseman and Ehrhart 1992; Wershoven and Wershoven 1992). The summer developmental habitat for green turtles also encompasses estuarine and coastal waters from North Carolina to as far north as Long Island Sound (Musick and Limpus 1997a). Additional important foraging areas in the western Atlantic Ocean include the Culebra archipelago and other Puerto Rico coastal waters, the

south coast of Cuba, the Mosquito Coast of Nicaragua, the Caribbean Sea coast of Panama, scattered areas along Colombia and Brazil (Hirth 1971), and the northwestern coast of the Yucatán Peninsula.

The complete nesting range of green turtles within the southeastern U.S. includes sandy beaches between Texas and North Carolina, as well as the U.S. Virgin Islands and Puerto Rico (Dow et al. 2007; NMFS and USFWS 1991). The vast majority of green turtle nesting within the southeastern U.S. occurs in Florida (Johnson and Ehrhart 1994; Meylan et al. 1995). Principal nesting areas in the U.S. are in eastern Florida, predominantly Brevard south through Broward Counties.

8.5.3 Vocalization and Hearing

Sea turtles are low frequency hearing specialists, typically hearing frequencies from 30 Hz to two kHz, with a range of maximum sensitivity between 100 to 800 Hz (Bartol et al. 1999; Lenhardt 1994; Lenhardt 2002; Moein Bartol and Ketten 2006; Ridgway et al. 1969). Piniak et al. (2016) found green turtle juveniles capable of hearing underwater sounds at frequencies of 50 Hz to 1,600 kHz (maximum sensitivity at 200 to 400 Hz). Hearing below 80 Hz is less sensitive but still possible (Lenhardt 1994). Based upon auditory brainstem responses of green turtles have been measured to hear in the 50 Hz to 1.6 kHz range (Dow et al. 2008), with greatest response at 300 Hz (Yudhana et al. 2010); a value verified by Moein Bartol and Ketten (2006). Other studies have similarly found greatest sensitivities between 200 to 400 Hz for the green turtle with a range of 100 to 500 Hz (Bartol and Ketten 2006; Ridgway et al. 1969) and around 250 Hz or below for juveniles (Bartol et al. 1999). However, Dow et al. (2008) found best sensitivity between 50 and 400 Hz.

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

In the French West Indies, a recent study recorded vocalizations of free-ranging juvenile green turtles (Charrier et al. 2022). Four main categories of vocalizations were recorded: pulses, low-amplitude calls, frequency-modulated calls, and squeaks. Pulses (mono, doublet, triplets, and multipulses consisting of an average of five pulses) had a main frequency around one kHz. Low-amplitude calls consisted of croaks and rumbles. The frequency range for croaks was 725 ± 330 Hz and the frequency range for rumbles was 323 ± 94 Hz. Frequency-modulated calls were either ascending, descending, or both, and ranged between 31 and 1,047 Hz. Squeaks were more than three kHz. Received levels of all vocalizations ranged between 102 to 124 dB re: one µPa (rms).

8.5.4 Status

Once abundant in tropical and sub-tropical waters, green turtles worldwide exist at a fraction of their historical abundance, as a result of over-exploitation for food and other products. Globally, egg harvest, the harvest of females on nesting beaches and directed hunting of sea turtles in foraging areas remain the three greatest threats to their recovery. In addition, bycatch in drift-net, long-line, set-net, pound-net, and trawl fisheries kill thousands of green turtles annually. Other threats include pollution, habitat loss through coastal development or stabilization, destruction of nesting habitat from storm events, and oil spills. On a regional scale, the different DPSs experience these threats as well, to varying degrees. Differing levels of abundance combined with different intensities of threats and effectiveness of regional regulatory mechanisms make each DPS uniquely susceptible to future perturbations. While the threats continue, the green turtle appears to be somewhat resilient to future perturbations.

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

8.5.5 Status in the Action Area

Important feeding areas for green turtles in U.S. waters are primarily located in Florida and southern Texas, but Long Island Sound and inshore waters of North Carolina appear to be important to juveniles during summer months (NMFS and USFWS 2007a). Juvenile green turtles are the second most commonly bycaught sea turtle species by the pound in net fisheries in the Pamlico Sound (Epperly et al. 1995); (Epperly et al. 2007a). Immature green turtles aggregate in certain neritic areas to forage. Modeling of young sea turtle dispersal after hatching showed relatively high abundances of young green turtles on the U.S. Atlantic coast (ages 0.5 to 1.5 years) and within the Sargasso Sea (ages 2.5 to 3.5 years) (Putman et al. 2020). Satellite tagging of juvenile green turtles showed movement along the Gulf Stream in oceanic (greater than 200 meters [656 feet] water depth) waters ((Mansfield et al. 2021). A majority of the tagged green turtles left the Gulf Stream around Cape Hatteras, North Carolina, and traveled into the western Sargasso Sea. Modeling and tagging of young (and harder to spot) green turtles suggest that there might be more individuals in the seismic survey area than indicated by observational data for older age classes. Although sightings are limited and most records are of stranding or bycatch, relatively high concentrations of green turtles are expected to occur offshore from North Carolina in the spring, summer, and autumn based on sighting per unit effort modeling (DoN 2008b); (DoN 2008c). Most sightings from 2010 through 2017 were made on the shelf during the summer (Palka et al. 2021). Modeling based on line transects and platform of opportunity shows little overlap of green turtle occurrence in the seismic survey area (DoN 2008b); (DoN 2008c).

There are four records of green turtles off the coast of North Carolina in the OBIS database for December through February (OBIS 2022).

8.5.6 Critical Habitat

Designated critical habitat for the North Atlantic DPS of green sea turtle is outside the action area. Accordingly, we find that the proposed actions will have no effect on designate critical habitat in the Atlantic Ocean and will not be considered further in this consultation.

8.5.7 Recovery Goals

In response to the current threats facing the species, NMFS developed goals to recover green turtle populations. These threats will be discussed in further detail in the Environmental Baseline of this consultation. See the 1998 and 1991 recovery plans for the Pacific, East Pacific, and Atlantic populations of green turtles for complete down-listing/delisting criteria for recovery goals for the species (NMFS 1991). Broadly, recovery plan goals emphasize the need to protect and manage nesting and marine habitat, protect and manage populations on nesting beaches and in the marine environment, increase public education, and promote international cooperation on sea turtle conservation topics. The following items were identified as major priorities to recover green turtles in the Atlantic Ocean:

1. Provide long-term protection to important nesting beaches.
2. Ensure at least 60 percent hatch success on major nesting beaches.
3. Implement effective lighting ordinances or lighting plans on nesting beaches.
4. Determine distribution and seasonal movements for all life stages in marine environment.
5. Minimize mortality from commercial fisheries.
6. Reduce threat to pollution and foraging habitat from marine pollution.

8.6 Kemp's Ridley Turtle

The Kemp's ridley turtle is considered to be the most endangered sea turtle, internationally (Groombridge 1982; Zwinenberg 1977). The Kemp's ridley turtle occurs from the Gulf of Mexico and along the Atlantic coast of the U.S., with nesting beaches limited to a few sites in Mexico and Texas (TEWG 2000) (Figure 8). Kemp's ridley sea turtles have occasionally been found in the Mediterranean Sea, which may be due to migration expansion or increased hatchling production (Tomás and Raga 2008).

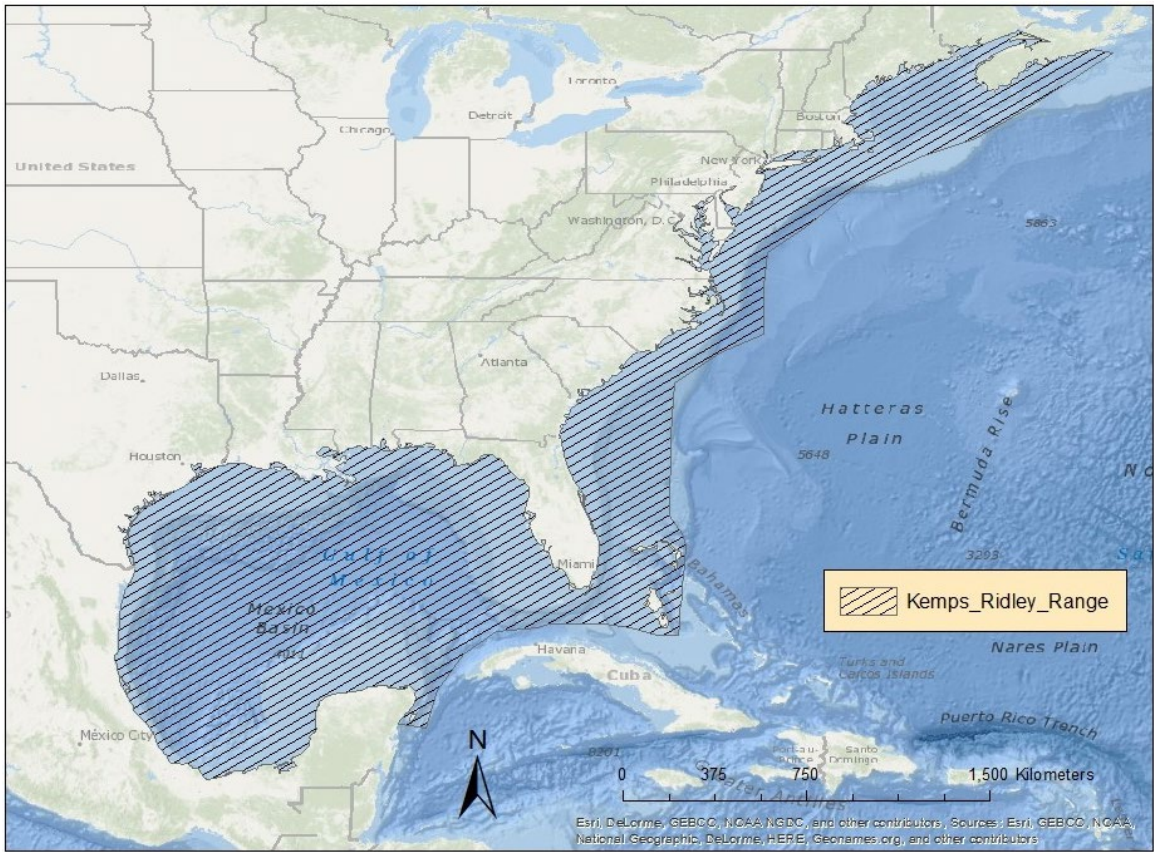

Figure 8. Map identifying the range of the endangered Kemp's ridley turtle.

8.6.1 The species was first listed under the ESA and listed as endangered under the ESA since 1970. Life History

Kemp's ridley turtles share a general life history pattern similar to other sea turtles. Females lay their eggs on coastal beaches where the eggs incubate in sandy nests. After 45 to 58 days of embryonic development, the hatchlings emerge and swim offshore into deeper, oceanic waters where they feed and grow until returning at a larger size. Their return to nearshore coastal habitats typically occurs around two years of age (Ogren 1989), although the time spent in the oceanic habitat may vary from one to four years or perhaps more (TEWG 2000). Females generally reach maturity at 12 years of age, but may range from five to 16 years. The average remigration is two years, although some animals nest annually. Nesting occurs from April through July in arribadas (large aggregations) mainly on beaches in the Gulf of Mexico, but primarily at Rancho Nuevo, Mexico. Historic records indicate a nesting range from Mustang Island, Texas, in the north to Veracruz, Mexico, in the south. Kemp's ridley turtles have also recently been nesting along the Atlantic coast of the U.S., with nests recorded from beaches in Florida, Georgia, North Carolina, South Carolina, and Virginia.

Females lay an average of 2.5 clutches per season. The annual average clutch size is 97 to 100 eggs per nest. The nesting location may be particularly important because hatchlings can more easily migrate to foraging grounds in deeper oceanic waters, where they remain for

approximately two years before returning to nearshore coastal habitats from April through November, but move towards more suitable overwintering habitat in deeper offshore waters (or more southern waters along the Atlantic coast) as water temperature drops. Adult habitat largely consists of sandy and muddy areas in shallow, nearshore waters less than 37 meters (120 feet) deep, although they can also be found in deeper offshore waters. As adults, Kemp's ridley turtles forage on swimming crabs, fish, jellyfish, mollusks, and tunicates (NMFS and USFWS 2011).

8.6.2 Population Dynamics

Of the sea turtles species in the world, the Kemp's ridley has declined to the lowest population level. Nesting aggregations at a single location (Rancho Nuevo, Mexico) were estimated at 40,000 females in 1947. By the mid-1980s, the population had declined to an estimated 300 nesting females. Nesting steadily increased through the 1990s, and then accelerated during the first decade of the 21st century. Following a significant, unexplained one-year decline in 2010, Kemp's ridley turtle nests in Mexico reached a record high of 21,797 in 2012 (NPS 2013). In 2013, there was a second significant decline, with 16,385 nests recorded. In 2014, there were an estimated 10,987 nests and 519,000 hatchlings released from three primary nesting beaches in Mexico (NMFS and USFWS 2015). The number of nests in Padre Island, Texas has increased over the past two decades, with one nest observed in 1985, four in 1995, 50 in 2005, 197 in 2009, and 119 in 2014 (NMFS and USFWS 2015).

From 1980 through 2003, the number of nests at three primary nesting beaches (Rancho Nuevo, Tepehuajes, and Playa Dos) increased 15 percent annually (Heppell et al. 2005); however, due to recent declines in nest counts, decreased survival at other life stages, and updated population modeling, this rate is not expected to continue (NMFS and USFWS 2015). In fact, nest counts dropped by more than a third in 2010 and continue to remain below predictions (Caillouet et al. 2018).

Genetic variability in Kemp's ridley turtles is considered to be high, as measured by heterozygosis at microsatellite loci (NMFS and USFWS 2011). Additional analysis of the mitochondrial DNA taken from samples of Kemp's ridley turtles at Padre Island, Texas, showed six distinct haplotypes, with one found at both Padre Island and Rancho Nuevo (Dutton et al. 2006). Additionally, the genetic diversity of immature Kemp's ridley turtles foraging in the northern Gulf of Mexico (along the Florida panhandle) closely correspond to that of nesting females in Rancho Nuevo, Mexico (Lamont et al. 2021). Despite recent declines in Kemp's ridley turtle populations, a recent study found that genetic diversity, as assessed through the mitochondrial genome, has remained stable (Frandsen et al. 2020).

Juvenile Kemp's ridley turtles, possibly carried by oceanic currents, have been recorded as far north as Nova Scotia. The vast majority of individuals stem from breeding beaches at Rancho Nuevo on the Gulf of Mexico coast of Mexico. During spring and summer, juvenile Kemp's ridley turtles occur in the shallow coastal waters of the northern Gulf of Mexico from south Texas to north Florida. In the fall, most Kemp's ridley turtles migrate to deeper or more southern, warmer waters and remain there through the winter (Schmid 1998). As adults, many

sea turtles remain in the Gulf of Mexico, with only occasional occurrence in the Atlantic Ocean (NMFS and USFWS 2011).

Kemp's ridley turtle nesting population was exponentially increasing (NMFS et al. 2011); however, since 2009 there has been concern over the slowing of recovery (Gallaway et al. 2016a; Gallaway et al. 2016b; Plotkin 2016).

8.6.3 Vocalization and Hearing

Sea turtles are low frequency hearing specialists, typically hearing frequencies 30 Hz to two kHz, with a range of maximum sensitivity between 100 to 800 Hz (Bartol et al. 1999; Lenhardt 1994; Lenhardt 2002; Moein Bartol and Ketten 2006; Ridgway et al. 1969). Hearing below 80 Hz is less sensitive but still possible (Lenhardt 1994). Juvenile Kemp's ridley turtles can hear from 100 to 500 Hz, with a maximum sensitivity between 100 to 200 Hz at thresholds of 110 dB re: one μPa (Bartol and Ketten 2006).

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

8.6.4 Status

Kemp's ridley turtles face many of the same threats as other sea turtle species, including destruction of nesting habitat from storm events, oceanic events such as cold-stunning, pollution (plastics, petroleum products, petrochemicals, etc.), ecosystem alterations (nesting beach development, beach nourishment and shoreline stabilization, vegetation changes, etc.), poaching, global climate change, fisheries interactions, natural predation, and disease.

The Kemp's ridley turtle was listed as endangered in response to a severe population decline, primarily the result of egg collection. In 1973, legal ordinances prohibited the harvest of sea turtles from May through August, and in 1990, the harvest of all sea turtles was prohibited by presidential decrees in Mexico. In 2002, Rancho Nuevo was declared a sanctuary. A successful head-start program has resulted in re-establishment of nesting at Texan beaches. While fisheries bycatch remains a threat, the use of sea turtle excluder devices mitigates take. Fishery interactions and strandings, possibly due to forced submergence, appear to be the main threats to the species. The *Deepwater Horizon* oil spill event reduced nesting abundance and associated hatchling production as well as exposures to oil in the oceanic environment which has resulted in large losses of the population across various age classes, and likely had an important population-level effect on the species. We do not have understanding of those impacts on the population trajectory for the species into the future. The species' limited range and low global abundance make it vulnerable to new sources of mortality as well as demographic and environmental randomness, all of which are often difficult to predict with any certainty. Therefore, its resilience to future perturbation is low.

8.6.5 Status in the Action Area

Hatchlings are carried by the prevalent off the nesting beaches and do not appear in the neritic zone until they are about two years old (Musick and Limpus 1997b). Those juvenile and immature Kemp's ridley turtles that migrate northward past Cape Hatteras, North Carolina probably do so in April and return southward in November (Musick et al. 1994). North of Cape Hatteras, North Carolina, juvenile and immature Kemp's ridley turtles prefer shallow water areas, particularly along North Carolina and in the Chesapeake Bay, Long Island Sound, and Cape Cod Bay (Musick et al. 1994); (Morreale et al. 1989); (Danton and Prescott. 1988); (Frazier et al. 2007).

Numerous sightings of Kemp's ridley turtles have been reported off North Carolina in all seasons (DoN 2008b); (DoN 2008c); (Palka et al. 2021), with most in winter and summer (DoN 2008b); (DoN 2008c). Strandings have also been reported during all seasons except winter, and mostly in spring and fall (DoN 2008b); (DoN 2008c). Modelling of young sea turtle dispersal after hatching showed a portion of Kemp's ridley turtles age 1.5 years concentrating mainly in shelf waters off North Carolina (Putman et al. 2020). Sighting per unit effort modeling based on line transects and platform of opportunity data showed little overlap of Kemp's ridley occurrence and the seismic survey area (DoN 2008a); (DoN 2008b). However, one sighting was reported for the seismic survey area by (DoN 2008b) during summer, and one sighting was recorded off North Carolina during 1978 through 1982 CETAP surveys (CETAP 1982). Rehabilitated Kemp's ridley turtles that were released off Long Island and tracked using satellite tags where recorded in the study area from December through June (Robinson et al. 2020). There are two records in the OBIS database for the North Carolina seismic survey area, one was made in May and the other in August (OBIS 2022).

8.6.6 Critical Habitat

No critical habitat has been designated for Kemp's ridley turtles.

8.6.7 Recovery Goals

In response to current threats facing the species, NMFS developed goals to recover Kemp's ridley turtle populations. These threats will be discussed in further detail in the Environmental Baseline of this consultation. See the 2011 Final Bi-National (U.S. and Mexico) Revised Recovery Plan for Kemp's ridley turtles for complete down listing/delisting criteria for each of their respective recovery goals (NMFS and USFWS 2011). The following items were identified as priorities to recover Kemp's ridley turtles:

1. Protect and manage nesting and marine habitats.
2. Protect and manage populations on the nesting beaches and in the marine environment.
3. Maintain a stranding network.
4. Manage captive stocks.
5. Sustain education and partnership programs.
6. Maintain, promote awareness of and expand U.S. and Mexican laws.

7. Implement international agreements.
8. Enforce laws.

8.7 Leatherback Turtle

The leatherback turtle ranges from tropical to subpolar latitudes, worldwide (Figure 9).

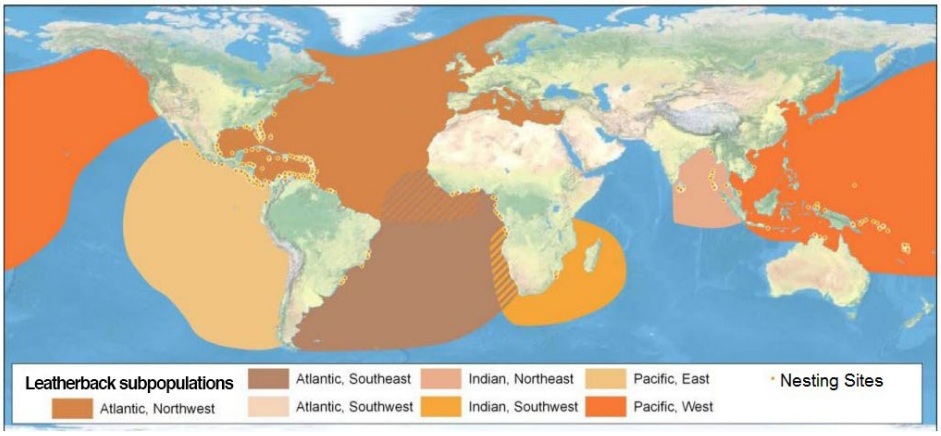

Figure 9. Map identifying the range of the endangered leatherback turtle. Adapted from Wallace et al. (2013).

The species was first listed under the Endangered Species Conservation Act (35 FR 8491) and listed as endangered under the ESA since 1973.

8.7.1 Life History

Leatherback turtles share a general life history pattern similar to other sea turtles. Females lay their eggs on coastal beaches where the eggs incubate in sandy nests. While a robust estimate of the life span does not exist, the current best estimate for the maximum age is 43 (Avens et al. 2009a). Age at maturity has been difficult to ascertain, with estimates ranging from 16 to 29 years (Avens et al. 2009b; Spotila et al. 1996). On average, they reach maturity at approximately 20 years (Jones et al. 2011).

Females usually lay up five to seven clutches (seven to 15 days apart) per nesting season (three to six months generally during the summer), with 20 to more than 100 eggs per clutch and eggs weighing greater than 80 grams (0.17 pounds) (Reina et al. 2002; Wallace et al. 2007) (Eckert et al. 2012; Eckert et al. 2015). 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) and approximately 30 percent of the eggs may be infertile. Eggs hatch after about two months (60 to 65 days) (Eckert et al. 2015). Females nest on sandy, tropical beaches at intervals of every one to 11 (average of two to four) years (Eckert et al. 2015). Nesting females exhibit low site-fidelity to their natal beaches, returning to the same region, but not necessarily the same beach, to nest (Dutton et al. 1999; Dutton et al. 2007). Females have been observed with fertility spans as long as 25 years (Hughes 1996). Natal homing, at least within an ocean basin, results in

reproductive isolation between five broad geographic regions: eastern and western Atlantic Ocean, Indian Ocean, and eastern and western Pacific Ocean.

In the Northwest Atlantic Ocean, the sex ratio appears to be skewed toward females. Hatchling sex ratios range from 30 to 100 percent females in Suriname, Tobago, Colombia, and Costa Rica (Dutton et al. 1985; Godfrey et al. 1996; Mickelson and Downie 2010; Mrosovsky 1994; Patino-Martinez et al. 2012). The proportion of females documented in foraging individuals and strandings ranges from 57 to 70 percent (Murphy et al. 2006; James et al 2007; TEWG 2007), and the ratio of females to males during an individual breeding season is thought to be closer to 1:1 (Stewart and Dutton 2014). Reports of nearshore and onshore stranding data from the Atlantic Ocean and Gulf of Mexico coasts indicate that 60 percent of strandings were females (TEWG 2007b). James et al. (2007) collected size and sex data from large subadult and adult leatherback turtles off Nova Scotia and also concluded a bias toward females at a rate of 1.86:1.

Leatherback turtles are distributed in oceans throughout the world (Figure 9). 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).

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. 2005b; 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 prey availability foraging success and duration (Hays 2000; Price et al. 2004).

Unlike other sea turtles, leatherback turtles have several unique traits that enable them to live in cold water. For example, leatherback turtles have a countercurrent circulatory system (Greer et al. 1973), a thick layer of insulating fat (Davenport et al. 1990; Goff and Lien 1988), gigantothermy (Paladino et al. 1990), and they can increase their body temperature through increased metabolic activity (Bostrom and Jones 2007; Southwood et al. 2005). These adaptations allow leatherback turtles to be comfortable in a wide range of temperatures, which helps them travel further than any other sea turtle species (NMFS and USFWS 1995). For example, a leatherback turtle may swim more than 10,000 kilometers (6,000 miles) in a single year (Benson et al. 2007a; Benson et al. 2011a; Eckert 2006; Eckert et al. 2006). They search for food between latitudes 71 degrees North and 47 degrees South, in all oceans, and travel extensively to and from their tropical nesting beaches.

While leatherback turtles will look for food in coastal waters, they appear to prefer the open ocean at all life stages (Heppell et al. 2003b). Leatherback turtles have pointed tooth-like cusps

and sharp-edged jaws that are adapted for a diet of soft-bodied prey such as jellyfish and salps. A leatherback turtle's mouth and throat also have backward-pointing spines that help retain jelly-like prey as water is expelled. Leatherback turtles favorite prey occur commonly in temperate and northern or subarctic latitudes and likely has a strong influence on their distribution in these areas (Plotkin 1995). Leatherback turtles are known to be deep divers, with recorded depths in excess of one kilometer (3,280.8 feet) for almost 90 minutes, but they may also come into shallow waters to locate prey items. In the Atlantic Ocean, they are found as far north as the North Sea, Barents Sea, Newfoundland, and Labrador, and as far south as Argentina and the Cape of Good Hope, South Africa (NMFS USFWS 2013). In the U.S., important nesting areas include Florida, St. Croix, and Puerto Rico. Other islands of the Caribbean Sea south to Brazil and Venezuela are also important nesting areas in the Western Atlantic Ocean (NMFS USFWS 2013).

The survival and mortality rates for leatherback turtles are difficult to estimate and vary by location. For example, the annual mortality rate for leatherback turtles that nested at Playa Grande, Costa Rica, was estimated to be 34.6 percent in 1993 through 1994 and 34 percent in 1994 through 1995 (Spotila et al. 2000b). In contrast, overall survival rates for nesting females is relatively high at 85 percent (Pfaller et al. 2018), with mean estimated annual survival rates of 70 to 99 percent in French Guiana (Rivalan et al. 2005), 89 percent in St. Croix (Dutton et al. 2005), and 89 to 96 percent on the coast of the Atlantic Ocean of Florida (Stewart et al. 2007b; Stewart et al. 2014), respectively. For the St. Croix population the average annual juvenile survival rate was estimated to be approximately 63 percent and the total survival rate from hatchling to first year of reproduction for a female was estimated to be between 0.4 percent and two percent (assuming age at first reproduction is between nine and 13 years (Eguchi et al. 2006)). Spotila et al. (1996) estimated first-year survival rates for leatherback turtles at 6.25 percent.

Migratory routes of leatherback turtles are not entirely known; however, information from satellite tags have documented long travels between nesting beaches and foraging areas in the Atlantic Ocean and Pacific Ocean basins (Benson et al. 2007a; Benson et al. 2011a; Eckert 2006; Eckert et al. 2006; Ferraroli et al. 2004; Hays et al. 2004; James et al. 2005a). Leatherback turtles nesting in the northwest Atlantic Ocean move throughout most of the North Atlantic Ocean from the equator to about 50 degrees North latitude. Leatherback turtles nesting in Central America and Mexico travel thousands of miles through tropical and temperate waters of the South Pacific Ocean (Eckert and Sarti 1997; Shillinger et al. 2008). Data from satellite tagged animals suggest that they may be traveling in search of seasonal aggregations of jellyfish (Benson et al. 2007b; Bowlby et al. 1994; Graham 2009; Shenker 1984; Starbird et al. 1993; Suchman and Brodeur 2005).

8.7.2 Population Dynamics

Leatherback turtles are globally distributed, with nesting beaches in the Atlantic, Indian, and Pacific Oceans. Movements of adults and subadults span across all major ocean basins and range from equatorial waters to temperate high-latitude regions (Shillinger and Bailey 2015).

Leatherback turtles originating from the same nesting beach may forage in diverse and geographically distant regions, with variance among individuals (Eckert 2006; Eckert et al. 2006b; Hays et al 2006; Benson et al. 2011; Witt et al. 2011; Namboothri et al. 2012a). Conversely, leatherback turtles from different nesting beaches may move to the same foraging regions as adults (Fosette et al. 2010b, 2014). Patterns of leatherback turtle movements between nesting beaches and foraging areas are complex, and appear to be linked to ocean currents that facilitate hatchling dispersal (Gaspar et al. 2012) or adult movements throughout the oceans (Lambardi et al. 2008). Adults are known to return to the same foraging areas after nesting (Seminoff et al. 2012), and hatchlings from different nesting beaches may reach the same foraging areas, creating a mosaic of overlapping population ranges. Wallace et al. (2010) identified seven global regional management units (subpopulations) by reviewing the genetic data available and performing a spatial analysis of these genetic data combined with nesting, tagging, and tracking data, these include: northwest Atlantic Ocean, southwest Atlantic Ocean, southeast Atlantic Ocean, northeast Indian Ocean, west Pacific Ocean, and east Pacific Ocean.

Detailed population structure is unknown, but is likely dependent upon nesting beach location and influenced by physical barriers (i.e., land masses), current systems, and long migrations. The total index of nesting female abundance in the Northwest Atlantic Ocean is 20,659 females. Based on estimates calculated from nesting data, there are approximately 18,700 (10,000 to 31,000 nesting females) total adult leatherback turtles in the North Atlantic Ocean (TEWG 2007a). The total index of nesting female abundance in the Southwest Atlantic Ocean is approximately 27 females. The total index of nesting female abundance in the Southeast Atlantic Ocean is approximately 9,198 females. The total index of nesting female abundance in the Southwest Indian Ocean is approximately 149 females. The total index of nesting female abundance in the Northeast Indian Ocean is approximately 109 females. The total index of nesting female abundance in the West Pacific Ocean is approximately 1,277 females. The total index of nesting female abundance in the East Pacific Ocean is approximately 755 females. The total index of nesting female abundance is likely an underestimate because we did not have adequate data from many nesting beaches, which have the potential for being unmonitored or unidentified.

Declines in nesting can occur rapidly in populations of leatherback turtles. In the Pacific Ocean, nesting has declined precipitously in recent decades (Benson et al. 2015). Aerial surveys of nesting beaches in Mexico detected declines from 70,000 nesting females in 1982 to fewer than 250 in 1998, with an annual mortality rate of 22.7 percent (Spotila et al. 2000a). The Terengganu, Malaysia nesting population was reduced to less than one percent of its original size between the 1950s and 1995 (Chan and Liew 1996) and is no considered functionally extinct. Significant declines in nesting have been documented for other nesting aggregations, such as Gabon, French Guiana, and Indonesia.

Population growth rates for leatherback turtles vary by ocean basin. Leatherback turtles in the Northwest Atlantic Ocean exhibit a decreasing nest trend at nesting beaches with the greatest

known nesting female abundance. This decline has become more pronounced (2008 through 2017), and the available nest data reflect a steady decline for more than a decade (Eckert and Mitchell 2018). Leatherback turtles in the Southwest Atlantic Ocean exhibit an increasing, although variable, nest trend (nearly five percent average annual increase, with the largest increase occurring in the past decade). Leatherback turtles in the Southeast Atlantic Ocean exhibit a declining nest trend (8.6 percent annually) at the largest nesting aggregation (Gabon). Leatherback turtles in the Southwestern Indian Ocean exhibit a slightly decreasing nest trend at monitored nesting beaches (South Africa). Leatherback turtles in the Northeast Indian Ocean exhibit a drastic population decline with extirpation of its largest nesting aggregation in Malaysia. The overall nest trend has drastically decreased over the past several decades. Leatherback turtles in the West Pacific Ocean exhibit low hatching success and a declining nest and population trend. Leatherback turtles in the East Pacific Ocean exhibit a decreasing trend since monitoring began, with a 97.4 percent decline (depending on the nesting beach) since the 1980s or 1990s Wallace et al. (2013). Despite intense conservation efforts, the decline in nesting has not been reverse as of 2011 (Benson et al 2015).

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).

Subpopulations are reproductively isolated with little to no gene flow connecting them. However, within some subpopulations there is fine-scale genetic structure. Genetic analyses using microsatellite data revealed fine-scale genetic differentiation among neighboring subpopulations in the Northwest Atlantic Ocean including: Trinidad, French Guiana/Suriname, Florida, Costa Rica, and St. Croix (Dutton and H. 2013). Tagging studies indicate individual movement and gene flow among nesting aggregations.

In the Atlantic Ocean, equatorial waters appear to be a barrier between breeding populations. In the northwestern Atlantic Ocean, post-nesting female migrations appear to be restricted to north of the equator but the migration routes vary (Eckert et al. 2012; Saba 2013 as cited in NMFS USFWS 2013). Genetic studies support the satellite telemetry data indicating a strong difference in migration and foraging fidelity between the breeding populations in the northern and southern hemispheres of the Atlantic Ocean (Dutton et al. 2013b; Stewart et al. 2013 as cited in NMFS USFWS 2013).

8.7.3 Vocalization and Hearing

Sea turtles are low frequency hearing specialists, typically hearing frequencies from 30 Hz to two kHz, with a range of maximum sensitivity between 100 and 800 Hz (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 Hz and 1.6

kHz in air between 50 Hz and 1.2 kHz in water (lowest sensitivity recorded was 93 dB re: one μPa at 300 Hz).

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 Hz, with slow declines below 100 Hz and rapid declines above 700 Hz, and almost no sensitivity above three kHz (Wever and Vernon 1956). Wood turtles are sensitive up to about 500 Hz, followed by a rapid decline above one kHz and almost no responses beyond three to four kHz (Patterson 1966).

Leatherback eggs and hatchlings have been recorded producing sounds. (Ferrara et al. 2014) recorded sounds including pulses, sounds with harmonic and nonharmonic frequency bands, sounds with frequency and amplitude modulation, and hybrid sounds with characteristics of pulsed and harmonic sounds. Pulses, sounds without harmonically related frequency bands, and sound with harmonic frequency bands were recorded in nests with both eggs and hatchlings. These were produced at a frequency range of about 187.5 to 1,343.8 Hz, 282.2 to 1,640.6 Hz, and 119 to 24,000 Hz, respectively. All sounds were less than 0.5 seconds. (McKenna et al. 2019) also recorded sounds (no pulses) of leatherback turtle hatchlings, sounds were produced at an average frequency range of 2.41 ± 3.02 kHz and average duration of 0.14 ± 0.13 seconds.

8.7.4 Status

The leatherback turtle is an endangered species whose once large nesting populations have experienced steep declines in recent decades. The status of the subpopulations in the Atlantic, Indian, and Pacific Oceans are generally declining, except for the subpopulation in the Southwest Atlantic Ocean, which is slightly increasing. Leatherback turtles show a lesser degree of nest site fidelity than occurs with hardshell sea turtle species.

The primary threats to leatherback turtles include fisheries interactions (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, vegetation changes, sand extraction, beach nourishment, shoreline stabilization, and natural disasters (e.g., storm events and tsunamis) as well as cold-stunning, vessel interaction, pollution (contaminants, marine debris and plastics, petroleum products, petrochemicals), ghost fishing gear, natural predation, parasites, and disease. Artificial lights on or adjacent to nesting beaches alter nesting adult female behavior and are often fatal to post-nesting females and emerging hatchlings as they are drawn to light sources and away from the sea. Ingestion of marine debris (plastic) is common in leatherback turtles and can block gastrointestinal tracts leading to death. Climate change may alter sex ratios (as temperature determines hatchling sex) and nest success, range (through expansion of foraging habitat as well as alter spatial and temporal patterns), and habitat (through the loss of nesting beaches, because of sea-level rise and storms). Oceanographic regime shifts possibly impact foraging conditions that may affect nesting female size, clutch size, and egg size of populations. The species' resilience to additional perturbation is low.

8.7.5 Status in the Action Area

Leatherback turtle sightings off North Carolina are frequent during summer, although sightings have been reported for all seasons; most sightings were on the shelf, with fewer along the shelf break and in offshore waters (DoN 2008b; DoN 2008c)(Conley et al. 2017)(Palka et al. 2021). Sightings per unit effort modeling based on line transects and platform of opportunity data shows some overlap of leatherback occurrence with the northeastern portion of the seismic survey area (DoN 2008b). During (CETAP 1982) surveys, leatherback turtles were sighted off North Carolina during spring, summer, and fall. Some leatherback turtles tagged outside of Cape Cod, Massachusetts, seemed to forage relatively close to the coast of North Carolina during the summer; in the autumn and spring, they showed longer distance movements and movement offshore, including over the seismic survey area (Dodge et al. 2014). Tagged leatherback turtles have been tracked moving through the seismic survey area (Palka et al. 2021)(Rider et al. 2022)(SWOT 2022). Modeling of the active dispersal of juvenile leatherback turtles in the North Atlantic Ocean suggests that two- to six-year-old leatherback turtles could occur in the waters offshore from North Carolina including the seismic survey area, but at low densities (Lalire and Gaspar 2019). One individual was seen from September 16 through October 18, 2014 during an L-DEO seismic survey just north of the seismic survey area (RPS 2015). In 2019, an interaction between a leatherback turtle and longline fishery was reported for within the seismic survey area (Garrison and Stokes 2021). There are 22 records for the North Carolina seismic survey area in the OBIS database, for January through August (OBIS 2022).

8.7.6 Critical Habitat

Designated critical habitat for leatherback turtles is outside the action area. Accordingly, we find that the proposed actions will have no effect on designated critical habitat and will not be considered further in this consultation.

8.7.7 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 of this consultation. See the 1998 and 1991 Recovery Plans (NMFS 1998c) for the U.S Pacific and U.S. Caribbean, Gulf of Mexico, and Atlantic leatherback turtles for complete downlisting/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.

8.8 Loggerhead Turtle – Northwest Atlantic Ocean Distinct Population Segment

Loggerhead turtles are circumglobal, and are found in continental shelf and estuarine environments throughout the temperate and tropical regions of the Atlantic, Indian, and Pacific Oceans. Northwest Atlantic Ocean DPS of loggerhead turtles are found along eastern North America, Central America, and northern South America (Figure 10).

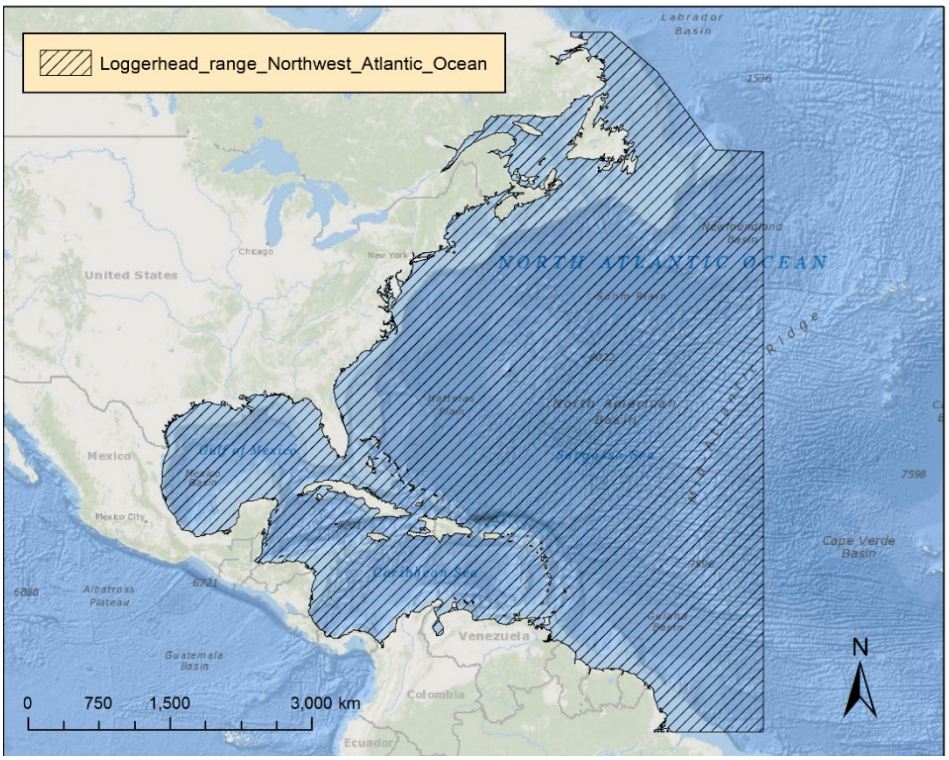

Figure 10. Map identifying the range of the threatened Northwest Atlantic Ocean distinct population segment of loggerhead turtle.

The species was first listed as threatened under the ESA in 1978 (43 FR 32800). On September 22, 2011, the NMFS designated nine DPSs of loggerhead turtles, with the Northwest Atlantic Ocean DPS listed as threatened (75 FR 12598).

8.8.1 Life History

Loggerhead turtles share a general life history pattern similar to other sea turtles. Females lay their eggs on coastal beaches where the eggs incubate in sandy nests. The eight stages of the life cycle and the ecosystems those stages generally use include: egg (terrestrial zone), hatchling (terrestrial zone), hatchling swim frenzy and transitional (neritic zone), juvenile (oceanic zone), juvenile (neritic zone), adult (oceanic zone), adult (neritic zone), nesting female (terrestrial zone) (NMFS and USFWS 2008a). Loggerhead turtles reach sexual maturity between 20 to 38 years of age, although this varies widely among populations (Frazer and Ehrhart 1985; NMFS 2001). Mean age at first reproduction for female loggerhead turtles is 30 years. The annual mating season occurs from late March through early June, and females lay eggs throughout the summer months. Females lay an average of four clutches per season (Murphy and Hopkins 1984), and an

average remigration interval is 3.7 years (Tucker 2010). The annual average clutch size is 100 to 126 eggs per nest (Dodd 1988). Eggs incubate for 42 to 75 days before hatching (NMFS and USFWS 2008a). Nesting occurs on beaches, where warm, humid sand temperatures incubate the eggs. Temperature determines the sex of the loggerhead turtle during the middle of the incubation period.

The majority of nesting occurs at the western rims, concentrated in the north and south temperate zones and subtropics, of the Atlantic and Indian Oceans (NRC 1990). For the Northwest Atlantic Ocean DPS of loggerhead turtles, most nesting occurs along the East coast of the U.S., from southern Virginia to Alabama. Additional nesting occurs along the northern and western Gulf of Mexico, eastern Yucatán peninsula, at Cay Sal Bank in the eastern Bahamas (Addison 1997; Addison and Morford 1996), off the southwestern coast of Cuba (Gavilan 2001), and along the coasts of Central America, Colombia, Venezuela, and the eastern islands of the Caribbean Sea. Non-nesting, adult females are reported throughout the Atlantic Ocean, Gulf of Mexico, and Caribbean Sea. Little is known about the distribution of adult males who are seasonally abundant near nesting beaches.

Habitat uses within continental shelf and estuarine environments vary by life stage. Loggerhead turtles spend the post-hatchling stage in pelagic waters. The juvenile stage is spent first in the oceanic zone and later in the neritic zone (i.e., coastal waters). Coastal waters provide important foraging habitat, inter-nesting habitat, and migratory habitat for adult loggerhead turtles. Neritic juvenile loggerhead turtles are omnivorous and forage on crabs, mollusks, jellyfish, and vegetation at or near the water's surface, whereas subadults and adults typically prey on benthic invertebrates such as mollusks and decapod crustaceans in hardbottom habitats in coastal waters.

As post-hatchlings, loggerhead turtles hatched on beaches enter the "oceanic juvenile" life stage, migrating offshore and becoming associated with *Sargassum* habitats, driftlines, and other convergence zones (Carr 1986; Conant et al. 2009b; Witherington 2002). Oceanic juveniles grow at rates of 2.9 to 5.4 centimeters (one to two inches) per year (Bjorndal et al. 2003; Snover 2002) over a period as long as seven to 12 years (Bolten et al. 1998) before moving to more coastal habitats. Studies have suggested that not all loggerhead turtles follow the model of circumnavigating the North Atlantic Gyre as pelagic juveniles, followed by permanent settlement into benthic environments (Bolten and Witherington 2003; Laurent et al. 1998). These studies suggest some animals may either remain in the oceanic habitat in the North Atlantic Ocean longer than hypothesized or they move back and forth between oceanic and coastal habitats interchangeably (Witzell 2002). When immature loggerhead turtles reach 40 to 60 centimeters (15 to 24 inches), they begin to reside in coastal inshore waters of the continental shelf throughout the Atlantic Ocean and Gulf of Mexico (Witzell 2002).

After departing the oceanic zone, neritic juveniles in the Northwest Atlantic Ocean inhabit continental shelf waters from Cape Cod Bay, Massachusetts, south through Florida, the Bahamas, Cuba, and the Gulf of Mexico. Estuarine waters of the U.S., including areas such as Long Island Sound, Chesapeake Bay, Pamlico and Core Sounds, Mosquito and Indian River

Lagoons, Biscayne Bay, Florida Bay, and numerous embayments fringing the Gulf of Mexico, comprise important inshore habitat. Along the shorelines of the Atlantic Ocean and Gulf of Mexico, essentially all shelf waters are inhabited by loggerhead turtles (Conant et al. 2009b).

Like juveniles, non-nesting adults also use the neritic zone. However, these adults do not use the relatively enclosed shallow-water estuarine habitats with limited ocean access as frequently as juveniles. Areas such as Pamlico Sound, North Carolina, and the Indian River Lagoon, Florida, are regularly used by juveniles but not by adults. Adults do tend to use estuarine areas with more access to the open ocean, such as the Chesapeake Bay in the mid-Atlantic Ocean. Shallow-water habitats with large expanses of access to the open ocean, such as Florida Bay, provide year-round resident foraging areas for significant numbers of female and male adults (Conant et al. 2009b).

Loggerhead turtles are circumglobal, occurring throughout the temperate and tropical regions of the Atlantic, Indian, and Pacific Oceans, returning to their natal region for mating and nesting. Adults and sub-adults occupy nearshore habitat. While in their oceanic phase, loggerhead turtles undergo long migrations using ocean currents. Individuals from multiple nesting colonies can be found on a single feeding ground. Loggerhead turtle hatchlings from the western Atlantic Ocean disperse widely, most likely using the Gulf Stream to drift throughout the Atlantic Ocean. Mitochondrial DNA evidence demonstrates that juvenile loggerhead turtles from southern Florida nesting beaches comprise the vast majority (71 to 88 percent) of individuals found in foraging grounds throughout the western and eastern Atlantic Ocean: Nicaragua, Panama, Azores and Madeira, Canary Islands and Andalusia, Gulf of Mexico, and Brazil (Masuda 2010).

Offshore, adults primarily inhabit continental shelf waters, from New York through Florida, the Bahamas, Cuba, and the Gulf of Mexico. Seasonal use of shelf waters in the mid-Atlantic Ocean, especially offshore of New Jersey, Delaware, and Virginia during summer months, and offshore shelf waters, such as Onslow Bay (off the North Carolina coast), during winter months has been documented (Hawkes et al. 2014; Hawkes et al. 2007). Satellite telemetry has identified the shelf waters along the west coast of Florida, the Bahamas, Cuba, and the Yucatán peninsula as important resident areas for adult females that nest in Florida (Foley et al. 2008; Girard et al. 2009; Hart et al. 2012). The southern edge of the Grand Bahama Bank is important habitat for nesting on the Cay Sal Bank in the Bahamas, but nesting females are also resident in the bights of Eleuthera, Long Island, and Ragged Islands. They also reside in Florida Bay. Moncada et al. (2010) report the recapture in Cuban waters of five adult females originally flipper-tagged in Quintana Roo, Mexico, indicating that Cuban shelf waters likely also provide foraging habitat for adult females that nest in Mexico.

8.8.2 Population Dynamics

It is difficult to estimate the overall abundance for sea turtle populations because individuals spend most of their time in water, where they are difficult to count, especially considering their large range and use of many different and distance habitats. Females, however, converge on their natal beaches to lay eggs and nests are easily counted. The total number of annual U.S. nest

counts for the Northwest Atlantic DPS of loggerhead turtles is over 110,000 (NMFS and USFWS 2023).

In water estimates of abundance include juvenile and adult life stages of loggerhead turtle males and females are difficult to perform on a wide scale. In the summer of 2010, NMFS' Northeast Fisheries Science Center and Southeast Fisheries Science Center estimated the abundance of juvenile and adult loggerhead turtles along the continental shelf between Cape Canaveral, Florida and the mouth of the Gulf of St. Lawrence, Canada, based on the Atlantic Marine Assessment Program for Protected Species aerial line-transect sighting survey and satellite tagged loggerhead turtles (NMFS 2011d). They provided a preliminary regional abundance estimate of 588,000 individuals (approximate inter-quartile range of 382,000 to 817,000 individuals) based on positively identified loggerhead turtle sightings (NMFS 2011). A separate, smaller aerial survey, conducted in the southern portion of the Mid-Atlantic Bight and Chesapeake Bay in 2011 and 2012, demonstrated uncorrected loggerhead turtle abundance ranging from a spring high of 27,508 to a fall low of 3,005 loggerhead turtles (NMFS and USFWS 2023). We are not aware of any current rangewide in-water estimates for the Northwest Atlantic Ocean DPS of loggerhead turtle.

Based on genetic analysis of subpopulations, the Northwest Atlantic Ocean DPS of loggerhead turtle is further categorized into five recovery units corresponding to nesting beaches. These are Northern Recovery Unit, Peninsular Florida Recovery Unit, Dry Tortugas Recovery Unit, Northern Gulf of Mexico Recovery Unit, and the Greater Caribbean Recovery Unit (Conant et al. 2009a). A more recent analysis using expanded mitochondrial DNA sequences revealed that rookeries from the Gulf and Atlantic coasts of Florida are genetically distinct, and that rookeries from Mexico's Caribbean coast express high haplotype diversity (Shamblin et al. 2014). Furthermore, the results suggest that the Northwest Atlantic Ocean DPS of loggerhead turtle should be considered as ten management units: (1) South Carolina and Georgia, (2) central eastern Florida, (3) southeastern Florida, (4) Cay Sal, Bahamas, (5) Dry Tortugas, Florida, (6) southwestern Cuba, (7) Quintana Roo, Mexico, (8) southwestern Florida, (9) central western Florida, and (10) northwestern Florida (Shamblin et al. 2012).

The Northern Recovery Unit, from North Carolina to northeastern Florida, and is the second largest nesting aggregation in the Northwest Atlantic Ocean DPS of loggerhead turtle, with an average of 5,215 nests from 1989 through 2008, and approximately 1,272 nesting females per year (NMFS and USFWS 2008b). The nesting trend from daily beach surveys showed a significant decline of 1.3 percent annually from 1989 through 2008. Aerial surveys of nests showed a 1.9 percent decline annually in nesting in South Carolina from 1980 through 2008. Overall, there is strong statistical data to suggest the Northern Recovery Unit has experienced a long-term decline over that period of time. Data since that analysis are showing improved nesting numbers and a departure from the declining trend. Nesting in Georgia has shown an increasing trend since comprehensive nesting surveys began in 1989. Nesting in North Carolina

and South Carolina has begun to show a shift away from the declining trend of the past. Increases in nesting were seen from 2009 through 2012.

The Peninsular Florida Recovery Unit is the largest nesting aggregation in the Northwest Atlantic Ocean DPS of loggerhead turtle, with an average of 64,513 nests per year from 1989 through 2007, and approximately 15,735 nesting females per year (NMFS and USFWS 2008a). Following a 52 percent increase between 1989 through 1998, nest counts declined sharply (53 percent) from 1998 through 2007. However, annual nest counts showed a strong increase (65 percent) from 2007 through 2017 (FFWCC 2018). Index nesting beach surveys from 1989 through 2013 has identified three trends. From 1989 through 1998, there was a 30 percent increase that was then followed by a sharp decline over the subsequent decade. Large increases in nesting occurred since then. From 1989 through 2013, the decade-long decline had reversed and there was no longer a demonstrable trend. From 1989 through 2016, the Florida Fish and Wildlife Research Institute concluded that there was an overall positive change in the nest counts, but the change was not statistically significant.

The Dry Tortugas, Gulf of Mexico, and Greater Caribbean Recovery Units are much smaller nesting assemblages, but they are still considered essential to the continued existence of loggerhead turtles. The Dry Tortugas Recovery Unit includes all islands west of Key West, Florida. The only available data for the nesting subpopulation on Key West comes from a census conducted from 1995 through 2004 (excluding 2002), which provided a range of 168 to 270 (mean of 246) nests per year, or about 60 nesting females (NMFS and USFWS 2007c). There was no detectable trend during this period (NMFS and USFWS 2008a).

The Gulf of Mexico Recovery Unit has between 100 to 999 nesting females annually, and a mean of 910 nests per year. Analysis of a dataset from 1997 through 2008 of index nesting beaches in the northern Gulf of Mexico shows a declining trend of 4.7 percent annually. Index nesting beaches in the panhandle of Florida has shown a large increase in 2008, followed by a decline in 2009 through 2010 before an increase back to levels similar to 2003 through 2007 in 2011.

The Greater Caribbean Recovery Unit encompasses nesting subpopulations in Mexico to French Guiana, the Bahamas, and the Lesser and Greater Antilles. The majority of nesting for this recovery unit occurs on the Yucatán peninsula, in Quintana Roo, Mexico, with 903 to 2,331 nests annually (Zurita et al. 2003a). Other significant nesting sites are found throughout the Caribbean Sea, and including Cuba, with approximately 250 to 300 nests annually (Ehrhart et al. 2003), and over 100 nests annually in Cay Sal in the Bahamas (NMFS and USFWS 2008b). Survey effort at nesting beaches has been inconsistent, and not trend can be determined for this subpopulation (NMFS and USFWS 2008a). Zurita et al. (2003b) found an increase in the number of nests on seven of the beaches on Quintana Roo, Mexico from 1987 through 2001, where survey effort was consistent during the period. Nonetheless, nesting has declined since 2001, and the previously reported increasing trend appears to not have been sustained (NMFS and USFWS 2008a).

Nesting data are the best current indicator of population trends in sea turtles, but in-water data also provide some insight. In-water research suggests the abundance of neritic juveniles is steady or increasing. Although Ehrhart et al. (2007) found no significant regression-line trend in a long-term dataset, researchers have observed notable increases in catch per unit effort (Arendt et al. 2009; Ehrhart et al. 2007; Epperly et al. 2007b). Researchers believe that this increase in catch per unit effort is likely linked to an increase in abundance of juveniles. Although it is unclear whether this increase in abundance represents a true population increase among juveniles or merely a shift in spatial occurrence. Bjorndal et al. (2005) caution about extrapolating localized in-water trends to the broader population and relating localized trends in neritic sites to population trends at nesting beaches. The apparent overall increase in the abundance of the largest oceanic/neritic juveniles (historically referred to as small benthic juveniles), which could indicate a relatively large number of individuals around the same age may mature in the near future (TEWG 2009). However, in-water studies throughout the eastern U.S. indicate a substantial decrease in the abundance of the smallest oceanic/neritic juvenile loggerhead turtles, a patter corroborated by stranding data (TEWG 2009).

8.8.3 Vocalization and Hearing

Sea turtles are low frequency hearing specialists, typically hearing frequencies from 30 Hz to two kHz, with a range of maximum sensitivity between 100 and 800 Hz (Bartol et al. 1999; Lenhardt 1994; Lenhardt 2002; Moein Bartol and Ketten 2006; Ridgway et al. 1969). Hearing below 80 Hz is less sensitive but still possible (Lenhardt 1994). Bartol et al. (1999) reported effective hearing range for juvenile loggerhead turtles is from at least 250 to 750 Hz. Both yearling and two-year old loggerhead turtles had the lowest hearing threshold at 500 Hz (yearling: about 81 dB re: one µPa and two-year olds: about 86 dB re: one µPa), with threshold increasing rapidly above and below that frequency (Bartol and Ketten 2006). Underwater tones elicited behavioral responses to frequencies between 50 and 800 Hz and auditory evoked potential responses between 100 and 1,131 Hz in one adult loggerhead turtle (Martin et al. 2012). The lowest threshold recorded in this study was 98 dB re: one µPa at 100 Hz. Lavender et al. (2014) found post-hatchling loggerhead turtles responded to sounds in the range of 50 to 800 Hz while juveniles responded to sounds in the range of 50 Hz to one kHz. Post-hatchlings had the greatest sensitivity to sounds at 200 Hz while juveniles had the greatest sensitivity at 800 Hz (Lavender et al. 2014).

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 Hz, with slow declines below 100 Hz and rapid declines above 700 Hz, and almost no sensitivity above three kHz (Wever and Vernon 1956). Wood turtles are sensitive up to about 500 Hz, followed by a rapid decline above one kHz and almost no responds beyond three or four kHz (Patterson 1966).

8.8.4 Status

Based on the currently available information, the overall nesting trend of the Northwest Atlantic Ocean DPS of loggerhead turtle appears to be stable, neither increasing or decreasing, for over

two decades (NMFS and USFWS 2023). Destruction and modification of terrestrial and marine habitats threaten the Northwest Atlantic Ocean DPS of loggerhead turtles. On beaches, threats and interfere with successful nesting, egg incubation, hatchling emergence, and transit to the sea include erosion, erosion control, coastal development, artificial lighting, beach use, and beach debris (NMFS and USFWS 2023). In the marine environment, threats that interfere with foraging and movement include marine debris, oil spills and other pollutants, harmful algal blooms, and noise pollution (NMFS and USFWS 2023).

8.8.5 Status in the Action Area

The U.S. Navy has mapped numerous sightings of loggerhead turtles off the coast of North Carolina, especially during spring and summer (DoN 2008b); (DoN 2008c). Most records are for shelf waters, but there are also sightings on the shelf break and farther offshore; sightings of loggerhead turtles were by far the most numerous of any sea turtle. (Palka et al. 2021) also showed sightings of loggerhead turtles on the shelf off North Carolina during all seasons. Females stay closer to the shore after nesting but move farther offshore towards the end of summer (Hopkins-Murphy et al. 2003). Satellite tagging of juvenile loggerhead turtles in the Chesapeake Bay and off North Carolina showed two different movement strategies: some individuals stayed on the shelf in a north–south pattern, and others exhibited an oceanic dispersal strategy into the Gulf Stream to the North Atlantic Ocean (Mansfield et al. 2009). During colder temperatures (below 20 degrees Celsius [68 Fahrenheit]), shelf-dwelling turtles moved south of Cape Hatteras, North Carolina, to inhabit waters between North Carolina's Outer Banks and the western edge of the Gulf Stream. Individuals also exhibited strong seasonal movements to Virginia (summer foraging habitat) and North Carolina (winter habitat). Sighting per unit effort modeling based on line transects and platform of opportunity data shows some overlap of occurrence of loggerhead turtles with the study area (DoN 2008a); (DoN 2008b). Tagged loggerhead turtles have been tracked moving through the seismic survey area ((Palka et al. 2021); (SWOT 2022). Four sightings of seven individuals were made from September 16 through October 18, 2014 during an L-DEO seismic survey off Cape Hatteras, North Carolina; only one sighting overlapped the seismic survey area. They are the most common sea turtle caught as bycatch by the pound net fisheries in Pamlico Sound (Epperly et al. 2007a), to the west of the seismic survey area. There are 86 records in the OBIS database for the North Carolina study area that were made throughout the year (OBIS 2022).

8.8.6 Critical Habitat

Northwest Atlantic Ocean DPS of loggerhead turtle designated critical habitat is outside the action area. Accordingly, we find that the proposed actions will have no effect on designated critical habitat and will not be considered further in this consultation.

8.8.7 Recovery Goals

In response to the current threats facing the species, NMFS developed goals to recover loggerhead turtle populations. These threats will be discussed in further detail in the

Environmental Baseline of this consultation. See the 2009 Final Recovery Plan for the Northwest Atlantic Population of loggerhead turtles for complete down-listing/delisting criteria for each of the following recovery objectives (NMFS 2008).

1. Ensure that the number of nests in each recovery unit is increasing and that this increase corresponds to an increase in the number of nesting females.
2. Ensure the in-water abundance of juveniles in both neritic and oceanic habitats is increasing and is increasing at a greater rate than strandings of similar age classes.
3. Manage sufficient nesting beach habitat to ensure successful nesting.
4. Manage sufficient feeding, migratory, and internesting marine habitats to ensure successful growth and reproduction.
5. Eliminate legal harvest.
6. Implement scientifically based nest management plans.
7. Minimize nest predation.
8. Recognize and respond to mass/unusual mortality or disease events appropriately.
9. Develop and implement local, state, Federal, and international legislation to ensure long-term protection of loggerheads and their terrestrial and marine habitats.
10. Minimize bycatch in domestic and international commercial and artisanal fisheries.
11. Minimize trophic changes from fishery harvest and habitat alteration.
12. Minimize marine debris ingestion and entanglement.
13. Minimize vessel strike mortality.

9 ENVIRONMENTAL BASELINE

The "environmental baseline" refers to the condition of the ESA-listed species or its designated critical habitat in the action area, without the consequences of the ESA-listed species or designated critical habitat caused by the proposed action. The environmental baseline includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process. The consequences to ESA-listed species or designated critical habitat from ongoing agency activities or existing agency facilities that are not within the agency's discretion to modify are part of the environmental baseline (50 C.F.R. §402.02). In this section, we discuss the environmental baseline within the action area as it applies to species that are likely to be adversely affected by the proposed actions.

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 populations in the action area for this consultation. Some of these activities, most notably commercial whaling, occurred extensively in the past and continue at low levels that no longer appear to significantly affect marine mammal populations, although the effects of past reductions in numbers persist today. The following discussion summarizes the

impacts, which include climate change, vessel interactions (vessel strike and whale watching), fisheries (fisheries interactions), pollution (marine debris, pollutants and contaminants, and hydrocarbons), aquatic nuisance species, anthropogenic sound (vessel sound and commercial shipping, aircraft, seismic surveys, offshore energy development, marine construction, active sonar, and military activities), and scientific research activities.

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

9.1 Climate Change

There is a large and growing body of literature on past, present, and future impacts of global climate change, exacerbated and accelerated by human activities. Effects of climate change include sea level rise, increased frequency and magnitude of severe weather events, changes in air and water temperatures, and changes in precipitation patterns, all of which are likely to affect ESA resources. NOAA's climate information portal provides basic background information on these and other measured or anticipated climate change effects (see https://climate.gov). This section provides some examples of impacts to ESA-listed species and their habitats that have occurred or may occur as the result of climate change in the action area. We address climate change as it has affected ESA-listed species and continues to affect species, and we look to the foreseeable future to consider effects that we anticipate would occur as a result of ongoing activities. While the consideration of future impacts may also be suited for our Cumulative Effects analysis (Section 11), it is discussed here to provide a comprehensive analysis of the effects of climate change. While it is difficult to accurately predict the consequences of climate change to a particular species or habitat, a range of consequences are expected that are likely to change the status of the species and the condition of their habitats both within and outside of the action area.

The rising concentrations of greenhouse gases in the atmosphere, now higher than any period in the last 800,000 years, have also affected the chemistry of the ocean, causing it to become more acidic. Ocean acidification negatively affects crustaceans, crabs, mollusks, and other calcium carbonate-dependent organisms such as pteropods (free-swimming pelagic sea snails and sea slugs) which are an important part of the food web in the waters of the Northwest Atlantic Ocean . 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 and sea turtles.

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 2014b; Kintisch 2006; Learmonth et al. 2006; Macleod et al. 2005; McMahon and Hays 2006b; Robinson et al. 2005). Though predicting the precise consequences of climate change on highly mobile marine species is difficult (Simmonds and Isaac 2007), recent research has indicated a range of consequences already occurring. Changes in the marine ecosystem caused by global climate change (e.g., ocean acidification, salinity, oceanic currents, dissolved oxygen levels, nutrient distribution) could influence the distribution and abundance of lower trophic levels (e.g., phytoplankton, zooplankton, submerged aquatic vegetation, crustaceans, mollusks, forage fish), ultimately affecting primary foraging areas of ESA-listed species including marine mammals and sea turtles in the action area. Also, 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). MacLeod (2009) estimated, based upon expected shifts in water temperature, 88 percent of cetaceans would be affected by climate change, with 47 percent predicted to experience unfavorable conditions (e.g., range contraction).

Similarly, climate-related changes in important prey species populations are likely to affect predator populations. Climate-mediated changes in the distribution and abundance of keystone prey species like zooplankton and in cephalopod populations worldwide would likely affect marine mammal populations as they re-distribute throughout the world's oceans in search of prey. Pecl and Jackson (2008) predicted climate change would 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. Sperm whales, whose diets can be dominated by cephalopods, would have to re-distribute following changes in the distribution and abundance of their prey. This statement assumes that projected changes in global climate would only affect the distribution of cephalopod populations, but would not reduce the number or density of cephalopod populations. If, however, cephalopod populations collapse or decline dramatically, sperm whale populations are likely to collapse or decline dramatically as well. 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).

Large-scale changes in the earth's climate are in turn causing changes locally to the waters off North Carolina's climate and environment. Climate change impacts can vary widely depending on depth since deeper areas may experience different temperature fluctuations than shallow areas. Over the last 100 years, sea surface temperatures have increased across much of the Northwest Atlantic Ocean, consistent with the global trend of increasing sea surface temperature

due to anthropogenic climate change (Beazley et al. 2021). The effects of ocean warming have already been observed in the marine ecosystem across the Northwest Atlantic Ocean, through northward shifts in the range of commercially harvested fish and their catch distribution (Pinsky and Fogarty 2012) and varying shifts of ESA-listed marine mammals. Chavez-Rosales et al. (2022) examined habitat suitability for 16 species of cetaceans in the western Northwest Atlantic Ocean, including fin whale, sei whale, and sperm whale using generalized additive models developed from data collected by the NMFS Northeast Fisheries Science Center from 2010 through 2017. The models were based on observed species distribution as a function of 21 environmental covariates and compared species-specific core habitats between 2010 and 2017. Chavez-Rosales et al. (2022) noted that the largest shifts in the core habitat was for several species including fin whale, sei whale, and sperm whale. It was noted that the effects of these shifts are still unknown, but for already stressed species, the contraction or displacement of their historical habitat cold worsen their population status. In addition to cetaceans, McMahon and Hays (2006a) 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.

In addition to increased ocean warming and changes in species' distribution, climate change is linked to increased extreme weather and climate events including, but not limited to, hurricanes, cyclones, tropical sotrms, heat waves, and droughts (IPCC 2022). Research from IPCC (2022) shows that it is likely extratropical storm tracks have shifted poleward in both the Northern and Southern Hemispheres, and heavy rainfalls, and mean maximum wind speeds associated with hurricane events will increase with continued greenhouse gas warming. These extreme weather events have the potential to have adverse effects on ESA-listed sea turtles in the action area. For example after Hurricane Dorian, a category five hurricane that swept over the Bahamas in 2019, the country saw a loss of up to 1,500 sea turtle nests (Garza 2019). Increased instances of extreme weather events such as these have the potential to reduce sea turtle populations by reducing hatchling success rates.

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

9.2 Vessel Interactions

Within the action area, vessel interactions pose a threat to ESA-listed marine mammals. Overall, the action area sees a great deal of vessel activity, from cargo and commercial shipping, to recreational vessels, cruise ships, and whale watching vessels. Vessel interactions can come in the form of vessel strike and whale watching and tourism.

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). A blue whale aborted its ascent when it was 57.5 meters (188.6 feet) from the vessel, and stayed underwater for three minutes beyond its projected surfacing time (Szesciorka et al. 2019). When vessels were at an average distance of less than 366 meters (1,200.8 feet), individuals made fewer dives involving prey capture, and spent less time in these dives. The researchers found differences in response between the sexes, with females making fewer fives than males when vessels were less than 366 meters (1,200.8 feet) (Holt et al. 2021).

9.2.1 Vessel Strike

Vessel strikes are considered a serious and widespread threat to ESA-listed marine mammals (especially large whales) and are the most well-documented "marine road" interaction with large whales (Pirotta et al. 2019). In a review of global vessel strike data from 1820 through 2019, Winkler et al. (2020) indicated that the highest occurrence of reported vessel strikes with cetaceans were in the Atlantic Ocean with over 62.4 percent of occurrences compared to other ocean basins.

Vesses strike is an increasing threat 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). As vessels to become faster and more widespread, an increase in vessel interactions with cetaceans is to be expected. All sizes and types of vessels can hit whales, but most lethal and severe injuries are caused by vessels 80 meters (262.5 feet) or longer (Laist et al. 2001). For whales, studies show that the probability of fatal injuries from vessel strikes increases as vessels operate at speeds above 26 kilometers per hour (14 knots) (Laist et al. 2001). Evidence suggests that not all whales killed as a result of vessel strike are detected, particularly in offshore waters, and some detected carcasses are never recovered while those that are recovered may be in advanced stages of decomposition that preclude a definitive cause of death determination (Glass et al. 2010). The vast majority of commercial vessel strike mortalities of cetaceans are likely undetected and unreported, as most are likely never reported. Most animals killed by vessel strike likely end up sinking rather than washing up on shore (Cassoff 2011). Kraus et al. (2005) estimated that 17 percent of vessel strikes are actually detected. Therefore, it is likely that the number of documented cetacean mortalities related to vessel strikes is much lower than the actual number of moralities associated with vessel strikes, especially for less buoyant species such as blue, humpback, and fin whales (Rockwood et al. 2017). Rockwood et al. (2017) modeled vessel strike mortalities of blue whales, fin whales, and humpback 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, two, and 2.7 times the recommended limit for blue whale, fin whale, and humpback whale stocks in this area, respectively. In the Northwest Atlantic Ocean, in areas adjacent to the action area, along the North Carolina and Virginia border (south of Northampton, Virginia), unpublished data

from the NMFS Marine Mammal Health and Stranding Response Program show there are four records of vessel strike for fin whales and three records of vessel strike on sei whale.

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. 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 gray whales, humpback whales, North Atlantic right whales, 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 and recreational) and Federal vessel (e.g., military and research), but traffic that is most likely to result in vessel strikes comes from commercial shipping. The latest five-year (2015 through 2019) annual average mortalities and serious injuries related to vessel strikes for ESA-listed marine mammal stocks within U.S. waters likely to be found in the action area and experience adverse effects as a result of the proposed action are given in Table 10 below. These data represent only known human-caused mortalities and serious injuries. It is probable that more undocumented mortalities and serious injuries within the action area have likely occurred.

Table 10. Five-year annual average mortalities and serious injuries related to vessel strikes for Endangered Species Act-listed marine mammals for stocks in the Atlantic Ocean within the action area.

Species	Observed	Estimated
Blue Whale	NA (1 reported in 1998)	NA
Fin Whale	0.4	NA
Sei Whale	0.2	NA
Sperm Whale	NA (4 reported since 1994)	NA

NA=not available.

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. 2010b). All sea turtles must surface to breather 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 four 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. 2010b). 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 vessel strike or vessel speed increases.

9.2.2 Whale Watching

Whale watching is a profitable and rapidly growing business with more than 3,300 operators worldwide, serving 13 million participants in 119 countries and territories, and may increase types of disturbance and negatively affect the species (Hoyt 2001; O'connor et al. 2009). As of 2010, commercial whale watching was a one billion dollar global industry per year (Lambert et al. 2010). Private vessels may partake in this activity as well. NMFS has issued regulations and guidelines relevant to whale watching. As noted previously, many of the cetaceans and pinnipeds considered in this consultation are highly migratory, so may also be exposed to whale watching activity occurring outside of the action area.

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

Several studies have examined the short-term effects of whale watching vessels on marine mammals (Au and Green 2000; Corkeron 1995; Erbe 2002b; Felix 2001; Magalhaes et al. 2002; Richter et al. 2003; Scheidat et al. 2004; Simmonds 2005a; Watkins 1986b; 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 the cumulative time minke whales spent with whale watching boats in Iceland to assess the biological significance of whale watching disturbances and found that, through some whales were repeatedly exposed to whale watching boats throughout the feeding season, the estimated cumulative time they spent with boats was very low. Christiansen et al. (2014) suggested that the whale watching industry, in its current state, is likely not having any long-term negative effects on vital rates.

At least one whale watching (including dolphin and other wildlife) company (H_20 Captain Eco-Tour Boat Excursions) operates out of North Carolina and is certified to operate in the offshore waters. Depending on the client's wishes, it is possible, but unlikely that this whale watching vessel may occur within or near the seismic survey area. Other whale watching vessels that

operate in the region are not expected to venture far offshore due to the vessel size and duration of the tour.

It is difficult to precisely quantify or estimate the magnitude of the risks posed to marine mammals in general from vessel approaches associated with whale watching. The high-energy seismic survey would take place approximately five kilometers (2.7 nautical miles from the 100 meter (328.1 feet) isobaths, 35 kilometers (18.9 nautical miles) from state waters, and 40 kilometers (21.6 nautical miles) from the coast of Cape Hatteras, North Carolina (Figure 1). Given the seismic survey activities would occur in a remote area away from populated areas where whale watching may occur and not occur within approximately 40 kilometers (21.6 nautical miles) of land (coastline of North Carolina), few (if any) whale watching vessels would be expected to co-occur with the proposed action's research vessel.

9.3 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 because of injury or drowning. Non-target species are captured in fisheries (i.e., bycatch), and can represent a significant threat to non-target populations. 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 of marine mammals and sea turtles.

9.3.1 Fisheries Interactions

Globally, 6.4 million tons of fishing gear is lost in the oceans every year (Wilcox et al. 2015). Marine mammal and sea turtle entanglement (bycatch) is a global problem that every year results in the death of hundreds of thousands of animals worldwide. Entrapment and entanglement in fishing gear is a frequently documented source of human-caused mortality in cetaceans (see Dietrich et al. 2007). Materials entangled tightly around a body part may cut into tissues, enable

infection, and severely compromise an individual's health (Derraik 2002). Entanglements also make animals more vulnerable to additional threats (e.g., predation and vessel strikes) by restricting agility and swimming speed. The majority of marine mammals that die from entanglement in fishing gear likely sink at sea rather than strand ashore, making it difficult to accurately determine the extent of such mortalities. In excess of 97 percent of entanglement is caused by derelict fishing gear (Baulch and Perry 2014a). From 2007 through 2020, the Southeast Atlantic coast of the U.S. had the lowest number of large whale entanglements compared to other regions of the U.S. Nevertheless, from 2007 through 2020, the U.S. Southeast Atlantic Ocean had an average of 2.8 large whale entanglement per year. Unpublished entanglement data over the last ten years from the NMFS Marine Mammal Health and Stranding Response Program indicate that two sei whales were found entangled off the coast of North Carolina and Florida and one sperm whale was entangled off the coast of Georgia. It is unconfirmed if all entanglement events were from fishing line as some were unidentified lines, which may be attributed to marine debris.

The latest five-year (2015 through 2019) annual average mortalities and serious injuries related to fisheries interactions for the ESA-listed marine mammals likely to be found in the action area within U.S. waters are given in Table 11 below. Data represent only known human-caused mortalities and serious injuries; more, undocumented mortalities and serious injuries for these and other marine mammals found within the action area have likely occurred.

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

Species	Serious Injury and Mortality
Blue Whale	NA
Fin Whale	1.45
Sei Whale	0.4
Sperm Whale	NA

NA=not available.

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

In addition to these direct impacts, cetaceans may also be subject to indirect impacts from fisheries. Marine mammals probably consume at least as much fish as is harvested by humans (Kenney et al. 1985). Many cetacean species (particularly fin whales) are known to feed on

species of fish that are harvested by humans (Carretta et al. 2016). Thus, competition with humans for prey is a potential concern. Reductions in fish populations, whether natural or human-caused, may affect the survival and recovery of ESA-listed marine mammal populations. Even species that do not directly compete with human fisheries could be indirectly affected by fishing activities through changes in ecosystem dynamics. However, in general the effects of fisheries on marine mammals 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.

Recreational fishing occurs throughout the action area. Commercial and recreational fisheries may impact marine mammals and sea turtles as they migrate through the action area through direct interactions (i.e., incidental take or bycatch) and indirectly through competition for prey resources and other impacts on prey populations.

9.4 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, pollutants and contaminants, and hydrocarbons.

9.4.1 Marine Debris

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

Marine debris affects marine habitats and marine life worldwide, primarily by entangling or choking individuals that encounter it (Gall and Thompson 2015). Entanglement in marine debris can lead to injury, infection, reduced mobility, increased susceptibility to predation, decreased feeding ability, fitness consequences, and mortality for ESA-listed species in the action area. Entanglement can also result in drowning for air breathing marine species including marine mammals. The ingestion of marine debris has been documented to result in blockage or obstruction of the digestive tract, mouth, and stomach lining of various species and can lead to serious internal injury or mortality (Derraik 2002). In addition to interference with alimentary processes, plastics lodged in the alimentary tract could facilitate the transfer of pollutants into the

bodies of whales and dolphins (Derraik 2002). Law et al. (2010) presented a time series of plastic content at the water's 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 Northwest Atlantic Ocean, but we assume similar effects from marine debris documented within other ocean basins could also occur to ESA-listed species from marine debris.

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

Given the limited knowledge about the impacts of marine debris on 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. In 2008, two sperm whales stranded along the coast of California, with an assortment of fishing related debris (e.g., net scraps and rope) and other plastics inside their stomachs (Jacobsen et al. 2010b). One whale was emaciated, and the other had a ruptured stomach. It was suspected that gastric implications was the cause of both deaths. Jacobsen et al. (2010b) speculated the debris likely accumulated over many years, possibly in the North Pacific gyre that would carry derelict Asian fishing gear into the waters of the Eastern Pacific Ocean.

Ingestion of marine debris can be a serious threat to sea turtles. Floating material have been shown to concentrate in ocean gyres and convergence zones where *Sargassum* and consequently juvenile sea turtles are known to occur (Carr 1987). 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 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 turtles 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 sea 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 loggerhead turtles) had ingested plastic marine debris (Pham et al. 2017). Green turtles in their oceanic lifestage 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). Plastic waste in the ocean can leach chemical additives into the water or these additives, such as brominated flame retardants, stabilizers, phthalate esters, biphenyl A, and nonylphenols (Panti et al. 2019). Additionally, plastic waste in the ocean chemically attracts hydrocarbon pollutants such as polychlorinated biphenyl and dichlorodiphenyltrichloroethane. Marine mammals and sea turtles can mistakenly consume these wastes containing elevated levels of toxins instead of their prey. Once consumed, plastics can act as nutritional dilutants in the gut, making the animal feel satiated before it has acquired the necessary amount of nutrients required for general fitness (reviewed in (Machovsky-Capuska et al. 2019)). It is expected that marine mammals and sea turtles may be exposed to marine debris over the course of the proposed actions although the risk of ingestion or entanglement and the resulting impacts are uncertain at the time of this consultation.

9.4.2 Pollutants 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 and sea turtles, such as age, sex and birth order, diet, and locality/habitat use (Mongillo et al. 2012; Muñoz and Vermeiren 2020). 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). Polychlorinated-biphenyls have been found in muscle tissue samples taken from stranded sperm whales in the North Atlantic Ocean (Megson et al. 2022). While exposure to pollutants and other contaminants is likely to continue and occur for marine mammals in the action area through the duration of the seismic survey activities, the level of risk and degree of impact is unknown. Also, for sea turtles, maternal transfer of persistent oraganic pollutants threatens developing embryos with a pollution legacy and poses conservation concerns due to its potential adverse effects on subsequent generations (Muñoz and Vermeiren 2020).

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).

Because persistent organic pollutants are both ubiquitous and persistent in the environment, marine mammals, sea turtles, and other forms of marine life in the action area would continue to

be exposed to persistent organic pollutants for all of their lives. The effects of persistent organic pollutants to ESA-listed species are unknown and not directly studied, but it is possible that the effects could be sub-lethal and long-term in nature, and include impacting reproduction, immune function, and endocrine activity. These effects become more apparent as time goes on.

9.4.3 Hydrocarbons

Hydrocarbons that may pose a threat to ESA-listed marine mammals and sea turtles consist of natural seeps as well as oil spills. Hydrocarbons also have the potential to affect prey populations, and therefore may affect ESA-listed species indirectly by reducing food availability.

Oil spills are accidental and unpredictable events, but are a direct consequence of oil and gas development and production from oil and gas activities as well as from the use of vessels. Oil spills are caused by collisions, groundings, hull failures, equipment failures, fires and explosions, and other events such as weather damage and human error. Oil releases can occur at any number of points during the exploration, development, production, and transport of oil. There are no known oil and gas exploration, development, and production in the action area in the Northwest Atlantic Ocean off North Carolina. Most instances of oil spill are generally small (less than 1,000 barrels), but larger spills occur as well. Over the last two decades, there has not been a large-scale oil spill in the action area, but several small-scale vessel spills have occurred as documented by NOAA's ResponseLink (https://responselink.orr.noaa.gov). For example, on June 4, 2021, the USS *Truxtun* discharged an estimated 35,000 gallons of fuel oil approximately 111.1 kilometers (60 nautical miles) east of Virginia Beach, Virginia. On April 4, 2008, an unknown amount of oil was discharged from the M/V *Mevlut Doven* off Cape Henry, Virginia. On July 15, 1986, an unknown amount of oil was discharged and no identification of the source was evident off Cape Hatteras, North Carolina.

There has never been a large-scale oil spill in the action area, but numerous small-scale vessel spills likely occur. A nationwide study examining vessel oil spills from 2002 through 2006 found that over 1.8 million gallons of oil were spilled from vessels in all U.S. waters (Dalton and Jin 2010). In this study, "vessel" included numerous types of vessels, including barges, tankers, tugboats, and recreational and commercial vessels, demonstrating that the threat of an oil spill can come from a variety of vessel types. The International Tanker Owners Pollution Federation Limited's (ITOPF) tanker spill statistics (2022) provides information on persistent and non-persistent oil spills from tankers since 1970. Globally, the number of oil spills and volume of oil spilled from tankers has significantly decreased over the last few decades. The annual average number of large oil spills per year has decreased by 90 percent from 79 in the 1970's to six in the 2010's and five in the 2020's. The average annual number of medium oil spills has also significantly decreased since 1970; however, the data on small oil spills is not reliable due to lack of reporting. In addition to vessels, oil spills can come from other sources like pipelines, oil industry activities, petroleum usage like "run-off" from roads, rail cars, other land-based sources, and natural seepage, but in this discussion, we focus on spills to water. Below we review the effects of oil spills on marine mammals more generally. Much of what is known comes from

studies of large oil spills such as the *Deepwater Horizon* oil spill since no information exists on the effects of small-scale oil spills within the action area.

Exposure to hydrocarbons released into the environment via oil spills and other discharges pose risks to marine species. Marine mammals and sea turtles 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 (Arienzo 2023; Grant and Ross 2002). Acute exposure of marine mammals to petroleum products causes changes in behavior and may directly injure animals (Geraci 1990). Also, sea turtles may experience serous health and reproductive problems, with toxicity varying between species and largely depending on the route of exposure, sex, and life stage of the organism (Arienzo 2023).

Perhaps one of the most famous oil spills in U.S. history occurred in the Gulf of Alaska when, in 1989 the *Exxon Valdez* released at least 11 million gallons of Alaska crude oil into one of the largest and most productive estuaries in North America. The Alaska Department of Environmental Conservation estimated that 149 kilometers (92.6 miles) of shoreline was heavily oiled and 459 kilometers (285.2 miles) were at least lightly oiled. Oil spills, both small and large, occur widely along U.S. shores at refining and transfer facilities and extraction sites. The *Exxon Valdez* oil spill was the worst in U.S. history until the 2010 *Deepwater Horizon* event.

The *Deepwater Horizon* oil spill in the Gulf of Mexico in 2010 led to the exposure of tens of thousands of marine mammals to oil, causing reproductive failure, adrenal disease, lung disease, and poor body condition.

Cetaceans have a thickened epidermis that greatly reduces the likelihood of petroleum toxicity from skin contact with oils (Geraci 1990), but they may inhale these compounds at the water's surface and ingest them while feeding (Matkin and Saulitis 1997). For example, because 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. Large 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. This estimation of effects to large whales is largely based on observed impacts to bottlenose dolphins resulting from exposure to oil from the *Deepwater Horizon* event. The oil spill from the *Deepwater Horizon* event occurred in deep water, which is sperm whale habitat. The same routes of internal oil exposure (ingestion, inhalation, and aspiration) would have occurred in sperm whales that have been shown to adversely affect bottlenose dolphins in coastal habitat. The surface oil and vapors at the water's surface were more concentrated offshore near the leaking well head that could have exposed sperm whales to high levels of contaminants between dives that were known to have occurred with bottlenose dolphins. Linnehan et al. (2021) concluded that bottlenose dolphins impacted by oil showed evidence of cardiac abnormalities (i.e.,

significantly thinner left ventricular walls, smaller left atria, and higher prevalence of valvular abnormalities) as well as pulmonary hypertension. 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 vapor, 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. Other response activities, including vessel strikes and dredging also resulted in sea turtle deaths.

As noted above, to our knowledge the past and present impacts of oil spills on ESA-listed species (blue whale, fin whale, sei whale, sperm whale, North Atlantic DPS of green turtle, Kemp's ridley turtle, leatherback turtle, and Northwest Atlantic Ocean DPS of loggerhead 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* and *Exxon Valdez* oil spills and small-scale vessel spills, as examples of the possible impacts that oil spill can have on ESA-listed species within the action area. For the Northwest Atlantic Ocean off North Carolina, oil spills from vessels may be comparable to the *Exxon Valdez*, but oil spills from drilling may not be comparable to the *Deepwater Horizon* as no drilling for oil and gas purposes is known to occur in the action area.

9.5 Aquatic Nuisance Species

Aquatic nuisance species are nonindigenous species that threaten the diversity or abundance of native species, the ecological stability of infested waters, or any commercial, agricultural or recreational activities dependent on such waters. Aquatic nuisance species include nonindigenous species that may occur within inland, estuarine, or marine waters and that presently or potentially threaten ecological processes and natural resources. Invasive species have been referred to as one of the top four threats to the world's oceans (Pughiuc 2010; Raaymakers 2003; Raaymakers and Hilliard 2002; Terdalkar et al. 2005). Introduction of these species is cited as a major threat to biodiversity, second only to habitat loss (Wilcove et al. 1998). A variety of vectors are thought to have introduced non-native species including, but not limited to aquarium and pet trades, recreation, and ballast water discharges from ocean-going vessels. Common impacts of invasive species are alteration of habitat and nutrient availability, as well as altering species composition and diversity within an ecosystem (Strayer 2010). Shifts in

the base of food webs, a common result of the introduction of invasive species, can fundamentally alter predator-prey dynamics up and across food chains (Moncheva and Kamburska 2002), potentially affecting prey availability and habitat suitability for ESA-listed species. They have been implicated in the endangerment of 48 percent of ESA-listed species (Czech and Krausman 1997). Currently, there is little information on the level of aquatic nuisance species and the impacts of these invasive species may have on marine mammals and sea turtles in the action area through the duration of the high-energy seismic survey. Therefore, the level of risk and degree of impact to ESA-listed marine mammals and sea turtles is unknown.

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

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

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

Risks associated with oceanic shipping come primarily from hitchhiking species on vessel hulls (fouling) and in ballast water (Drake and Lodge 2007; Keller and Perrings 2011). In general, the introduction of aquatic nuisance species is one of the primary causes decreased biodiversity in an ecosystem (Trombulak et al. 2004). The impact of aquatic nuisance species in marine systems ranges from extirpation of native species through competition or predation, shifts in ecosystem food webs, to changes to the physical structure of the habitat (Norse et al. 2005). Although it is not possible to predict which aquatic nuisance species would arrive and thrive in the Atlantic Ocean, it is reasonably certain that they would be yet another facet of change and potential stress to native biota which may affect either the health or prey base of native fauna.

9.6 Anthropogenic Sound

The ESA-listed species that occur in the action area are regularly exposed to several sources of anthropogenic sounds. These include, but are not limited to maritime activities (vessel sound and commercial shipping), aircraft, seismic surveys (exploration and research), marine construction, and military readiness activities. These activities occur to varying degrees throughout the year. Cetaceans generate and rely on sound to navigate, hunt, avoid predators, and/or communicate with other individuals and anthropogenic sound can interfere with these important activities

(Nowacek et al. 2007). The ESA-listed species have the potential to be impacted by either increased levels of anthropogenic-induced background sound or high intensity, short-term anthropogenic sounds.

The addition of anthropogenic sound to the marine environment is a known stressor that can possibly harm marine animals or significantly interfere with their normal activities (NRC 2005). Within the action area, ESA-listed marine mammals may be impacted by anthropogenic sound in various ways. Responses to sound exposure may include lethal or nonlethal injury, temporary hearing impairment, behavioral harassment and stress, or no apparent response. For example, some sounds may produce a behavioral response, including but not limited to, avoidance of impacted habitat areas affected by irritating sounds, changes in diving behavior, or (for cetaceans) changes in vocalization patterns (MMC 2007).

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

9.6.1 Vessel Sound and Commercial Shipping

Individual vessels produce unique acoustic signatures, although these signatures may change with vessel speed, vessel load, and activities that may be taking place on the vessel. Sound levels are typically higher for the larger and faster vessels. Peak spectral levels for individual

commercial vessels are in the frequency band of 10 to 50 Hz and range from 195 dB re: one μPa^2 second at one meter for fast-moving (greater than 37 kilometers per hour [20 knots]) supertankers to 140 dB re: one μPa^2 second at one meter for smaller vessels (NRC 2003c). Although large vessels emit predominantly low frequency sound, studies report broadband sound from large cargo vessels about two kHz, which may interfere with important biological functions of cetaceans (Holt 2008b). At frequencies below 300 Hz, ambient sound levels are elevated by 15 to 20 dB when exposed to sounds from vessels at a distance (McKenna et al. 2013b).

Much of the increase in sound in the ocean environment over the past several decades is due to increased shipping, as vessels become more numerous and of larger tonnage (Hildebrand 2009b; McKenna et al. 2012; NRC 2003c; NRC 2003b). Commercial shipping continues to be a major source of low-frequency sound in the ocean, particularly in the Northern Hemisphere where the majority of vessel traffic occurs (Hildebrand 2004). Although large vessels emit predominantly low frequency sound, studies report broadband sound from large cargo vessels above two kHz. The low frequency sounds from large vessels overlap with many mysticetes predicted hearing ranges (seven Hz to 35 kHz) (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 2008a). At frequencies below 300 Hz, ambient sound levels are elevated by 15 to 20 dB when exposed to sounds from vessels at a distance (McKenna et al. 2013a). Analysis of sound from vessels revealed that their propulsion systems are a dominant source of radiated underwater sound at frequencies less than 200 Hz (Ross 1976). Additional sources of vessel sound include rotational and reciprocating machinery that produces tones and pulses at a constant rate. Other commercial and recreational vessels also operate within the action area and may produce similar sounds, although to a lesser extent given their much smaller size.

Vessels produce unique acoustic signatures, although these signatures may change with vessel speed, vessel load, and activities that may be taking place on the vessel. Peak spectral levels for individual commercial vessels are in the frequency band of ten to 50 Hz and range from 195 dB re: μPa^2-second at one meter for fast-moving (greater than 37 kilometers per hour [20 knots]) supertankers to 140 dB re: μPa^2-second at one meter for small fishing vessels (NRC 2003b). Small boats with outboard or inboard engines produce sound that is generally highest in the mid-frequency (one to five kHz) range and at moderate (150 to 180 dB re: one µPa at one meter) sound 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 Hz) 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 would help provide a better understanding of current and future impacts of vessel sound on ESA-listed species. NOAA is working cooperatively with the ship building industry to find technologically-based solutions to reduce the amount of sound produced by commercial vessels.

Sonar systems are used on commercial, recreational, and military vessels and may also affect cetaceans (NRC 2003a). The action area may host many of these vessel types during any time of the year. Although little information is available on potential effects of multiple commercial and recreational sonars to ESA-listed marine mammals, 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 on active sonar and anthropogenic sound from military activities on ESA-listed species located within the action area and considered in this consultation, see Sections 9.6.5 and 9.6.6.

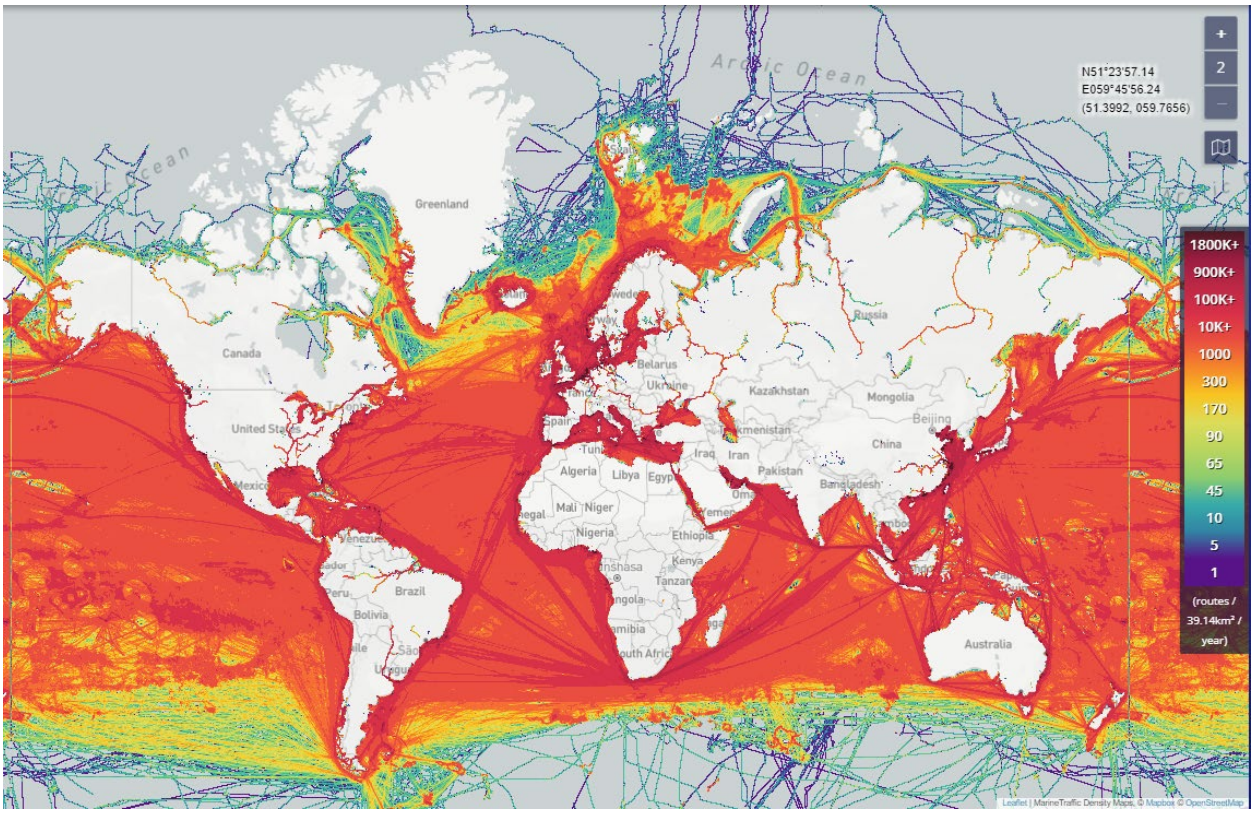

Figure 11. Map of the global vessel traffic density in 2021. Image retrieved from Marine Traffic.

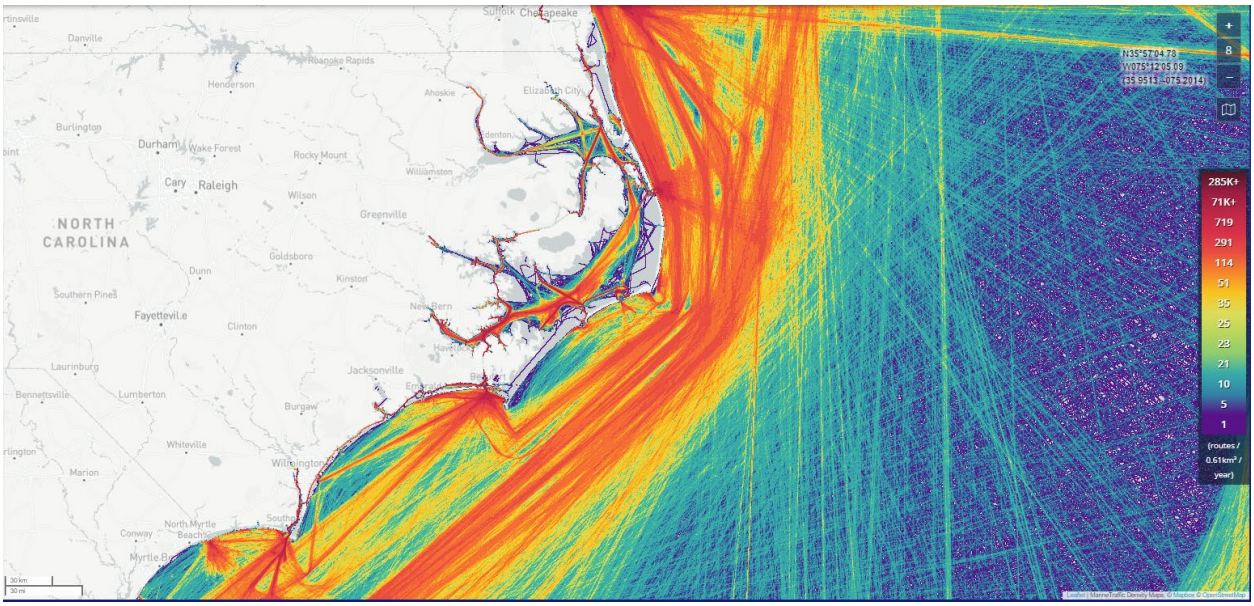

Figure 12. Map of vessel traffic density in the Northwest Atlantic Ocean off North Carolina. Image retrieved from Marine Traffic.

9.6.2 Aircraft

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

9.6.3 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 hydrocarbon deposits, fault structure, and other geological hazards. 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 kHz (Goold and Coates 2006). Seismic airgun noise can propagate substantial distances at low frequencies (e.g., Nieukirk et al. 2004). These activities may produce noise that could affect ESA-listed marine mammals within the action area.

These airgun arrays generate intense low-frequency sound pressure waves capable of penetrating the seafloor and are fired repetitively at intervals of ten to 20 seconds for extended periods (NRC 2003b). Most of the energy from the airguns is directed vertically downward, but significant sound emission also extends horizontally. Peak sound pressure levels from airguns usually reach 235 to 240 dB re: one μPa (rms) at dominant frequencies of five to 300 Hz (NRC 2003a). Most of the sound energy is at frequencies below 500 Hz, which is within the hearing range of baleen whales and sperm whales (Nowacek et al. 2007). In the U.S., seismic surveys involving the use of airguns with the potential to take marine mammals are generally covered by incidental take authorizations under the MMPA, and if they involve ESA-listed species, undergo formal ESA section 7 consultation. In addition, the Bureau of Ocean Energy Management authorizes oil and gas activities in domestic federal waters and the NSF and USGS funds and/or conducts these seismic survey activities in domestic, international, and foreign waters, and in doing so, consults with NMFS to ensure their actions do not jeopardize the continued existence of ESA-listed species or adversely modify or destroy designated critical habitat. More information on the effects of these activities on ESA-listed species, including authorized takes, can be found in recent biological opinions associated with these consultations.

The NSF funded and L-DEO conducted seismic surveys in the Northwest Atlantic Ocean on the R/V *Maurice Ewing* in 200 and R/V *Marcus G. Langseth*, in 2014 through 2015. The NSF plans to fund and L-DEO plans to conduct a high-energy seismic survey in the Northwest Atlantic Ocean on the Blake Plateau on the R/V *Marcus G. Langset*h in 2023. The USGS funded and conducted seismic surveys in the Northwest Atlantic Ocean on the R/V *Marcus G. Langseth* in 2014 through 2015 and R/V *Hugh R. Sharp* in 2018. In 2018, we issued an opinion on the Bureau of Ocean Energy Management's issuance of five oil and gas permits for geological and geophysical seismic surveys off the U.S. coast of the Atlantic Ocean and NMFS Permits Division's issuance of associated IHAs. Presently, no oil and gas development is planned for the Mid-Atlantic Ocean and South Atlantic Ocean region as leasing consideration for waters off North Carolina, South Carolina, Georgia, and Florida were withdrawn. Each of these seismic surveys include a MMPA IHA and each are subject to a separate ESA section 7 consultation. The finalized consultations all resulted in a "no jeopardy" opinion.

9.6.4 Marine Construction

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

9.6.5 Active Sonar

Active sonar emits high-intensity acoustic energy and receives reflected and/or scattered energy. A wide range of sonar systems are in use for both civilian and military applications. The primary sonar characteristics that vary with application are the frequency band, signal type (pulsed or

continuous), rate of repetition, and sound source level. Sonar systems can be divided into categories, depending on their primary frequency of operation; low-frequency for one kHz and less, mid-frequency for one to ten kHz, high-frequency for ten to 100 kHz; and very high-frequency for greater than 100 kHz (Hildebrand 2004). Low-frequency systems are designed for long-range detection (Popper et al. 2014a). The effective sound source level of a low-frequency airgun array, when viewed in the horizontal direction can be 235 dB re: one µPa at one meter or higher (Hildebrand 2004). Signal transmissions are emitted in patterned sequences that may last for days or weeks. Mid-frequency military sonars include tactical anti-submarine warfare sonars, designed to detect submarines over several tens of kilometers, depth sounders, and communication sonars. High-frequency military sonars includes those incorporated into weapons (e.g., torpedoes and mines) or weapon countermeasures (mine countermeasures or anti-torpedo devices), as well as side-scan sonar for seafloor mapping. Commercial sonars are designed for fish finding, depth sounds, and sub-bottom profiling. They typically generate sound at frequencies of three to 200 kHz, with sound source levels ranging from 150 to 235 dB re: one µPa at one meter (Hildebrand 2004). Depth sounders and sub-bottom profilers are operated primarily in nearshore and shallow environments; however, fish finders are operated in both deep and shallow areas.

9.6.6 Military Activities

Many researchers have described behavioral responses of marine mammals to the sounds produced by helicopters and fixed-wing aircraft, boats and ships, as well as dredging, construction, geological explorations, etc. (Richardson et al. 1995d). Most observations have been limited to short-term behavioral responses, which included cessation of feeding, resting, or social interactions. Smultea et al. (2008b) documented a recognized “stress behavioral reaction” by a group of sperm whales in response to small aircraft fly-bys. The group ceased forward movement, moved closer together in a parallel flank-to-flank formation, and formed a fan-shaped semi-circle with the lone calf remaining near the middle of the group. In-air noise levels from aircraft can be problematic for marine life, and that sound can also extend into water.

Within the action area, multiple stressors associated with military activities pose a threat to ESA-listed marine mammals and sea turtles. 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 Atlantic Fleet Training and Testing range complex overlaps with the action area for the NSF and L-DEO’s high-energy 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 and research activities the U.S. Navy conducts in the action area are similar, if not identical to activities that have been occurring in the same locations for decades; therefore, the ESA-listed species located in the action area have been exposed to these military activities often and repeatedly.

The U.S. Navy's activities produce sound and visual disturbance to marine mammals 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 lower energy expenditures to traveling, avoidance, and behavioral states that require higher energy expenditures. Based on the currently available scientific information, behavioral responses that result from stressors associated with these training and testing and research activities are expected to be temporary and would not affect the reproduction, survival, or recovery of these species. Sound (in-air and in-water) produced during U.S. Navy activities is also expected to result in instances of PTS, TTS, and behavioral harassment to marine mammals and sea turtles. The U.S. Navy's activities constitute a federal action and take of ESA-listed marine mammals, sea turtles, and designated critical habitat considered for these activities have previously undergone separate ESA section 7 consultation. Through these consultations with NMFS, the U.S. Navy has implemented monitoring and conservation measures to reduce the potential effects of in-air and underwater sound from activities on ESA-listed species in the Atlantic Ocean. Conservation measures include employing visual observers and implementing minimization zones during activities using active sonar and explosives.

9.7 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 Northwest Atlantic Ocean, some of which extend into portions of the action area for the proposed actions. 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 surveys, vessel surveys, close approaches, photography, videography, behavioral observations, active acoustics (i.e., auditory evoked potentials, playbacks, , prey mapping, and remote ultrasound), passive acoustic monitoring, biological sampling (i.e., biopsy sampling, breath sampling, fecal sampling, and sloughed skin sampling), and tagging. Research activities generally involve non-lethal "takes" of these marine mammals.

Authorized research on ESA-listed sea turtles includes aerial surveys, vessel surveys, close approaches, active acoustics, capture, handling, holding, restraint, and transportation, tagging, shell and chemical marking, biological sampling (i.e., biopsy, blood and tissue collection, tear, fecal and urine, and lavage), drilling, pills, imaging, ultrasound, antibiotic (tetracycline) injections, captive experiments, laparoscopy, and mortality. Most recent 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 all over the world, including for research activities in the action area. The consultations that took place on the issuance of these ESA scientific research permits each found that the authorized research activities would 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 in the Effects of the Action 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 would occur in the near term. However, our analysis assumes that these "takes" would occur since they have been authorized. It is also noteworthy that these "takes" are distributed across the Atlantic Ocean. Although marine mammals are generally wide-ranging, we do not expect many of the authorized "takes" to involve individuals that would also be "taken" under the proposed high-energy seismic survey and research activities.

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

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

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

We consider the best indicator of the aggregate impact of the Environmental Baseline on ESA-listed resources to be the status and trends of those species. As noted in Section 8, some of the species considered in this consultation are experiencing increases in population abundance, some are declining, and for others, their status remains unknown. Taken together, this indicates that the activities identified in the Environmental Baseline are affecting 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 Species Likely to be Adversely Affected (Section 8) of this consultation and what this means for the populations is discussed in the Integration and Synthesis (Section 12).

10 EFFECTS OF THE ACTIONS

Section 7 regulations define "effects of the action" as all consequences to ESA-listed species or critical habitat that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action (50 C.F.R. §402.02). This effects analyses section is organized following the stressor, exposure, response, and risk assessment framework described in Section 2.

In this section, we further describe the potential stressors associated with the proposed actions, the probability of individuals of ESA-listed species being exposed to acoustic noise from the airgun array based on the best scientific and commercial evidence available, and the probable responses of those individuals (given their probable exposures) based on the available evidence. As described in Section 10.3, for any responses that would be expected to reduce an individual's fitness (i.e., growth, survival, annual reproductive success, or lifetime reproductive success), the assessment would consider the risk posed to the viability of the population(s) those individuals comprise and to the ESA-listed species those populations represent. For this consultation, we are particularly concerned about behavioral and stress-related physiological disruptions and potential unintentional mortality that may result in animals that fail to feed, reproduce, or survive because these responses are likely to have population-level consequences. The purpose of this assessment and, ultimately, of this consultation is to determine if it is reasonable to expect the proposed action to have effects on ESA-listed species that could appreciably reduce their likelihood of surviving and recovering in the wild.

10.1 Stressors Remaining to be Considered

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 IHA would 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 actions are:

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

Based on a review of available information, during consultation we determined which of these possible stressors would be reasonably certain to occur and which would be insignificant or discountable effects to the species and habitats affected by these activities. These species and habitats were discussed in Section 7.

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

10.2 Conservation Measures to Avoid or Minimize Exposure

As described in the Description of the Proposed Actions (Section 3), the NSF and L-DEO's proposed action and NMFS Permits Division's proposed IHA and possible renewal requires conservation measures that includes the use of shutdown and buffer zones, shutdown procedures, pre-start clearance and ramp-up procedures, vessel-based visual monitoring with NMFS-approved PSOs, passive acoustic monitoring, vessel strike avoidance measures, seasonal restrictions, and additional conservation measures considered in the presence of ESA-listed species to avoid or minimize exposure. The NMFS Permits Division's proposed IHA and possible renewal would contain additional conservation measures to minimize or avoid exposure that are described in Appendix A (Section 18).

Also, the NSF and L-DEO would use a 500 meter (1,640.4 feet) shutdown zone for the 18 airgun array as the shutdown distance for marine mammals (cetaceans). A 150 meter (492.1 feet) shutdown zone would be used as the shutdown distance for sea turtles. If a marine mammal (cetacean) or sea turtle is detected in or about to enter the shutdown zone, the airgun array would be shutdown (i.e., shut off) immediately.

10.3 Exposure Analysis

Exposure analyses identify the ESA-listed species that are likely to co-occur with the action's physical, chemical, and biological alterations of 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. Although there are multiple

acoustic and non-acoustic stressors associated with the proposed actions, the stressor of primary concern is the acoustic impacts of the airgun array.

In this section, we quantify the likely exposure of ESA-listed species to sound from the airgun array. For this consultation, the NSF, in collaboration with us, estimated exposure to the sounds from the airgun array that would result in take, as defined under the ESA, for ESA-listed species of marine mammals and sea turtles.

Take is defined as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct" (16 U.S.C. §1532(19)). Harm is defined by regulation (50 C.F.R. §222.102) as "an act which actually kills or injures fish or wildlife. Such an act may include significant habitat modification or degradation which actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including, breeding, spawning, rearing, migrating, feeding, or sheltering." NMFS does not have a regulatory definition of "harass." However, on December 21, 2016, NMFS issued interim guidance on the term "harass," defining it as to "create the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to breeding, feeding, or sheltering."

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. Some of these types of harassment may stem from TTS. However, exposure estimates do not differentiate behavioral response versus TTS, nor do they provide information regarding the potential fitness or biological consequences of the responses on the affected individuals. In the following sections we consider the best available scientific evidence to determine the likely nature of these behavioral responses their potential fitness consequences in accordance with the definitions of "take" related to harm or harass for ESA-listed species.

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

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

10.3.1 Estimates of Acoustic Exposure from the Airgun Array for Endangered Species Act-Listed Marine Mammals

As discussed in the Species Likely to be Adversely Affected (Section 8), there are four ESA-listed marine mammal species that are likely to be adversely affected by the proposed actions: blue whales, fin whales, sei whales, and sperm whales.

The NSF and L-DEO provided an estimate of the number of marine mammals that would be exposed to levels of sound in which they should broadly be considered "taken" during the high-energy seismic survey. We used the same values to determine the type and extent of take. An estimate of the number of marine mammals that would be exposed to sounds from the airgun array is also included in the NSF's draft environmental assessment/analysis.

During the development of the IHA, the NMFS Permits Division conducted an independent exposure analysis that is usually informed by comments received during the public comment period that was required on the proposed IHA. The exposure analysis does not include estimates of the number of ESA-listed marine mammals likely to be exposed to received levels at harm thresholds due to the small ensonified areas and the anticipated effectiveness of conservation measures (i.e., shutdown and buffer zones, shutdown procedures, pre-start clearance and ramp-up procedures, vessel-based visual monitoring by NMFS-approved PSOs, passive acoustic monitoring, vessel strike avoidance measures, seasonal restrictions, and additional conservation measures).

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

10.3.1.1 Marine Mammal Occurrence – Density Estimates

The blue whale, fin whale, sei whale, and sperm whale are the ESA-listed species likely to co-occur with the seismic survey activities . Blue whales, fin whales, and sei whales are classified in the low-frequency hearing group. Sperm whales are classified in the mid-frequency hearing group (NOAA 2018).

We reviewed available cetacean densities and group dynamics with the NSF, L-DEO, and the NMFS Permits Division and agreed upon which densities constituted the best available scientific

information for each ESA-listed marine mammal species. We have adopted these for our ESA exposure analysis.

NSF and L-DEO utilized estimates of marine mammal densities in the action area. NMFS Permits Division concurred with these data. The NSF and L-DEO used habitat-based stratified marine mammal densities for the North Atlantic Ocean for the U.S. Navy Atlantic Fleet Testing and Training Area from (Roberts et al. 2022). The habitat-based density models were produced by the Duke University Marine Geospatial Ecology Laboratory and represent the best available information regarding marine mammal densities in the seismic survey area. The density data from (Roberts et al. 2022) incorporates aerial and vessel line-transect survey data from NMFS and other organizations and incorporates data from eight physiographic and 16 dynamic oceanographic and biological covariates, and controls for the influence of sea state, group size, availability bias, and perception bias on the probability of making a sighting. These density models were originally developed for all taxa of cetaceans in the U.S. Atlantic Ocean in 2016 and in subsequent years certain models have been updated based on additional data as well as certain methodological improvements. More information is available online at: https://seamap.env.duke.edu/models/Duke/EC/. The habitat-based density models consisted of five kilometers (2.7 nautical miles) by five kilometers (2.7 nautical miles) grid cells. Average densities in the grid cells (e.g., rasters) for the U.S. Navy Atlantic Fleet Testing and Training Area overlapping the seismic survey area (plus a 40 kilometer [21.6 nautical mile] buffer) were averaged for each species for each of two water depth categories (intermediate and deep water depths) to determine monthly mean density values for each species. The highest mean monthly density was chosen for each species from the months of May through October.

Data sources and density calculations are described in detail in the NSF's draft environmental assessment/analysis (LGL 2022) and L-DEO's IHA application (LGL 2022). There is uncertainty about the representativeness of the density data and the assumptions used to estimate exposures. For some marine mammal species, the densities derived from past surveys may not be precisely representative of the densities that would be encountered during the seismic surveys activities. Density estimates for each marine mammal species are found in Table 12. The approach used here is based on the best available data.

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 seismic survey area along with the expected seasonal density of animals in the area (Table 12). Summing exposures along all of the tracklines yields the total exposures for each species for the proposed actions of the 18 airgun array configuration for the seismic survey activities. Requested takes for some ESA-listed species (e.g., blue whale) were also increased to mean group size.

Table 12. Densities of Endangered Species Act-listed marine mammals in the action area during National Science Foundation and Lamont-Doherty Earth Observatory's high-energy seismic survey in the Northwest Atlantic Ocean off North Carolina and National Marine Fisheries Service Permits Division's proposed issuance of an incidental harassment authorization and possible renewal.

Species	Season (Month of Highest Density during May through October for Intermediate/Deep Water Depths)	Density – Intermediate Water Depths (Individuals per km^2)	Density – Deep Water Depths (Individuals per km^2)
Blue Whale	Same Each Month	0.0000124000	0.0000150000
Fin Whale	May/May	0.0000935000	0.0000767000
Sei Whale	October/October	00001462270	0.0001743590
Sperm Whale	June/May	0.0010799300	0.0099250940

km^2=square kilometers.

10.3.1.2 Total Ensonified Area for Endangered Species Act-Listed Marine Mammals

The high-energy seismic survey would consist of approximately 6,083 kilometers (3,284.6 nautical miles) tracklines in the Northwest Atlantic Ocean off North Carolina. The daily ensonified area (for the 160 dB re: one µPa [rms] harassment threshold identified in our ESA acoustic guidance (NOAA 2018) is estimated to be approximately 217.9 square kilometers (63.5 square nautical miles) for intermediate water depths, and 1,146.1 square kilometers (334.1 square nautical miles) for deep water depths.

This was calculated by using the radial distances from the airgun array to the predicted isopleths corresponding to the 160 dB re: one µPa (rms) threshold, along a planned trackline that would be surveyed in one day (approximately 218 kilometers [117.7 nautical miles]) and is similar in proportion of water depths surveyed to the entire survey. The daily ensonified area is then multiplied by the total number of survey days (28). The product is then multiplied by 1.25 to account for the additional 25 percent contingency (e.g., potential delays) to allow for additional airgun array operations such as testing of the sound source or re-surveying tracklines with poor data quality. This also considers uncertainties in the density estimates used to estimate take.

This results in an estimate of the total area (square kilometers) expected to be ensonified to the ESA harm and harassment thresholds. The total area ensonified at 160 dB re: one µPa (rms) is 7,626.5 square kilometers (2,223.5 square nautical miles) and 40,113.5 square kilometers (11,695.2 square nautical miles) for intermediate and deep waters, respectively when accounting for overlap and using endcaps (Table 13).

Table 13. Relevant isopleths, trackline distance, ensonified area, number of survey days, percent increase, and total ensonified areas during the National Science Foundation and Lamont-Doherty Earth Observatory's high-energy seismic survey in the Northwest Atlantic Ocean off North Carolina and National Marine Fisheries Service Permits Division's proposed issuance of an incidental harassment authorization and possible renewal.

Criteria (Water Depth)	Distance to 160 dB re: one µPa (rms) (km)	Diameter (km)	Daily Trackline Distance (km)	Daily Ensonified Area (km^2)*	Survey Days	Ensonified Area (km^2)	Total Ensonified Area with 25 Percent Increase (km^2)*
Sound Source – 18 Airgun Array							
160 dB re: one µPa (rms) (greater than 1,000 m)	2.886	5.772	196.46	1,146.1	28	32,090.8	40,113.5
160 dB re: one µPa (rms) (100 to 1,000 m)	4.329	8.658	21.54	217.9	28	6,101.2	7,626.5

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

In addition to the ensonified area noted above, based on the small anticipated isopleths for ESA harm and in consideration of the conservation measures, we do not expect take in the form of harm. The estimated exposure of ESA-listed marine mammals at the ESA harassment threshold during the NSF and L-DEO's high-energy seismic survey on the R/V *Marcus G. Langseth* in the Northwest Atlantic Ocean off North Carolina can be found in Table 22. The approach assumes that no blue whales, fin whales, sei whales, and sperm whales, would 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. The extent to which marine mammals would move away from the sound source is difficult to quantify and is, therefore, not accounted for in the take estimates.

10.3.1.3 Marine Mammal Exposures as a Percentage of the Population

Blue whales, fin whales, sei whales, and sperm whales of all age classes are likely to be exposed during the seismic survey activities. Given that the high-energy seismic survey would be conducted in spring or summer (May through September), we expect that most animals would be on or migrating to/from their feeding grounds. Blue whales, fin whales, sei whales, and sperm whales are expected to be feeding, traveling, or migrating in the action area and some females may have young-of-the-year accompanying them. Mature male sperm whales are generally solitary and expected to be further north in the higher latitudes (poleward of about 40 to 50 degrees latitude) of their range in the Atlantic Ocean. Therefore, we expect a juvenile male and female bias to sperm whale exposure. For blue whales, fin whales, sei whales, and sperm whales, these individuals can be exposed to the seismic survey activities while they are transiting through the action area. We would normally assume that sex distribution is even for blue whales, fin whales, sei whales, and sexes are exposed at a relatively equal level.

It should be noted that the exposure numbers are expected to be conservative for several reasons. First, estimated exposure was increased by 25 percent, in the form of the ensonified area over the operational seismic survey days, therefore increasing the total ensonified area. This is based on past experience that accounts for the possibility of additional seismic survey activities associated with airgun array testing and repeat coverage of any areas where initial data quality is sub-standard, and in recognition of the uncertainties in the density estimates used to estimate exposures as described above. Additionally, marine mammals would be expected to move away from a loud sound source that represents an aversive stimulus, such as an airgun array, potentially reducing the number of exposures. However, the extent to which marine mammals (blue whales, fin whales, sei whales, and sperm whales) would move away from the sound source is difficult to quantify and is not accounted for in the exposure estimates. Due to the range of each of these species compared to the relatively small size of the action area and the relatively short duration of the seismic survey activities, the potential for exposure is reduced.

The population abundance estimates of marine mammal species (i.e., blue whale, fin whale, sei whale, and sperm whale) considered in this consultation represent the total number of individuals that make up a given stock or the total number estimated within a particular study or survey area. NMFS' stock abundance estimates for most species represent the total estimate of individuals within the geographic area, if known, that comprises the stock. For most species of marine mammals, stock abundance estimates are based on sightings within the U.S. Exclusive Economic Zone, however for some species, this geographic area may extend beyond U.S. waters. Survey abundance estimates may be used for other species. All managed stocks in this region are assessed in NMFS' U.S. Atlantic stock assessment reports (Hayes et al. 2020; Hayes et al. 2021; Hayes et al. 2022). The percentage of exposure for each ESA-listed species of marine mammal in the action area is summarized below.

Blue Whale – The estimated exposure of the Western North Atlantic stock (approximately 402 individuals) of blue whales is one animal, which is approximately 0.25 percent of the stock or

regional population. For reasons previously described, this estimate is conservative, that is, it is likely higher than the actual exposures and a fewer number are not likely to be exposed given the conservation and monitoring measures that will be implemented or that the same animal may be exposed multiple times, resulting in effects to fewer individuals. Because of the large range of this species compared to the relatively small size of the NSF and L-DEO's action area, combined with the relatively short duration of the seismic survey activities, it is more likely that there will be multiple exposures of a smaller number of individuals that will occur within the action area.

Fin Whale – The estimated exposure of the Western North Atlantic stock (approximately 6,802 individuals) of fin whales is four animals, which is approximately 0.06 percent of the stock or regional population. For reasons previously described, this estimate is conservative, that is, it is likely higher than the actual exposures and a fewer number are not likely to be exposed given the conservation and monitoring measures that will be implemented or that the same animal may be exposed multiple times, resulting in effects to fewer individuals. Because of the large range of this species compared to the relatively small size of the NSF and L-DEO's action area, combined with the relatively short duration of the seismic survey activities, it is more likely that there will be multiple exposures of a smaller number of individuals that will occur within the action area.

Sei Whale – The estimated exposure of the Nova Scotia (formerly Western North Atlantic) stock (approximately 6,292 individuals) of sei whales is eight animals, which is approximately 0.13 percent of the stock or regional population. For reasons previously described, this estimate is conservative, that is, it is likely higher than the actual exposures and a fewer number are not likely to be exposed given the conservation and monitoring measures that will be implemented or that the same animal may be exposed multiple times, resulting in effects to fewer individuals. Because of the large range of this species compared to the relatively small size of the NSF and L-DEO's action area, combined with the relatively short duration of the seismic survey activities, it is more likely that there will be multiple exposures of a smaller number of individuals that will occur within the action area.

Sperm Whale – The estimated exposure of the regional population (approximately 4,349 individuals) of sperm whales is 406 animals, which is approximately 9.34 percent of the stock or regional population. For reasons previously described, this estimate is conservative, that is, it is likely higher than the actual exposures and a fewer number are likely to be exposed given the conservation and monitoring measures that will be implemented or that the same animal may be exposed multiple times, resulting in effects to fewer individuals. Because of the large range of this species compared to the relatively small size of the NSF and L-DEO's action area, combined with the relatively short duration of the seismic survey activities, it is more likely that there may be multiple exposures of a smaller number of individuals that will occur within the action area.

10.3.2 Estimates of Acoustic Exposure from the Airgun Array for Endangered Species Act-Listed Sea Turtles

As discussed in the Status of Species Likely to be Adversely Affected (Section 8), there are four ESA-listed sea turtle species that are likely to be adversely affected by the proposed actions: the

North Atlantic DPS of green turtle, Kemp's ridley turtle, leatherback turtle, and the Northwest Atlantic Ocean DPS of loggerhead turtle.

The NSF and L-DEO provided an estimate of the number of sea turtles that would be exposed to levels of sound in which they should broadly be considered "taken" during the high-energy seismic survey.

We used the same values to determine the type and extent of take. An estimate of the number of sea turtles that would be exposed to sounds from the airgun array is also included in the NSF's draft environmental assessment/analysis.

In this section, we describe the NSF, L-DEO, and our analytical methods to estimate the number of ESA-listed sea turtle species that might be exposed to the sound field.

10.3.2.1 Sea Turtle Occurrence – Density Estimates

Of the five species of sea turtles that have the reasonable potential to co-occur with the seismic survey activities, the North Atlantic DPS of green turtle, Kemp's ridley turtle, leatherback turtle, and Northwest Atlantic Ocean DPS of loggerhead turtle, are likely to be adversely affected by the high-energy seismic survey.

We reviewed available sea turtle densities with the NSF and L-DEO and agreed upon which densities constituted the best available scientific information for each ESA-listed sea turtle species. We have adopted them for our exposure analysis.

Densities for pelagic-stage sea turtle were derived from outputs of the model described in (Putman et al. 2020). The model was used to estimate the mean daily abundance of the North Atlantic DPS of green turtle, Kemp's ridley turtle, and the Northwest Atlantic Ocean DPS of loggerhead turtles within the seismic survey area in May through October for the years 2010 through 2017. Sea turtle densities in intermediate and deep water were then calculated by dividing the abundance by the extent of the proposed seismic survey area in each water-depth category. Densities for leatherback turtle were derived from those reported in the southeast Florida current (Bovery and Wyneken 2015). Table 14 shows the estimated densities for the North Atlantic DPS of green turtle, Kemp's ridley turtle, leatherback turtle, and Northwest Atlantic Ocean DPS of loggerhead turtle.

Data sources and density calculations are described in detail in the NSF and L-DEO's environmental assessment/analysis. There is uncertainty about the representativeness of the density data and the assumptions used to estimate exposures. For some sea turtle species, the densities derived from past surveys may not be precisely representative of the densities that would be encountered during the seismic surveys activities. Density estimates for each sea turtle species are found in Table 14. The approach used here is based on the best available data.

Table 14. Densities of Endangered Species Act-listed sea turtles in the action area during National Science Foundation and Lamont-Doherty Earth Observatory's high-energy seismic survey in the Northwest Atlantic Ocean off North Carolina.

Species	Season (Month of Highest Density during May through October for Intermediate/Deep Water Depths)	Density – Intermediate Water Depths (Individuals per km^2)	Density – Deep Water Depths (Individuals per km^2)
Green Turtle – North Atlantic DPS	NA	0.094135614	0.019301854
Kemp's Ridley Turtle	NA	0.001099572	0.000179786
Leatherback Turtle	NA	0.000180000	0.000180000
Loggerhead Turtle – Northwest Atlantic Ocean DPS	NA	0.634819792	0.049096035

km^2=square kilometers.

10.3.2.2 Total Ensonified Area for Endangered Species Act-Listed Sea Turtles

The high-energy seismic survey would consist of approximately 6,083 kilometers (3,284.6 nautical miles) tracklines in the Northwest Atlantic Ocean off North Carolina. The daily ensonified area (for the 175 dB re: one µPa [rms] threshold) is estimated to be approximately 40.5 square kilometers (11.8 square nautical miles) for intermediate water depths, and 238.7 square kilometers (69.6 square nautical miles) for deep water depths.

This was calculated by using the radial distances from the airgun array to the predicted isopleths corresponding to the 175 dB re: one µPa (rms) threshold, along a planned trackline that would be surveyed in one day (approximately 218 kilometers [117.7 nautical miles]) and is similar in proportion of water depths surveyed to the entire survey. The daily ensonified area is then multiplied by the total number of survey days. The product is then multiplied by 1.25 to account for the additional 25 percent contingency (e.g., potential delays) to allow for additional airgun array operations such as testing of the sound source or re-surveying tracklines with poor data quality. This also considers uncertainties in the density estimates used to estimate take.

This results in an estimate of the total area (square kilometers) expected to be ensonified to the ESA harassment threshold. The total area ensonified at 175 dB re: one µPa (rms) is 1,417.5 square kilometers (413.3 square nautical miles) and 8,354.5 square kilometers (2,435.8 square nautical miles) for intermediate and deep waters, respectively when accounting for overlap and using endcaps (Table 15).

Table 15. Relevant isopleths, trackline distance, ensonified area, percent increase, and total ensonified areas during the National Science Foundation and Lamont-Doherty Earth Observatory's high-energy seismic survey in the Northwest Atlantic Ocean off North Carolina.

Criteria (Water Depth)	Distance to 175 dB re: one µPa (rms) (km)	Diameter (km)	Daily Trackline Distance (km)	Daily Ensonified Area (km^2)*	Survey Days	Ensonified Area (km^2)	Total Ensonified Area with 25% Increase (km^2)*
Sound Source – 18 Airgun Array							
175 dB re: one µPa (rms) (Greater than 1,000 m)	0.606	1.212	196.46	238.7	28	6,683.6	8,354.5
175 dB re: one µPa (rms) (100 to 1,000 m)	0.909	1.818	21.54	40.5	28	1,134.0	1,417.5

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

In addition to the ensonified area noted above, based on the small anticipated isopleths for ESA harm (in this case considered to be received sound levels exceeding the sea turtle threshold for PTS) and in consideration of the conservation measures (i.e., shutdown and buffer zones, shutdown procedures, pre-start clearance and ramp-up procedures, vessel-based visual monitoring by NMFS-approved PSOs, vessel strike avoidance measures, seasonal restrictions, and additional conservation measures), we do not expect take in the form of harm. The estimated exposure of ESA-listed sea turtles at the ESA harassment threshold during the NSF and L-DEO's high-energy seismic survey on the R/V *Marcus G. Langseth* in the Northwest Atlantic Ocean off North Carolina can be found in Table 28. The approach assumes that no sea turtles 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. The extent to which sea turtles will move away from the sound source is difficult to quantify and is, therefore, not accounted for in the exposure estimates.

10.3.2.3 Sea Turtle Exposures as a Percentage of the Population

Adults, juveniles, and post-hatchlings North Atlantic DPS of green turtles, Kemp's ridley turtles, leatherback turtles, and Northwest Atlantic Ocean DPS of loggerhead turtles are likely to be exposed during the seismic survey activities. Given that the high-energy seismic survey would be conducted in spring or summer, we expect that most animals would be nesting or foraging. All sea turtle species are expected to be feeding, traveling, or migrating in the action area and some females may move closer to shore to nest. Because the seismic survey area is further offshore and away from nesting beaches, we would assume that sex distribution is skewed toward more females for North Atlantic DPS of green turtles, Kemp's ridley turtles, leatherback turtles, and Northwest Atlantic Ocean DPS of loggerhead turtles as most males would be near nesting beaches and about half the females would have stayed further offshore, and females are exposed at a higher level.

It should be noted that the exposure numbers are expected to be conservative for several reasons. First, estimated exposure was increased by 25 percent, in the form of the ensonified area over the operational seismic survey days, therefore increasing the total ensonified area. Thisis based on past experience that accounts for the possibility of additional seismic survey activities associated with airgun array testing and repeat coverage of any areas where initial data quality is sub-standard, and in recognition of the uncertainties in the density estimates used to estimate exposures as described above. Additionally, sea turtles would be expected to move away from a loud sound source that represents an aversive stimulus, such as an airgun array, potentially reducing the number of exposures. However, the extent to which sea turtles (North Atlantic DPS of green turtles, Kemp's ridley turtles, leatherback turtles, and Northwest Atlantic Ocean DPS of loggerhead turtles) would move away from the sound source is difficult to quantify and is not accounted for in the exposure estimates. Due to the range of each of these species compared to the relatively small size of the action area and the relatively short duration of the seismic survey activities, the potential for exposure is reduced.

It should be noted that the number of exposures presented in Table 28 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 acoustic threshold. While the exposures in Table 28 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 28 likely represent individual animals. As for the duration of each instances of exposure estimated in Table 28, 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 28 are expected to less than a single day due to the movement of the research vessel and animals.

Green Turtle – North Atlantic DPS – The estimated exposure of the North Atlantic DPS (population abundance unknown) of green turtle is 251 individuals, which is an unknown percentage of the regional population. For reasons previously described, this estimate is conservative, that is, it is likely higher than the actual exposures and a fewer number are not likely to be exposed given the conservation and monitoring measures that will be implemented. Because of the large range of this species compared to the relatively small size of the NSF and L-DEO's action area, combined with the relatively short duration of the seismic survey activities, it is more likely that there will be multiple exposures of a smaller number of individuals that will occur in the action area.

Kemp's Ridley Turtle – The estimated exposure of Kemp's ridley turtles (regional population abundance unknown) is two individuals, which is an unknown percentage of the regional population. For reasons previously described, this estimate is conservative, that is, it is likely higher than the actual exposures and a fewer number are not likely to be exposed given the conservation and monitoring measures that will be implemented. Because of the large range of this species compared to the relatively small size of the NSF and L-DEO's action area, combined with the relatively short duration of the seismic survey activities, it is more likely that there will be multiple exposures of a smaller number of individuals that will occur in the action area.

Leatherback Turtle – The estimated exposure of leatherback turtles (regional population abundance unknown) is two individuals, which is an unknown percentage of the regional population. For reasons previously described, this estimate is conservative, that is, it is likely higher than the actual exposures and a fewer number are not likely to be exposed given the conservation and monitoring measures that will be implemented. Because of the large range of this species compared to the relatively small size of the NSF and L-DEO's action area, combined with the relatively short duration of the seismic survey activities, it is more likely that there will be multiple exposures of a smaller number of individuals that will occur in the action area.

Loggerhead Turtle – Northwest Atlantic Ocean DPS – The estimated exposure of the Northwest Atlantic Ocean DPS (population abundance unknown) of loggerhead turtle is 1,047 individuals, which is an unknown percentage of the regional population. For reasons previously described, this estimate is conservative, that is, it is likely higher than the actual exposures and a fewer number are not likely to be exposed given the conservation and monitoring measures that will be implemented. Because of the large range of this species compared to the relatively small size of the NSF and L-DEO's action area, combined with the relatively short duration of the seismic survey activities, it is more likely that there will be multiple exposures of a smaller number of individuals that will occur in the action area.

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

The response analysis evaluates the available evidence to determine how individuals of those ESA-listed species are likely to respond given their probable exposure. The response analysis

also considers information on the potential effects on the prey of ESA-listed marine mammals and sea turtles that are likely to be adversely affected in the action area.

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 consultation. Possible responses considered in this analysis consist of:

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

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

During the proposed actions, ESA-listed marine mammals and sea turtles may be exposed to sound from the airgun array. The NSF, L-DEO, and NMFS Permits Division (for marine mammals) provided estimates of the expected number of ESA-listed marine mammals and sea turtles exposed to received levels greater than or equal to 160 dB re: one µPa (rms) for marine mammals, and received levels greater than or equal to 175 dB re: one µPa (rms) for sea turtles, for the airgun array sound source. Based upon information presented in the response analysis, ESA-listed marine mammals and sea turtles exposed to these sound sources could be harmed, exhibit changes in behavior, suffer stress, or even strand.

In consideration of the received sound levels in the nearfield, we expect the potential for ESA harm of low-frequency cetaceans (blue whales, fin whales, and sei whales) mid-frequency cetaceans (sperm whales) and sea turtles (North Atlantic DPS of green turtle, Kemp's ridley turtle, leatherback turtle, and Northwest Atlantic Ocean DPS of loggerhead turtle) to be de minimis, even before the likely moderating effects of aversion and/or other compensatory behaviors (e.g., Nachtigall et al. 2018) are considered. Based on the small anticipated isopleths for ESA harm and in consideration of the conservation and monitoring measures, take by ESA harm is not expected to occur.

We rely on acoustic thresholds to determine sound levels at which marine mammals and sea turtles are expected to exhibit a response that may be considered take under the ESA such as harassment, then utilize these thresholds to calculate ensonified areas, and finally, multiply these areas by data on species density to estimate the number of marine mammals and sea turtles

exposed to sounds generated by the airgun array that are likely to result in adverse effects to the animals.

We evaluated both the NSF and L-DEO's (and the NMFS Permit Division for marine mammal species) exposure estimates of the number of ESA-listed marine mammals and sea turtles that will be "taken."

Generally, we estimate "take" by considering:

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

For sea turtles, take is relative to the 175 dB re: one μPa (rms) threshold, which is the standard established by NOAA's acoustic guidance (NOAA 2018). We estimate "take" by considering:

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

As discussed in more detail below, depending on the severity of TTS, there could potentially be injury (i.e., tissue damage) to marine mammals and sea turtles (Houser 2021). If this is the case, the type of ESA "take" for those instances of TTS resulting in injury would be reclassified as "harm" instead of "harassment." However, at this time, we do not have sufficient information to determine whether (or at what level) TTS with injury is occurring as a result of the proposed actions. It is believed that no ESA harm or PTS would be incurred in these marine mammals and sea turtles as a result of the seismic survey activities, because of the constant movement of both the R/V *Marcus G. Langseth* and of the marine mammals and sea turtles in the action area, the fact that the research vessel is not expected to remain in any one area in which individual marine mammals and will be expected to concentrate for an extended period of time (i.e., since the duration of exposure to loud sounds will be relatively short), and the implementation of conservation measures. Also, as described more below, we expect that marine mammals and sea turtles would 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 slow speed when conducting seismic survey activities.

10.4.1 Acoustic Thresholds for Marine Mammals

To determine at what point during exposure to airgun arrays marine mammals are considered "harassed", NMFS applies certain acoustic thresholds. These thresholds are used in the development of radii for buffer and shutdown zones around a sound source and the necessary minimization requirements necessary to limit marine mammal exposure to harmful levels of sound (NOAA 2018). The references, analysis, and methodology used in the development of these thresholds are described in *NOAA 2018 Revision to Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing* (NOAA 2018), which is summarized for ESA species at the following website: https://www.fisheries.noaa.gov/s3/2023-02/ESA%20all%20species%20threshold%20summary_508_OPR1.pdf. For behavioral harassment for marine mammals, NMFS has historically relied on an acoustic threshold of 160 dB re: one µPa (rms) for impulsive sound sources. This value is based on observations of behavioral responses of mysticetes, but is used for all marine mammals species. For this action, we continued to rely on this historic NMFS acoustic threshold to estimate the number of takes of ESA-listed marine mammals.

Table 16. Low- and mid-frequency functional hearing groups, generalized hearing ranges, and acoustic thresholds identifying the onset of permanent threshold shift and temporary threshold shift for marine mammals exposed to impulsive sounds underwater (NOAA 2018).

Hearing Group	Generalized Hearing Range*	Permanent Threshold Shift Onset	Temporary Threshold Shift Onset
Low-Frequency Cetaceans (Baleen Whales) (LE,LF, 24 Hour)	7 Hz to 35 kHz	$L_{pk,flat}$: 219 dB $L_{E,LF,24h}$: 183 dB	$L_{pk,flat}$: 213 dB $L_{E,LF,24h}$: 168 dB
Mid-Frequency Cetaceans (Dolphins, Toothed Whales, Beaked Whales, Bottlenose Whales) (LE,MF,24 Hour)	150 Hz to 160 kHz	$L_{pk,flat}$: 230 dB $L_{E,MF,24h}$: 185 dB	$L_{pk,flat}$: 224 dB $L_{E,MF,24h}$: 170 dB

LE, X, 24 Hour=Frequency Sound Exposure Level (SEL) Cumulated over 24 Hour, LF=Low-Frequency, MF=Mid-Frequency
*Represents the generalized hearing range for the entire group as a composite (i.e., all species within the group), where individual species' hearing ranges are typically not as broad. Generalized hearing range was chosen based on approximately 65 dB threshold from normalized composite audiogram, with the exception for lower limits for low frequency cetaceans (Southall et al. 2007a) (approximation).
Note: Dual metric acoustic thresholds for impulsive sounds (peak and/or SEL_{cum}): Use whichever results in the largest (most conservative for the ESA-listed species) isopleth for calculating PTS onset. If a non-impulsive sound has the potential of exceeding the peak sound pressure level thresholds associated with impulsive sounds, these thresholds should also be considered.
Note: Peak sound pressure (Lpk) has a reference value of one µPa, and cumulative sound exposure level (LE) has a reference value of one μPa^2 second. 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, we evaluated the exposure and take estimates of ESA-listed marine mammals associated with the sounds from the airgun array.

10.4.2 Modeled Sound Fields of the Airgun Array for Marine Mammals

In this section, we first evaluate the likelihood that marine mammals will be exposed to sound fields from the airgun array during the high-energy seismic survey at or above 160 dB re: one µPa (rms) based upon the information described above, and the acoustic thresholds correlating to harm provided in Table 16. If we find that such exposure above any particular threshold is likely, we then estimate the number of instances in which we expect marine mammals to be exposed to these sound levels, based on the ensonified areas at or above these sound levels and information on marine mammal density.

The methodologies for estimating the number of ESA-listed species that might be exposed to the sound field used by the NSF, L-DEO, NMFS Permits Division, and us were largely the same. They estimated the number of marine mammals predicted to be exposed to sound levels that will result in ESA-defined harassment and harm by using radial distances to predicted isopleths. We used those radial distances to calculate the ensonified area around the airgun array for the 160 dB re: one µPa (rms) zone, which corresponds to the ESA harassment threshold for ESA-listed marine mammals. The area estimated to be ensonified (within each depth category and functional hearing group) of the seismic survey activities is then calculated, based on the areas predicted to be ensonified around the airgun array and the estimated trackline distance traveled by the R/V *Marcus G. Langseth*. Overlap was considered in the exposure and response analysis, as the NSF and L-DEO's calculations of the ensonified areas included endcaps and accounted for the extent of overlap of the tracklines and buffer. 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 NSF and L-DEO, we have determined that marine From modeling by the L-DEO, the NSF provided sound source levels of the airgun array and estimated distances for the 160 dB re: one µPa (rms) sound levels as well as ESA harm thresholds generated by the airgun array configurations and water depth. The predicted and modeled radial distances for the various ESA harm and harassment thresholds for marine mammals for the R/V *Marcus G. Langseth*'s airgun arrays can be found in Table 17 and Table 18.

Table 17. Predicted radial distances in meters from the Research Vessel *Marcus G. Langseth* seismic sound sources to isopleth corresponding to the harassment (160 dB re: one µPa [rms]) threshold for marine mammals.

Sound Source	Volume (in^3)	Maximum Tow Depth (m)	Water Depth (m)	Predicted Distance to Threshold (160 dB re: one µPa [rms]) (m)[1]
18 Airguns	3,300	6	100 to 1,000	4,329
18 Airguns	3,300	6	Greater than 1,000	2,886

in^3=cubic inches, m=meters, [1]Distances for depths 100 to 1,000 meters are deep water values with a 1.5 times correction factor. Distances for depths greater than 1,000 meters (3,281 feet) are based on L-DEO's model results.

Table 18. Modeled radial distances in meters from the Research Vessel *Marcus G. Langseth*'s 18 airgun array corresponding to harm thresholds.

Functional Hearing Group	SEL_{cum} Threshold (dB)	Airgun Array Distance to SEL_{cum} Threshold (m)	Peak SPL_{flat} Threshold (dB)	Airgun Array Distance to Peak SPL_{flat} Threshold (m)	Shutdown Zone for all Water Depths (m)
Sound Source – 18 Airgun Array					
Low Frequency Cetaceans (L_{pk} flat: 219 dB; L_E,LF,24$_h$: 183 dB)	183	101.9	219	23.3	500
Mid Frequency Cetaceans (L_{pk} flat: 230 dB; L_E,MF,24$_h$: 185 dB)	185	0	230	11.2	500

SELcum=cumulative sound exposure level, dB=Decibel, m=meters, SPL=sound pressure level, LF=low frequency, h=hours, MF=mid-frequency

Note: Peak sound pressure (L_{pk}) has a reference value of 1 µPa, and cumulative sound exposure level (L_E) has a reference value of 1µPa^{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 (LF, MF, and HF cetaceans, and PW and OW pinnipeds) 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.

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

Because of some of the assumptions included in the methods used, isopleths produced may be overestimated to some degree, which will ultimately result in some degree of overestimate of takes by harm. However, these tools offer the best way to predict appropriate isopleths when more sophisticated three-dimensional modeling methods are not available, and NMFS continues to develop ways to quantitatively refine these tools and will qualitatively address the output where appropriate. For mobile sources, such as the seismic surveys, the NMFS User Spreadsheet predicts the closest distance at which a stationary animal will not incur PTS if the sound source traveled by the animal in a straight line at a constant speed.

10.4.3 Total Ensonified Area for Harassment for Marine Mammals

The tables below explain the calculations for total ensonified areas and exposures for harm and harassment from the seismic survey activities during NSF and L-DEO's high-energy seismic survey in the Northwest Atlantic Ocean off North Carolina.

Table 19. Total ensonified areas (with 25 percent increase) for Endangered Species Act-listed marine mammals in the action area during the National Science Foundation and Lamont-Doherty Earth Observatory's high-energy seismic survey in the Northwest Atlantic Ocean off North Carolina and National Marine Fisheries Service Permits Division's proposed issuance of an incidental harassment authorization and possible renewal.

Species	Potential Harassment 160 dB re: one µPa (rms) Ensonified Area (km^2)		Potential Harassment 160 dB re: one µPa (rms) Ensonified Area with 25 Percent Increase (km^2) (Total)	
	Intermediate Water Depth (100 to 1,000 m)	Deep Water Depth (Greater than 1,000 m)	Intermediate Water Depth (100 to 1,000 m)	Deep Water Depth (Greater than 1,000 m)
Blue Whale	6,101.2	32,090.8	7,626.5	40,113.5
Fin Whale	6,101.2	32,090.8	7,626.5	40,113.5
Sei Whale	6,101.2	32,090.8	7,626.5	40,113.5
Sperm Whale	6,101.2	32,090.8	7,626.5	40,113.5

dB=decibel, re: one µPa=referenced to one microPascal, rms=root mean square, km^2=square kilometers, m=meters.

Table 20. Density, total ensonified area, and calculated exposures during the National Science Foundation and Lamont-Doherty Earth Observatory's high-energy seismic survey in the Northwest Atlantic Ocean off North Carolina and National Marine Fisheries Service Permits Division's proposed issuance of an incidental harassment authorization and possible renewal.

Species	Estimated Density (Individuals per km^2)		Potential Harassment 160 dB re: one µPa (rms) Total Ensonified Area (km^2)		Potential Harassment 160 dB re: one µPa (rms) Calculated Exposures of Animals (*)
	Intermediate Water Depth (100 to 1,000 m)	Deep Water Depth (Greater than 1,000 m)	Intermediate Water Depth (100 to 1,000 m)	Deep Water Depth (Greater than 1,000 m)	
Blue Whale	0.0000124000	0.0000150000	7,626.5	40,113.5	0.4 (1)
Fin Whale	0.0000935000	0.0000767000	7,626.5	40,113.5	4
Sei Whale	00001462270	0.0001743590	7,626.5	40,113.5	8
Sperm Whale	0.0010799300	0.0099250940	7,626.5	40,113.5	406

km^2=square kilometers, re: one µPa=referenced to one microPascal, m=meters.
*Increased to mean group size.

Table 21. 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 Division to the airgun arrays during the high-energy seismic survey in the Northwest Atlantic Ocean off North Carolina.

Species	Potential Permanent Threshold Shift	Potential Temporary Threshold Shift and Behavioral Harassment*
Blue Whale	0	1
Fin Whale	0	4
Sei Whale	0	8
Sperm Whale	2**	406

*Exposures for blue whales are increased to mean group size.
** For the purposes of this consultation, the NMFS Permits Division is not including any MMPA Level A take in their IHA. We are also not exempting any take in the form of ESA harm.

Table 22. 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 Division to the airgun arrays during the high-energy seismic survey in the Northwest Atlantic Ocean off North Carolina.

Species	Estimated Density (Individuals per km^2)		Daily Ensonified Area (km^2)		Number of Days of Airgun Array Operations	Potential Harassment 160 dB re: one µPa (rms) Calculated Exposures of Animals	Calculated Exposures of Animals Adjusted for Mean Group Size*
	Intermediate Water depth (100 to 1,000 m)	Deep Water depth (Greater than 1,000 m)	Intermediate Water Depth (100 to 1,000 m)	Deep Water Depth (Greater than 1,000 m)			
Blue Whale	0.0000124000	0.0000150000	217.9	1,146.1	28	0.4	1
Fin Whale	0.0000935000	0.0000767000	217.9	1,146.1	28	4	4
Sei Whale	00001462270	0.0001743590	217.9	1,146.1	28	8	8
Sperm Whale	0.0010799300	0.0099250940	217.9	1,146.1	28	406	406

km^2=square kilometers.
*Exposures for blue whales are increased to mean group size.

10.4.4 Acoustic Thresholds for Sea Turtles

In order to estimate exposure of ESA-listed sea turtles to sound fields generated by the airgun array that will be expected to result in a behavioral response, which is harassment under the ESA, we relied on acoustic thresholds derived from the best available scientific literature and presented in our ESA summary of acoustic thresholds: https://www.fisheries.noaa.gov/s3/2023-02/ESA%20all%20species%20threshold%20summary_508_OPR1.pdf. Currently, the best available data come from studies by O'Hara and Wilcox (1990) and McCauley et al. (2000b), 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: one µPa (rms) (or slightly less) in a shallow canal. McCauley et al. (2000b) reported a noticeable increase in swimming behavior for both green and loggerhead turtles at received levels of 166 dB re: one µPa (rms). At 175 dB re: one µPa (rms), both green and loggerhead turtles displayed increased swimming speed and increasingly erratic behavior (McCauley et al. 2000b). Based on these data, NMFS and the U.S. Navy concluded that sea turtles will exhibit behavioral disturbance when exposed to received levels of 175 dB re: one µPa (rms) and higher. Thus, we use this threshold to determine at what point sea turtles will be

harassed under the ESA, and to estimate the number of instances of exposure that will result in behavioral harassment. The predicted and modeled distances to which sound levels of 175 dB re: one µPa (rms) will be received from the 18 airgun array in intermediate (100 to 1,000 meters [328.1 to 3,280.8 feet]) and deep (greater than 1,000 meters [3,280.8 feet]) water depths for sea turtles during the seismic survey activities in the Northwest Atlantic Ocean off North Carolina are in Table 24 and Table 25.

In order to estimate exposure of ESA-listed sea turtles to sound fields generated by the airgun array that will be expected to result in sound-induced hearing loss (i.e., TTS or PTS, harassment or harm), 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). 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. 2014c). 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 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 23).

Table 23. Generalized hearing range and acoustic thresholds identifying the onset of permanent threshold shift and temporary threshold shift for sea turtles exposed to impulsive sounds underwater (U.S. Navy 2017).

Hearing Group	Generalized Hearing Range	Permanent Threshold Shift Onset	Temporary Threshold Shift Onset
Sea Turtles	30 Hz to 2 kHz	$L_{p,0\text{-pk,flat}}$: 232 dB re: one µPa SPL (0-peak) $L_{E,p,\,TU,24h}$: 204 dB re: one µPa^2-s SEL_{cum}	$L_{p,0\text{-pk,flat}}$: 226 dB re: one µPa SPL (0-peak) $L_{E,p,\,TU,24h}$: 189 dB re: one µPa^2-s SEL_{cum}

Hz=Hertz, kHz=kilohertz, dB=decibel; µPa=micro Pascal, s=second; SELcum=cumulative sound exposure level; SPL=sound pressure level.

Using the above acoustic thresholds, we (as well as NSF and L-DEO) evaluated the exposure and take estimates of ESA-listed sea turtles associated with sounds from the airgun array.

10.4.5 Modeled Sound Fields of the Airgun Array for Sea Turtles

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 175 dB re: one µPa (rms) based on the information described above, and the acoustic thresholds correlating to the onset of harassment and harm provided in Table 23. 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 sound levels, based on the ensonified areas at or above these sound levels and information on sea turtle density (Section 10.3.2).

We have determined that harm 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, harm 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 chances of PTS occurring. We therefore conclude that the risk of PTS is extremely unlikely (i.e., discountable). Also, NSF and L-DEO will use a 150 meter (492.1 feet) shutdown zone for the 18 airgun array as the shutdown distance for sea turtles, which is expected to be larger than the radii for PTS and is protective from harm. The predicted distance for the PTS threshold is 11.8 meters (38.7 feet).

Based on information provided by the NSF and L-DEO, 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. Modeling by the L-DEO, the NSF and L-DEO provided estimated distances for the 175 dB re: one µPa (rms) sound levels generated by the 18 airgun array configurations. The predicted radial distances for the behavioral harassment threshold for sea turtles for the R/V *Marcus G. Langseth's* airgun array can be found in Table 24.

Table 24. Predicted radial distances from the Research Vessel *Marcus G. Langseth*'s airgun array to isopleths corresponding to the behavioral harassment threshold (175 dB re: one µPa [rms]) for sea turtles.

Source	Volume (in^3)	Maximum Tow Depth (m)	Water Depth (m)	Predicted Distance to Threshold (175 dB re: one µPa [rms]) (m)
18 Airguns	3,300	6	100 to 1,000	909
18 Airguns	3,300	6	Greater than 1,000	606

In^3=cubic inches; m=meters; dB=decibels; re: one µPa=referenced to one microPascal; rms=root mean square.

Table 25. Modeled radial distances in meters from the Research Vessel *Marcus G. Langseth*'s 18 airgun array corresponding to harm thresholds for sea turtles.

Hearing Group	SEL_{cum} Threshold (dB)	Airgun Array Distance to SEL_{cum} Threshold (m)	Peak SPL_{flat} Threshold (dB)	Airgun Array Distance to Peak SPL_{flat} Threshold (m)	Shutdown Zone for all Water Depths (m)
Source – 18 Airgun Array					
Sea Turtles	204	11.8	232	9.95	150

SEL_{cum}=cumulative sound exposure level, dB=Decibel, GI=Generator Injector, m=meters, SPL=sound pressure level

Note: Peak sound pressure (L_{pk}) has a reference value of 1 µPa, and cumulative sound exposure level (L_E) has a reference value of 1µPa^{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 (LF, MF, and HF cetaceans, and PW and OW pinnipeds) 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.
Note: The largest distances of the dual criteria (SEL_{cum} or Peak SPL_{flat}) were used to calculate takes and harm threshold distances. Because of some of the assumptions included in the methods used, isopleths produced may be overestimated to some degree, which will ultimately result in some degree of overestimate of takes by harm. However, these tools offer the best way to predict appropriate isopleths when more sophisticated three-dimensional modeling methods are not available, and NMFS continues to develop ways to quantitatively refine these tools and will qualitatively address the output where appropriate. For mobile sources, such as the seismic surveys, the NMFS User Spreadsheet predicts the closest distance at which a stationary animal will not incur PTS if the sound source traveled by the animal in a straight line at a constant speed.

10.4.6 Total Ensonified Area for Harassment for Sea Turtles

The tables below explain the calculations for total ensonified areas and exposures for harm and harassment from the seismic survey activities during NSF and L-DEO's high-energy seismic survey in the Northwest Atlantic Ocean off North Carolina.

Table 26. Total ensonified areas (with 25 percent increase) for Endangered Species Act-listed sea turtles in the action area during the National Science Foundation and Lamont-Doherty Earth Observatory's high-energy seismic survey in the Northwest Atlantic Ocean off North Carolina.

Species	Potential Harassment 175 dB re: one µPa (rms) Ensonified Area (km^2)		Potential Harassment 175 dB re: one µPa (rms) Ensonified Area with 25 Percent Increase (km^2)	
	Intermediate Water Depth (100 to 1,000 m)	Deep Water Depth (Greater than 1,000 m)	Intermediate Water Depth (100 to 1,000 m)	Deep Water Depth (Greater than 1,000 m)
Green Sea Turtle – North Atlantic DPS	1,134.0	6,683.6	1,417.5	8,354.5

Species	Potential Harassment 175 dB re: one µPa (rms) Ensonified Area (km^2)		Potential Harassment 175 dB re: one µPa (rms) Ensonified Area with 25 Percent Increase (km^2)	
	Intermediate Water Depth (100 to 1,000 m)	Deep Water Depth (Greater than 1,000 m)	Intermediate Water Depth (100 to 1,000 m)	Deep Water Depth (Greater than 1,000 m)
Kemp's Ridley Sea Turtle	1,134.0	6,683.6	1,417.5	8,354.5
Leatherback Sea Turtle	1,134.0	6,683.6	1,417.5	8,354.5
Loggerhead Sea Turtle – Northwest Atlantic Ocean DPS	1,134.0	6,683.6	1,417.5	8,354.5

dB=decibel, re: one µPa= referenced to one microPascal, rms=root mean square, km^2=square kilometers, m=meters.

Table 27. Density, total ensonified area, and calculated exposures for Endangered Species Act-listed sea turtles during the National Science Foundation and Lamont-Doherty Earth Observatory's high-energy seismic survey in the Northwest Atlantic Ocean off North Carolina.

Species	Estimated Density (Individuals per km^2)		Potential Harassment 175 dB re: one µPa (rms) Total Ensonified Area (km^2)		Potential Harassment 175 dB re: one µPa (rms) Calculated Exposures of Animals
	Intermediate Water Depth (100 to 1,000m)	Deep Water Depth (Greater than 1,000 m)	Intermediate Water Depth (100 to 1,000 m)	Deep Water Depth (Greater than 1,000 m)	
Green Sea Turtle – North Atlantic DPS	0.09414	0.01930	1,417.5	8,354.5	251
Kemp's Ridley Sea Turtle	0.00110	0.00018	1,417.5	8,354.5	3
Leatherback Sea Turtle	0.00018	0.00018	1,417.5	8,354.5	2
Loggerhead Sea Turtle –	0.63482	0.04910	1,417.5	8,354.5	1,047

Species	Estimated Density (Individuals per km^2)		Potential Harassment 175 dB re: one µPa (rms) Total Ensonified Area (km^2)		Potential Harassment 175 dB re: one µPa (rms) Calculated Exposures of Animals
	Intermediate Water Depth (100 to 1,000m)	Deep Water Depth (Greater than 1,000 m)	Intermediate Water Depth (100 to 1,000 m)	Deep Water Depth (Greater than 1,000 m)	
Northwest Atlantic Ocean DPS					

km^2=square kilometers, m=meters, dB=decibels, re: one µPa= referenced to one microPascal, rms=root mean square.

Table 28. Estimated exposure of Endangered Species Act-listed sea turtles calculated by the National Science Foundation and Lamont-Doherty Earth Observatory to the airgun arrays during the high-energy seismic survey in the Northwest Atlantic Ocean off North Carolina.

Species	Potential Permanent Threshold Shift	Potential Temporary Threshold Shift and Behavioral Disturbance
Green Sea Turtle – North Atlantic DPS	44*	251
Kemp's Ridley Sea Turtle	1*	3
Leatherback Sea Turtle	0	2
Loggerhead Sea Turtle – Northwest Atlantic Ocean DPS	263*	1,047

* We do not expect take in the form of harm (PTS) for sea turtles and are not exempting any take in the form of harm under the ESA.

Table 29. Estimated exposure of Endangered Species Act-listed sea turtles calculated by the National Science Foundation and Lamont-Doherty Earth Observatory to the airgun arrays during the high-energy seismic survey in the Northwest Atlantic Ocean off North Carolina.

Species	Estimated Density (Individuals per km^2)		Daily Ensonified Area (km^2)		Number of Days of Airgun Array Operations	Potential Harassment 175 dB re: one µPa (rms) Calculated Exposures of Animals
	Intermediate Water Depth (100 to 1,000 m)	Deep Water Depth (Greater than 1,000 m)	Intermediate Water Depth (100 to 1,000 m)	Deep Water Depth (Greater than 1,000 m)		
Green Sea Turtle – North Atlantic DPS	0.09414	0.01930	40.5	238.7	28	251
Kemp's Ridley Sea Turtle	0.00110	0.00018	40.5	238.7	28	3
Leatherback Sea Turtle	0.00018	0.00018	40.5	238.7	28	2
Loggerhead Sea Turtle – North west Atlantic Ocean DPS	0.63482	0.04910	40.5	238.7	28	1,047

km^2=square kilometers, m=meters, dB=decibels, re: one µPa= referenced to one microPascal, rms=root mean square.

10.4.7 Potential Responses of Marine Mammals to Acoustic Sources

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

Few data are available to precisely define each ESA-listed marine mammal species hearing range, let alone its sensitivity and levels necessary to induce TTS or PTS. Baleen whales (e.g., blue whales, fin whales, and sei whales) have an estimated functional hearing frequency range of seven Hz to 35 kHz and sperm whales have an estimated functional hearing frequency range of 150 Hz to 160 kHz (Table 16) (Southall 2007).

Thresholds for TTS and PTS are based on the best available information, which are derived from captive studies of marine mammals, our understanding of terrestrial mammal hearing, and extensive modeling. The best available information supports the position that received levels at a given frequency will need to be approximately 168 dB re: one μPa^2-second (SEL weighted) or 213 dB re: one µPa (Peak SPL) for TTS onset from impulsive sound for low-frequency cetaceans, and 170 dB re: one μPa^2-second (SEL weighted) or 224 dB re: one µPa (Peak SPL) for TTS onset from impulsive sound for high-frequency cetaceans (Southall et al. 2007c). Permanent threshold shift is expected at received levels of 183 dB re: one μPa^2-second (SEL weighted) or 219 dB re: one µPa (Peak SPL) from impulsive sound for low-frequency cetaceans, and 185 dB re: one μPa^2-second (SEL weighted) or 230 dB re: one µPa (Peak SPL) from impulsive sounds for high-frequency cetaceans (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: one µPa (Peak SPL) (Caldwell and Dragoset 2000b). If an individual experienced exposure to several airgun pulses of approximately 219 dB re: one µPa (Peak SPL) for low-frequency cetaceans and 230 dB re: one µPa (Peak SPL) for mid-frequency cetaceans, PTS could occur. Marine mammals (cetaceans) will have to be within certain modeled radial distances specified in Table 17 and Table 18 from the R/V *Marcus G. Langseth*'s 18 airgun array to be within the ESA harm threshold isopleth and risk a TTS and behavioral responses.

As stated earlier in Section 10, only harassment of ESA-listed cetaceans is expected during the high-energy seismic survey. 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.

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. As the seismic survey proceeds along each transect trackline and approaches ESA-listed individuals, the sound intensity increases, and individuals will experience conditions (stress, loss of prey, discomfort, etc.) that will likely prompt them to move away from the research vessel and sound source and thus avoid exposures that will induce TTS. Ramp-ups 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 likely move away and therefore unlikely to accumulate more injurious levels. Furthermore, conservation measures will be in place to initiate a shutdown if individuals enter or are about to enter the 500 meter (1,640.4 feet) shutdown zone during 18 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 potentially be exposed to 160 dB re: one µPa (rms) levels. We do not expect this to produce a cumulative TTS auditory 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 minimization 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 has fitness consequences. 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.

10.4.7.2 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 cues of predatory risk, mating opportunity, or foraging options (Francis and Barber 2013). Low frequency sounds are broad and tend to have relatively constant bandwidth, whereas higher frequency bandwidths are narrower (NMFS 2006h).

The sound frequency overlap of airgun array sounds and vocalizations of ESA-listed marine mammals, particularly baleen whales and to some extent sperm whales. The high-energy seismic survey could mask baleen whale and sperm 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 two to four kHz and ten to 16 kHz and, through the findings by Madsen et al. (2006) suggest frequencies of pulses from airgun arrays can overlap this range, the dominant frequency component of the R/V *Marcus G. Langseth*'s airgun array is below 200 Hz (two to 188 Hz). Any masking that might occur will likely be temporary because acoustic sources from the seismic surveys are not continuous and the research vessel will continue to transit through the area. In addition, the seismic survey

activities on the R/V *Marcus G. Langseth* are planned to occur over the course of approximately 33 days (i.e., approximately 28 days of airgun array operations, three days of [gravity and piston] coring activities and heat flow measurements, and two days of transit).

Given the disparity between sperm whale echolocation and communication-related sounds with the dominant frequencies for seismic surveys, masking is not likely to be significant for sperm whales (NMFS 2006h). Overlap of the dominant low frequencies of airgun pulses with low-frequency baleen whale calls may pose a somewhat greater risk of masking. Nieukirk et al. (2012) analyzed ten years of recordings from the Mid-Atlantic Ridge. When several surveys were recorded simultaneously, whale sounds were masked (drowned out), and the airgun noise became the dominant component of background noise levels. The R/V *Marcus G. Langseth*'s airgun array will emit an approximately 0.01 second pulse when fired approximately every ten seconds for the high-energy seismic survey, with sperm whale calls lasting 0.5 to one second. Therefore, pulses will not "cover up" the vocalizations of sperm whales to a significant extent (Madsen et al. 2002b). We address the response of ESA-listed marine mammals stopping vocalizations because of sound from the airgun array in the Marine Mammals and Behavioral Responses 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 impulsive sound can add significantly to the acoustic background (Guerra et al. 2011), potentially interfering with the ability of animals to hear otherwise detectible sounds in their environment.

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

elevated sound levels (Au 1993; Dahlheim 1987; Foote 2004; Holt et al. 2009; Holt 2009; Lesage 1999; Lesage 1993; Parks 2009b; Parks 2009a; Parks et al. 2007b; Parks 2007; Terhune 1999).

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

Some studies indicate that low- and mid-frequency cetaceans may also alter components of their vocalizations in response to anthropogenic noise. For example, humpback whales (*Megaptera novaeangliae*) in Glacier Bay National Park, Alaska were recorded increasing the amplitude of their vocalizations by 0.8 dB for every one dB increase in ambient noise (mostly due to vessel noise) while also vocalizing less frequently (Frankel and Gabriele 2017); (Fournet et al. 2018). Similarly, some North Atlantic right whales increased the amplitude of their vocalizations during periods of increased noise (Parks et al. 2011a) and gray whales (*Eschrichtius robustus*) exhibited changes in their calling rates, call received levels, number of pulses per call, and call repetition rates, increasing their calling rate and amplitude, when different noise sources were added to the environment during a sound playback experiment off Baja California Sur, Mexico (Dahlheim and Castellote 2016). However, there may be energetic costs to producing louder and more frequent calls. Additionally, masking is a much more prevalent issue for low-frequency cetaceans than high-frequency cetaceans, as many studies predicted decreased communication spaces of up to 80 percent or more for large mysticetes (e.g., (Cholewiak et al. 2018a); (Rey-Baquero et al. 2021). Other studies reported decreased likelihood of calling during periods of high noise, or even complete cessation of calling (e.g., (Melcón et al. 2012); (Tsujii et al. 2018). In the Beaufort Sea, bowhead whales recorded at sites near seismic survey airgun activity decreased their call localization rate (the number of localized calls per hours within a specified study area) during and after the seismic survey. In other words, calling was highest before seismic activity. In contrast, call localization rates or bowhead whales recorded at sites further away from the seismic survey activity were either unchanged before, during, and after seismic activity, or were lowest before seismic activity (Blackwell et al. 2013a).

In summary, high levels of sound generated by the seismic survey activities may act to mask the detection of weaker biologically important sounds by some marine mammals considered in this consultation. This masking is expected to be more prominent for baleen whales (including blue whales, fin whales, and sei whales), given the lower frequencies at which they hear best and produce calls. For toothed whales (sperm whales), which hear best at frequencies above the

predominant ones produced by airguns, there may be modifications to aspects of their vocalizations that allow them to reduce the effects of masking on higher frequency sounds such as echolocation clocks like other toothed whales mentioned above (e.g., belugas, Au et al. 1985). As such, toothed whales are not expected to experience significant masking during the period of time the airgun arrays are producing sound for the proposed actions.

10.4.7.3 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. The ESA-listed individuals may briefly respond to underwater sound by slightly changing their behavior or relocating a short distance, in which case some of the responses can equate to harassment of individuals but are unlikely to result in meaningful behavioral responses at the population level. Displacement from important feeding or breeding areas over a prolonged period would likely be more significant for individuals and could affect the population depending on the extent of the feeding area and duration of displacement. This has been suggested for humpback whales along the Brazilian coast as a result of increased seismic survey activity (Parente et al. 2007). Marine mammal responses to anthropogenic sound vary by species, state of maturity, prior exposure, current activity, reproductive state, time of day, and other factors (Ellison et al. 2012; Harris et al. 2018); this is reflected in a variety of aquatic, aerial, and terrestrial animal responses to anthropogenic noise that may ultimately have fitness consequences (Costa et al. 2016; Fleishman et al. 2016; Francis and Barber 2013; New et al. 2014; NRC 2005). Although some studies are available which address responses of ESA-listed marine mammals considered in this consultation directly, additional studies to other related whales (such as bowhead whales, gray whales, and North Atlantic right 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 considered here. Animals generally respond to anthropogenic perturbations as they would to 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 and request for comments and possible renewal (88 FR 17646 to 17677) 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 may continue calling while seismic surveys are operating locally (Greene Jr et al. 1999; Jochens et al. 2006; Madsen et al. 2002b; McDonald

et al. 1993; McDonald et al. 1995b; 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 whales, fin whales, and sperm whales stopped calling for short and long periods apparently in response to airguns (Bowles et al. 1994; Clark and Gagnon 2006; McDonald et al. 1995b). Fin whales (presumably adult males) engaged in singing in the Mediterranean Sea moved out of the area of a seismic survey while airguns were operational as well as for at least a week thereafter (Castellote et al. 2012b). The survey area affected was estimated to be about 100,000 square kilometers (29,155.3 square nautical miles) (Castellote et al. 2012a). Dunn and Hernandez (2009) tracked blue whales during a seismic survey on the R/V *Maurice Ewing* in 2007 and did not observe changes in call rates and found no evidence of anomalous behavior that they could directly ascribe to the use of airguns at sound levels of approximately less than 145 dB re: one 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: one µPa (rms), but did not change at received levels of 99 to 108 dB re: one µPa (rms) (Blackwell et al. 2013b). 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: one μPa^2-second over the course of ten minutes (Blackwell et al. 2015). Once sound levels exceeded approximately 127 dB re: one μPa^2-second over ten minutes, call rates began to decline and at approximately 160 dB re: one μPa^2-second over ten minutes, bowhead whales appeared ceased calling all together (Blackwell et al. 2015).

While we are aware of no data documenting changes in North Atlantic right whale vocalization in association with seismic surveys, as mentioned previously they do shift calling frequencies and increase call amplitude over both long and short term periods due to chronic exposure to vessel sound (Parks 2009a; Parks and Clark 2007; Parks et al. 2007a; Parks et al. 2007b; Parks et al. 2011a; Parks et al. 2011b; Parks et al. 2012; Parks et al. 2009; Tennessen and Parks 2016). Sperm whales, at least under some conditions, may be particularly sensitive to airgun sounds, as they have been documented to cease calling in association with airguns being fired hundreds of kilometers away (Bowles et al. 1994). Other studies have found no response by sperm whales to received airgun sound levels up to 146 dB re: one µPa (peak-to-peak) (Madsen et al. 2002a; McCall Howard 1999). For the species considered in this consultation, some exposed individuals 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 high-energy seismic survey once the acoustic stressor has diminished.

There are numerous studies of the responses of some baleen whales to airgun arrays. Although responses to lower-amplitude sounds are known, most studies seem to support a threshold of approximately 160 dB re: one µPa (rms) (the level used in this consultation to determine the extent of acoustic effects for marine mammals) as the received sound level to cause behavioral responses other than vocalization changes (Richardson et al. 1995b). Activity of individuals at the time of exposure 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. 1984b; Miller et al. 1999; Miller et al. 2005; Richardson et al. 1995a; Richardson et al. 1995b; Richardson et al. 1999). Migrating bowhead whales show strong avoidance reactions to received 120 to 130 dB re: one 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: one µPa [rms]) (Harris et al. 2007; Ljungblad et al. 1988; Miller et al. 1999; Miller et al. 2005; Richardson et al. 1995a; Richardson et al. 1995b; Richardson et al. 1999; Richardson et al. 1986a; Richardson et al. 1986b). Nations et al. (2009) also found that bowhead whales were displaced during migration in the Beaufort Sea during active seismic surveys. In fact, as mentioned previously, the available data indicate that most, if not all, baleen whale species exhibit avoidance of active seismic airguns (Barkaszi et al. 2012; Castellote et al. 2012a; Castellote et al. 2012b; Gordon et al. 2003; NAS 2017; Potter et al. 2007; Southall et al. 2007a; Southall et al. 2007b; Stone et al. 2017a; Stone and Tasker 2006). Despite the above observations and exposure to repeated seismic surveys, bowhead whales continue to return to summer feeding areas and when displaced, appear to re-occupy within a day (Richardson et al. 1986b). We do not know whether the individuals exposed in these ensonified areas are the same as those returning or whether though they tolerate repeat exposures, they may still experience a stress response. However, we expect the presence of the PSOs and the shutdown that will occur if a marine mammal were present in the shutdown zone will lower the likelihood that marine mammals will be exposed to sounds from the airgun array.

Gray whales respond similarly to seismic surveys as described for bowhead whales. Gray whales discontinued feeding and/or moved away at received sound levels of 163 dB re: one µPa (rms) (Bain and Williams 2006; Gailey et al. 2007; Johnson et al. 2007a; Malme and Miles 1985; Malme et al. 1984b; Malme et al. 1987; Malme et al. 1986; Meier et al. 2007; Würsig et al. 1999; Yazvenko et al. 2007). Migrating gray whales began to show changes in swimming patterns at approximately 160 dB re: one µPa (rms) and slight behavioral changes at 140 to 160 re: one µPa (rms) (Malme and Miles 1985; Malme et al. 1984a; Malme et al. 1984b). As with bowhead whales, habitat continues to be used despite frequent seismic survey activity, but long-term effects have not been identified, if they are present at all (Malme et al. 1984a). 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 research in the area from 2002 through 2005. Furthermore, when strict conservation measures, such as those proposed by the NMFS Permits Division, are taken to avoid conducting

seismic surveys during certain times of the year when most gray whales are expected to be present and to closely monitor operations, gray whales may not exhibit any noticeable behavioral responses to seismic survey activities (Gailey et al. 2016). Given the similar conservation measures that will be implemented for this proposed actions, we expect some of the ESA-listed marine mammal species considered in this consultation will respond in a similar manner as gray whales.

Humpback whales exhibit a pattern of lower threshold responses when not occupied with feeding. Migrating humpbacks altered their travel path (at least locally) along Western Australia at received levels as low as 140 dB re: one µPa (rms) when females with calves were present, or seven 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: one µPa (rms). Closest approaches were generally limited to three to four 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: one µPa (rms). Changes in course and speed generally occurred at estimated received levels of 157 to 164 dB re: one 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: one 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). (Dunlop et al. 2020) also observed a decrease in the probability of a humpback whale group joining with another individual singer at 125 to 150 dB re: one μPa^2-second, although this was not statistically significant. Feeding humpback whales appear to be somewhat more tolerant. Humpback whales off the coast of Alaska startled at 150 to 169 dB re: one µPa (rms) and no clear evidence of avoidance was apparent at received levels up to 172 dB re: one µPa (rms) (Malme et al. 1984b; Malme et al. 1985). Potter et al. (2007) found that humpback whales on feeding grounds in the Atlantic Ocean did exhibit localized avoidance to airgun arrays. Among humpback whales on Angolan breeding grounds, no clear difference was observed in encounter rate or point of closest approach during seismic versus non-seismic periods (Weir 2008).

Observational data are sparse for specific baleen whale life histories (breeding and feeding grounds) in response to airguns. Available data support a general avoidance response. Some fin whale 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. 2017a; Stone and Tasker 2006). Other studies have found at least small differences in sighting rates (lower during seismic survey activities) as well as whales

being more distant during seismic survey activities (Moulton and Miller 2005b). When spotted at the average sighting distance, individuals will have likely been exposed to approximately 169 dB re: one µPa (rms) (Moulton and Miller 2005a).

Sperm whale response to airguns has thus far included mild behavioral disturbance (temporarily disrupted foraging, avoidance, cessation of vocal behavior) or no reaction. Several studies have found sperm whales in the Atlantic Ocean to show little or no response (Davis et al. 2000; Madsen et al. 2006; Miller et al. 2009; Moulton and Miller 2005b; Stone 2003; Stone et al. 2017a; 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: one 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: one µPa. Other anthropogenic sounds, such as pingers and sonars, disrupt behavior and vocal patterns (Goold 1999a; Watkins et al. 1985b; 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 five 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 five kilometers (2.7 nautical miles) were available to assess potential displacement within five kilometers (2.7 nautical miles) (Winsor and Mate 2013). In a follow-up study using additional data, Winsor et al. (2017) found no evidence to suggest sperm whales avoid active airguns within distances of 50 kilometers (27 nautical miles). The lack of response by this species may in part be due to its higher range of hearing sensitivity and the low-frequency (generally less than 200 Hz) pulses produced by seismic airguns (Richardson et al. 1995b). However, sperm whales are exposed to considerable energy above 500 Hz during the course of seismic surveys (Goold and Fish 1998), so even though this species generally hears at higher frequencies, this does not mean that it cannot hear airgun sounds. Breitzke et al. (2008) found that source levels were approximately 30 dB re: one µPa lower at one kHz and 60 dB re: one µPa lower at 80 kHz compared to dominant frequencies during a seismic source calibration. Another odontocete, bottlenose dolphins, progressively reduced their vocalizations as an airgun array came closer and got louder (Woude 2013). Reactions of sperm whales to impulse noise likely vary depending on the activity at the time of exposure. For example, in the presence of abundant food or during breeding encounters, toothed whales sometimes are extremely tolerant of noise pulses (NMFS 2010c).

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 (blue whales, fin whales, and sei whales) are expected to mostly exhibit avoidance behavior, and may alter their vocalizations. Toothed whales (sperm whales) are expected to exhibit less overt behavioral changes, but may alter foraging behavior, including echolocation vocalizations. 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.

10.4.7.4 Marine Mammals and Physical or Physiological Effects

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

Stress is an adaptive response and does not normally place an animal at risk. Distress involves a stress response resulting in a biological consequence to the individual. The mammalian stress response involves the hypothalamic-pituitary-adrenal axis 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 can cause short-term weight loss, the liberation of glucose into the bloodstream, impairment of the immune and nervous systems, elevated heart rate, body temperature, blood pressure, and alertness, and other responses (Busch and Hayward 2009; Cattet et al. 2003a; Cattet et al. 2003b; 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: one µPa at one meter peak-to-peak) and single pure tones (up to 201 dB re: one µPa) had increases in stress chemicals, including catecholamines, which could affect an individual's ability to fight off disease. During the time following September 11, 2001, shipping traffic and associated ocean noise decreased along the northeastern U.S. This decrease in ocean sound was associated with a significant decline in fecal stress hormones in North Atlantic right whales, providing evidence that chronic exposure to increased noise levels, although not acutely injurious, can produce stress (Rolland et al. 2012a; Rolland et al. 2012b). These levels returned to baseline after 24 hours of vessel traffic resuming.

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

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

variety of response categories, including behavioral and physiological responses, female animals appear to be more sensitive or respond more strongly than males. It is noteworthy that although various exposures to loud sound appear to have adverse results, exposure to music largely appears to result in beneficial effects in diverse taxa. Clearly, the impacts of even loud sounds are complex and not universally negative (Kight and Swaddle 2011). Given the available data, and the short duration of exposure to sounds generated by airgun arrays, we do not anticipate any effects to the reproductive and metabolic physiology of ESA-listed marine mammals exposed to these sounds.

It is possible that an animal's prior exposure to sounds from seismic surveys influences its future response. We have little information 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). Seismic survey activities can potentially lead cetaceans and pinnipeds to habituate to sounds from airgun arrays which may lead to additional energetic costs or reductions in foraging success (Nowacek et al. 2015). However, we do not believe sensitization will occur based upon the lack of severe responses previously observed in marine mammals exposed to sounds from seismic surveys that will be expected to produce a more intense, frequent, and/or earlier response to subsequent exposures (see Section 10.3). Additionally, the proposed actions will take place over approximately 33 days (approximately 28 days of airgun array operations, three days of [gravity and piston] coring activities and heat flow measurements, and two days of transit); minimizing the likelihood that sensitization will occur. As stated before, we believe that exposed individuals will move away from the sound source, especially in the open ocean of the action area, where we expect species to be transiting through.

10.4.7.5 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 inches]) 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 because of the high-energy seismic survey. The high-energy seismic survey would take place in the Northwest Atlantic Ocean off North Carolina, and the closest approach to the coastline of North Carolina will be at least approximately 40 kilometers (21.6 nautical miles). 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 would not be likely to strand.

10.4.8 Potential Responses of Sea Turtles to Acoustic Sources

10.4.8.1 Sea Turtles and Acoustic Thresholds

Like marine mammals, if exposed to loud sounds sea turtles may experience harassment and harm (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. 2000c; 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 a seismic airgun array (Smultea and Holst 2003). For this reason, conservation measures will be implemented to limit sea turtle exposures at 150 meters (492.1 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 effectiveness of conservation measures is not fully understood, we do not expect the vast majority of sea turtles present in the action area to be exposed to sound levels that will result in TTS, 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).

10.4.8.2 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. 2000b; 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. (2000b) reported behavioral changes of sea turtles in response to seismic airgun arrays. These studies formed the basis for our 175 dB re: one 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. 2005c; 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 that behavioral changes are only expected when sound levels rise above received sound levels of 175 dB re: one 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.

10.4.8.3 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 that breeding adult females may experience a lower stress response, as female green, hawksbill, and loggerhead turtles appear to have a physiological mechanism to reduce or eliminate hormonal responses to stress

(predator attack, high temperature, and capture) in order to maintain reproductive capacity at least during their breeding season; a mechanism apparently not shared with males (Jessop 2001; Jessop et al. 2000; Jessop et al. 2004). Individuals may experience a stress response at levels lower than approximately 175 dB re: one µPa (rms), but data are lacking to evaluate this possibility. Therefore, we follow the best available evidence identifying a behavioral response as the point at which we also expect a significant stress response.

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

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

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 that serve as prey may experience physical and physiological effects, including mortality, but in most cases, such effects are only expected at relatively close distances to the sound source.

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

There has been research suggesting that that seismic airgun arrays may lead to a significant reduction in zooplankton, including copepods. McCauley et al. (2017) found that the use of a single airgun (approximately 2,458.1 cubic centimeters [150 cubic inches]) lead to a decrease in zooplankton abundance by over 50 percent and a two- to three-fold increase in dead adult and larval zooplankton when compared to control scenarios. In addition, effects were observed out to 1.2 kilometers (0.6 nautical miles), the maximum distance to which sonar equipment used in the study was able to detect changes in abundance. McCauley et al. (2017) noted that for seismic survey activities to have a significant impact on zooplankton at an ecological scale, the spatial or temporal scale of the seismic activity must be large in comparison to the ecosystem in question. In particular, three-dimensional seismic surveys, which involve the use of multiple overlapping tracklines to extensively and intensively survey a particular area, are of concern (McCauley et al. 2017). This is in part because in order for such activities to have a measurable effect, they need to outweigh the naturally fast turnover rate of zooplankton (McCauley et al. 2017). The proposed actions take place over a broad spatial area and will last for 33 days (28 days of airgun array operations, three days of [gravity and piston] coring activities and heat flow measurements, and two days of transit), meaning that we do not believe that the spatial or temporal scale of the high-energy seismic survey is large in relation to the marine environment off the U.S. East Coast.

However, Fields et al. (2019a) has demonstrated different results through a series of control experiments using seismic shots from two airguns (4,260.6 cubic centimeters [260 cubic inches]) during 2009 and 2010 on *Calanus finmarchicus*. Their data show that seismic blasts have limited effects on the mortality or escape response of *C. finmarchicus* within ten meters (32.8 feet) of the seismic airguns, but there was no measurable impact at greater distances. The study also found significantly higher immediate mortality at distances greater than five meters (16.4 feet) from the

airgun and a higher cumulative mortality (seven days after exposure) at a distance somewhere between ten to 20 meters (32.8 to 65.6 feet) from the airgun, and observed nor sublethal effects, but did see changes in gene expression (Fields et al. 2019a). Furthermore, Fields et al. (2019a) demonstrated that shots from seismic airguns had no effect on the escape response of *C. finmarchicus*. They conclude that the effects of shots from seismic airguns are much less than reported by McCauley et al. (2017).

Given the results from each of these studies, it is difficult to assess the exact impact seismic airgun arrays may have on the instantaneous or long-term survivability of zooplankton/krill that are exposed. Furthermore, the energy of the seismic survey activities (54,077.3 cubic centimeters [3,300 cubic inches] versus 2,458.1 or 4,260.6 cubic centimeters [150 or 260 cubic inches]) proposed in this consultation suggests that any copepod or crustacean directly exposed to the seismic airgun array (underneath or within five meters [16.4 feet] would likely suffer mortality to an extent less than described by McCauley et al. (2017).

Additionally, the majority of copepod prey available to baleen whales or fishes which are prey to these marine mammals, are expected to be near the water's surface (Witherington et al. 2012b), results of McCauley et al. (2017) provide little information on the effects to copepods at the water surface since their analyses excluded zooplankton at the surface bubble layer. We expect that sounds from the airgun array will affect copepod prey within the action area less than that reported in McCauley et al. (2017) because the airguns will primarily transmit sound downward and will be towed at depths of six meters (19.7 feet) so sounds will be relatively low at the water surface where most copepods and crustaceans occur. While the high-energy seismic survey may temporarily alter copepod or crustacean abundance in the action area, we expect such effects to be insignificant because most copepods will be near the water surface where the sound from airgun arrays is expected to be relatively low and the high turnover rate of zooplankton and ocean circulation will minimize any effects.

Fish or invertebrate mortality may be expected from exposure to airguns, but 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. 2000c; McCauley et al. 2003; Popper et al. 2005; Santulli et al. 1999). Lethal effects, if any, are expected within a few meters of the airgun array (Buchanan et al. 2004; Dalen and Knutsen 1986). We expect that if fishes who are not within close range to the airgun array, detect the sound, and leave the area, that it is because the sound is perceived as a threat or it causes some discomfort. We expect that these fishes will return to the area once the disturbance abates. For example, a common response by fishes to airgun sound is a startle or distributional response, where fish react momentarily by changing orientation or swimming speed, or change their vertical distribution in the water column (Davidsen et al. 2019; Fewtrell 2013a). During airgun studies in which the received sound levels were not reported, Fewtrell (2013a) observed caged *Pelates* spp., pink snapper (*Pristipomoides filamentosus*), and trevally (*Caranx ignobilis*) to generally exhibited startle, displacement, and/or grouping responses upon

exposure to airguns. This effect generally persisted for several minutes, although subsequent exposures to the same individuals did not necessarily elicit a response (Fewtrell 2013a). In addition, Davidsen et al. (2019) performed controlled exposure experiments on Atlantic cod (*Gadus morhua*) and saithe (*Pollachius virens*) to test their response to airgun noise. Davidsen et al. (2019) noted that cod exhibited reduced heart rate (bradycardia) in response to the particle motion component of the sound from the airgun, indicative of an initial flight response, however, no behavioral startle response to the airgun was observed. Furthermore, both the Atlantic cod and saithe change swimming depth and horizontal position more frequently during airgun sound production (Davidsen et al. 2019). We expect that if fish detect a sound and perceive it as a threat or some other signal that induces them to leave the area, that 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 and sea turtles.

There are reports showing sub-lethal effects to some fish species from airgun arrays. Several species at various life stages have been exposed to high-intensity sound sources (220 to 242 dB re: one 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: one μPa^2-second, but pike did show ten 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: one 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: one µPa (Falk and Lawrence 1973).

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

Whiting (*Merlangius merlangus*) exhibited a downward distributional shift upon exposure to 178 dB re: one 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: one 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: one 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: one 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: one 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: one 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: one 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 important prey for sperm whales and some sea turtle species. Squid responses to operating airguns have also been studied, although to a lesser extent than fishes. In response to airgun exposure, squid exhibited both startle and avoidance responses at received sound levels of 174 dB re: one µPa (rms) by first ejecting ink and then moving rapidly away from the area (Fewtrell 2013b; McCauley et al. 2000a; McCauley et al. 2000c). 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: one 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 Hz at 157 ± 5 dB re: one 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: one µPa, with peak levels at 175 dB re: one µPa. Guerra et al. (2004) suggested that giant squid mortalities were associated with seismic surveys based upon coincidence of carcasses with the seismic surveys in time and space, as well as pathological information from the carcasses. Another laboratory observed abnormalities in larval scallops after exposure to low frequency noise in tanks (de Soto et al. 2013). Lobsters did not exhibit delayed mortality, or apparent damage to mechanobalancing systems after up to eight months post-exposure to airguns fired at 202 or 227 dB peak-to-peak pressure (Christian 2013; Payne et al. 2013). However, feeding did increase in exposed individuals (Christian 2013; Payne et al. 2013).

Sperm whales regularly feed on squid and some fishes and we expect individuals to feed while in the action area during the seismic survey activities. Based upon the best available information, fishes and squids located within the sound fields corresponding to the approximate 160 dB re: one 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 airgun noise. Although some ESA-listed baleen whales (e.g., fin whales and sei 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 in localized areas to baleen whales (i.e., blue whales, fin whales, and sei whales). Sperm whales regularly feed on squid and some fishes and we expect individuals to feed while in the action area during the seismic survey activities. Based upon the best available information, fishes and squids located within the sound fields corresponding to the approximate 160 dB re: one µPa (rms) or 175 dB re: one µPa (rms) isopleths could vacate the area and/or dive to greater depths. We do not expect indirect effects from airgun array operations through reduced feeding opportunities for ESA-listed marine mammals and sea turtles to be sufficient to reach a significant level. Effects are likely to be temporary and, if displaced, both marine mammals and their prey will re-distribute back into the action area once seismic survey activities have passed or concluded.

Based on the available data, we anticipate seismic survey activities will result in temporary and minor reduction in the availability of prey for ESA-listed species near the airgun array immediately following the use of active seismic sound sources. This may be due to changes in prey distributions (i.e., due to avoidance) or abundance (i.e., due to mortality) or both. However, we do not expect this to have a meaningful immediate impact on ESA-listed marine mammals and sea turtles. 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 could be temporarily displaced or otherwise affected.

10.5 Summary of Effects

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

We measure risks to individuals of threatened or endangered species based upon effects on the individual's fitness, which may be indicated by changes to the individual's growth, survival, annual reproductive fitness, and lifetime reproductive success. We expect up to one blue whales, four fin whales, eight sei whales, and 406 sperm whales (Table 22), to be exposed to the airgun array within the 160 dB re: one µPa (rms) ensonified areas during the seismic survey activities. We expect up to 251 North Atlantic DPS of green turtles, three Kemp's ridley turtles, two leatherback turtles, and 1,047 Northwest Atlantic Ocean DPS of loggerhead turtles (Table 29), to be exposed to the airgun array within 175 dB re: one µPa (rms) ensonified areas during the seismic survey activities.

Because of the required conservation measures in the NMFS Permits Division's proposed IHA, and the nature of the seismic survey activities (high-energy airgun array), as described above, we do not expect any injury or mortality to ESA-listed species from the exposure to the acoustic sources resulting from the proposed actions. As described above, the proposed actions will result in temporary effects, largely behavioral responses (e.g., avoidance, discomfort, loss of foraging opportunities, loss of mating opportunities, masking, alteration of vocalizations, and stress) but with some potential for TTS, to the exposed marine mammals (blue whale, fin whale, sei whale, and sperm whale). Additionally, as described above, the proposed actions will result in temporary effects, largely behavioral responses (e.g., avoidance, discomfort, loss of foraging opportunities, and stress) but with some potential for TTS, to the exposed sea turtles (North Atlantic DPS of green turtle, Kemp's ridley turtle, leatherback turtle, and Northwest Atlantic Ocean DPS of loggerhead turtle). Harassment is not expected to have more than short-term effects on individual ESA-listed marine mammal and sea turtle species (blue whale, fin whale, sei whale, and sperm whale; North Atlantic DPS of green turtle, Kemp's ridley turtle, leatherback turtle, and Northwest Atlantic Ocean DPS of loggerhead turtle). Harm under the ESA is not expected to occur given the conservation measures (e.g., shutdown and buffer zones, shutdown procedures, pre-start clearance and ramp-up procedures, vessel-based visual monitoring by NMFS-approved PSOs, passive acoustic monitoring, vessel strike avoidance measures, and additional conservation measures) in place for the seismic survey activities to protect ESA-listed species.

Given that individual blue whales, fin whales, sei whales, and sperm whales may experience temporary behavioral responses from the seismic survey activities and those exposures are a small percentage of the regional populations. Specifically, we estimate effects to 0.25 percent of blue whales, 0.064 percent of fin whales, 0.13 percent of sei whales, and 9.35 percent of sperm whales. Individual North Atlantic DPS of green turtles, Kemp's ridley turtles, leatherback turtles, and Northwest Atlantic Ocean DPS of loggerhead turtles may also experience temporary behavioral responses from the seismic survey activities, though those exposures are an unknown

percentage of the regional populations. These estimates are considered conservative (i.e., they are likely higher than what the actual exposures would be and a fewer number are likely to be harassed given the conservation measures that will be implemented). Because of the large ranges of the affected ESA-listed marine mammals and sea turtles compared to the relatively small size of the action area, combined with the relatively short duration of the seismic survey activities, there is the potential that there may be multiple exposures of a small number of individuals in the action area. No designated critical habitat for these species will be adversely affected by the seismic survey activities associated with the proposed actions (Section 7.3).

11 CUMULATIVE EFFECTS

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

We expect that those aspects described in the Environmental Baseline (Section 9) will continue to impact ESA-listed resources into the foreseeable future. We expect climate change, vessel interactions (vessel strikes and whale watching), fisheries (fisheries interactions), pollution (marine debris, pollutants and contaminants, and hydrocarbons), aquatic nuisance species, anthropogenic sound (vessel sound and commercial shipping, aircraft, seismic surveys, offshore energy development, marine construction, active sonar, and military activities), and scientific research activities to continue into the future for marine mammals.

Because of recent trends and based on available information, we expect the amount and frequency of vessel activity to persist in the action area, and that ESA-listed species will continue to be affected. Different aspects of vessel activity can affect ESA-listed species, such as vessel noise, disturbance, and the risk of vessel strike causing injury or mortality to marine mammals, especially large whales. However, movement towards bycatch reduction and greater foreign protections are generally occurring throughout the Northwest Atlantic Ocean off North Carolina, which may aid in abating the downward trajectory of some populations due to activities such as fishing in the action area.

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

An increase in these activities could similarly increase their effect on ESA-listed species and for some, an increase in the future is considered reasonably certain to occur. Given current trends in global population growth, threats, associated with climate change, pollution, fisheries, bycatch, vessel strikes and approaches, and anthropogenic sound are likely to continue to increase in the future, although any increase in effect may be somewhat countered by an increase in conservation and management activities. In contrast, more historical threats such as whaling are likely to remain low or potentially decrease. For the remaining activities and associated threats identified in the Environmental Baseline, and other unforeseen threats, the magnitude of increase and significance of any anticipated effects remain unknown. The best scientific and commercial data available provide little specific information on any long-term effects of these potential sources of disturbance on ESA-listed species. Thus, this consultation assumed effects in the future would be similar to those in the past and, therefore, are reflected in the anticipated trends described in the Species Likely to be Adversely Affected and Environmental Baseline, respectively.

12 INTEGRATION AND SYNTHESIS

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

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

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

12.1 Jeopardy Analysis

The jeopardy analysis relies upon the regulatory definition of "to jeopardize the continued existence of a listed species," which is "to engage in an action that would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed

species in the wild by reducing the reproduction, numbers, or distribution of that species" (50 C.F.R. §402.02). Therefore, the jeopardy analysis considers both the survival and recovery of the species.

Based on our effect analysis, adverse effect to ESA-listed species are likely to result from the proposed actions. The following discussions summarize the probably risks that seismic survey activities pose to ESA-listed species that are likely to be exposed over the approximately 33 days (28 days of airgun array operations, three days of [gravity and piston] coring activities and heat flow measurements, and two days of transit) of the high-energy seismic survey. These summaries integrate our exposure and response analyses from the Effects of the Actions (Section 10).

12.2 Blue Whale

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

The blue whale is endangered because of past commercial whaling. In the North Atlantic Ocean, at least 11,000 blue whales were harvested from the late 19th to mid-20th centuries. In the North Pacific Ocean, at least 9,500 blue whales were killed between 1910 and 1965. In the Southern Hemisphere, it is estimated that about 360,000 blue whales were killed in the last century, reducing the population of Antarctic blue whales from 239,000 individuals (95 percent CI=202,000 to 311,000 individuals) in 1904 to just 360 individuals (95 percent CI=150 to 840 individuals) in the early 1970's. Currently, the Antarctic blue whale population estimate is 2,280 individuals (CV=0.36) (NMFS 2020b). Commercial whaling no longer occurs, but blue whales are threatened by vessel strikes, marine debris and fishing gear ingestion and/or entanglement, anthropogenic noise, and loss of prey base due to climate change and ecosystem change.

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. In U.S. waters, NMFS recognizes three stocks: the eastern North Pacific Ocean, central North Pacific Ocean, and western North Atlantic Ocean. Blue whale abundance for the eastern North Pacific stock is estimated at 1,898 individuals (lower [N_{min}] and upper 20th percentile: 1,767 to 2,038 individuals) (Calambokidis and Barlow 2020). Abundance estimates for the central North Pacific stock (around the Hawaiian Islands) is 137 individuals (95 percent CI=23 to 796 individuals) (Bradford et al. 2021). There is much uncertainty when estimating abundance for the western North Atlantic stock due to low numbers of encountered and photographed individuals; however, researchers believe there may be between 400 to 600 individuals based on the Gulf of St. Lawrence photographic-identification catalog (N_{min}= 402 individuals; (Hayes et al. 2020). In the Southern Hemisphere, the abundance estimate for Antarctic blue whales is 2,280 individuals based on surveys from 1991/1992 through

2003/2004 (95 percent CI=1,160 to 4,500 individuals; (Branch 2007). While no range-wide estimate for pygmy blue whales exists (Thomas et al. 2016), the latest estimate for pygmy blue whales off the west coast of Australia is 662 to 1,559 individuals based on passive acoustic monitoring (McCauley and Jenner 2010), or 712 to 1,754 individuals based on photographic mark-recapture (Jenner 2008). The abundance estimate for pygmy blue whales off New Zealand based on a closed capture-recapture model is 718 individuals (95 percent CI=279 to 1,926 individuals) (Barlow et al. 2018). There are no current abundance estimates for the Chilean (unnamed subspecies) blue whale across its entire range; however, based on line transect surveys conducted off central Chile December 1997 through January 1998, estimated abundance is 303 individuals (95 percent CI=176 to 625 individuals) (Williams et al. 2011). Estimated abundance based on capture-recapture for central and southern Chile from 2004 through 2011 is between 570 to 760 individuals (95 percent CI for right and left flank photographs: 475 to 705 individuals and 638 to 933 individuals, respectively) (Galletti Vernazzani et al. 2017).

Current estimates indicate the Eastern North Pacific stock shows no signs of population growth since the early 1990s, perhaps because the population is nearly at carrying capacity (Carretta et al. 2018). An overall population growth rate for the species or growth rates for the two other individual U.S. stocks (central North Pacific Ocean and western North Atlantic Ocean) are not available at this time. In the Southern Hemisphere, it is estimated that whaling reduced the population from 239,000 individuals (95 percent CI=202,000 to 311,000 individuals) in 1904 to just 360 individuals (95 percent CI=150 to 840 individuals) in the early 1970's. Currently, the Antarctic population appears to be increasing at a rate of 8.2 percent per year (95 percent CI=1.6 to 14.8 percent; (95 percent confidence interval 1.6 to 14.8 percent, Branch 2007). Population trends are largely unknown for the pygmy blue whale, though it is estimated that the current population represents less than 23 percent of the historical pre-whaling population (NMFS 2020b).

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

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

The 2020 Recovery Plan for the blue whale (NMFS 2020b) lists recovery objectives for the species. The following recovery objectives are relevant to the impacts of the proposed actions:

- Increase blue whale resiliency and ensure geographic and ecological representation by achieving sufficient and viable populations in all ocean basins and in each recognized subspecies.
- Increase blue whale resiliency by managing or eliminating significant anthropogenic threats.

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

12.3 Fin Whale

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

The fin whale is endangered because of past commercial whaling. Prior to commercial whaling, hundreds of thousands of fin whales existed. The pre-exploitation estimate for the fin whale population in the North Pacific Ocean was 42,000 to 45,000 (Ohsumi and Wada 1974). In the North Atlantic Ocean, at least 55,000 fin whales were killed between 1910 and 1989. Approximately 704,000 fin whales were killed in the Southern Hemisphere from 1904 through 1975. Fin whales may be killed under "aboriginal subsistence whaling" in Greenland, under Japan's commercial whaling program, and Iceland's formal objection to the IWC's ban on commercial whaling. Additional threats include vessel strikes, reduced prey availability due to overfishing or climate change, and anthropogenic sound. The species' overall large population size may provide some resilience to current threats, but trends are largely unknown.

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. Of the three to seven stocks thought to occur in the North Atlantic Ocean (approximately 50,000 individuals), NMFS currently manages four stocks: Western North Atlantic, Northeast Pacific, California/Oregon/Washington, and Hawaii. The current population abundance estimate for the Western North Atlantic stock is 6,802 individuals (CV=0.24), and minimum population estimate (N_{min}) is 5,573 individuals (Hayes et al. 2022). While there are no reliable estimates of abundance (current or historical) for the entire Northeast Pacific stock, studies have estimated abundance for specific surveyed areas: eastern Bering Sea (in 2002: 419 individuals [CV=0.33];

in 2008: 1,368 individuals [CV=0.34]; in 2010: 1,061 individuals [CV=0.38]); western Alaska and the eastern and central Aleutian Islands (between 2001 and 2003: 1,652 individuals (95 percent CI=1,142 to 2,389 individuals); offshore waters of the Gulf of Alaska (in 2013: 3,168 individuals [CV=0.26] and in 2015: 916 individuals [CV=0.39]). The minimum population estimate for the Northeast Pacific stock is 2,554 individuals (Muto et al. 2021). For the California/Oregon/Washington and Hawaii stocks, the current population estimate is 11,065 individuals (CV=0.405) in 2018 (N_{min}=7,970 individuals) and 203 individuals (CV=0.99) in 2017 (N_{min}=101 individuals), respectively (Carretta et al. 2022). 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). The most current population estimate for fin whales in the Antarctic south of 60 degrees South is 5,445 individuals (95 percent CI=2,000 to 14,500 individuals) between 1991 and 2004 (Leaper and Miller 2011). The International Whaling Commission (IWC) also recognizes the China Sea stock of fin whales, found in the Northwest Pacific Ocean, which currently lacks an abundance estimate (Reilly et al. 2013). For apparent resident populations (Mediterranean Sea and East China Sea), population estimates for the western Mediterranean, Corsican-Ligurian-Provençal Basin, and Pelagos Sanctuary are 3,583 individuals (95 percent CI=2,130 to 6,027 individuals) in 1991, 901 individuals (95 percent CI=591 to 1,374 individuals) in 1992, and 539 individuals (95 percent CI=345 to 732 individuals), respectively (NMFS 2019).

Population trends for the Western North Atlantic, Hawaii, Southern Hemisphere, Mediterranean, and East China Sea stocks are not currently available. For the Northeast Pacific stock, there was an increasing trend by 4.8 percent (95 percent CI=4.1 to 5.4 percent) between 1987 and 2003 (Carretta et al. 2022). For the California/Oregon/Washington stock, there is strong evidence that population abundance is increasing; from 1991 through 2014, abundance increased 7.5 percent annually (Nadeem et al. 2016), though it is unknown how much of that rate could be attributed to immigration rather than birth and death processes (Carretta 2019b). An overall population trend in U.S. Pacific Ocean waters has not been established, but there is evidence that there has been increasing rates in the recent past in different parts of the region. 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 the distribution of fin whales from the Northwest Atlantic Ocean off North Carolina or changes to the geographic range of the species are expected because of the NSF and L-DEO's seismic survey activities and the NMFS Permits Division's issuance of an IHA and possible renewal.

No reduction in numbers is anticipated as part of the proposed actions. Therefore, no reduction in reproduction is expected because of the proposed actions. Non-lethal take of four individuals, adults, juveniles, and calves, is expected as a result of the seismic survey activities. We anticipate temporary behavioral responses (e.g., avoidance, discomfort, loss of foraging opportunities, loss of mating opportunities, masking, alteration of vocalizations, and stress) with

some potential for TTS, with individuals returning to normal shortly after the exposure has ended, and thus do not anticipate any delay in reproduction as a result. Given that we do not anticipate a reduction in numbers or reproduction of fin whales because of the seismic survey activities and the NMFS Permits Division's issuance of an IHA and possible renewal, a reduction in the species' likelihood of survival is not expected.

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

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

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

12.4 Sei Whale

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

The sei whale is endangered because of past commercial whaling. No estimates of pre-exploitation population size are available and the total number of sei whales in the North Atlantic Ocean is not known (Waring and et al. 2009). Now, only a few individuals are taken each year by Japan; however, Iceland has expressed an interest in targeting sei whales. Current threats include vessel strikes, fisheries interactions (including entanglement), climate change (habitat loss and reduced prey availability), and anthropogenic noise. 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.

Though there are no current estimates of global abundance for sei whales, (Wiles 2017) provides a rough estimate of 250,000 sei whales pre-whaling to 32,000 sei whales during the 1970s and 1980s. 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 central and eastern North Pacific Ocean population was estimated to be 29,632 individuals (95 percent CI=18,576 to 47,267 individuals) between 2010 and 2012 (IWC 2016; Thomas et al. 2016). Surveys of the western North Pacific Ocean were estimated to be 5,086 individuals (CV=0.38) in 2008 (Hakamada and Matsuoka

2016). In the Southern Hemisphere, pre-exploitation abundance is estimated at 65,000 individuals, with recent abundance estimated at 9,800 to 12,000 individuals. Three relatively small stocks occur in U.S. waters: Nova Scotia, Hawaii, and Eastern North Pacific Ocean. The Nova Scotia stock (Halifax, Nova Scotia to Florida) population is estimated at 6,292 individuals (CV=1.02; N_{min}=3,098 individuals) from surveys conducted in the spring from 2010 through 2013 (March through May, when sei whale density is predicted to be highest; (Hayes et al. 2022). The population estimate for the Hawaii stock of sei whales is 391 individuals (CV=0.9) based on a survey of the Hawaiian Islands Exclusive Economic Zone from August through December 2010 (Bradford et al. 2017). This is the best estimate even though a majority of sei whales would be expected to be in higher-latitude feeding grounds during that time of the year (Carretta et al. 2022). The minimum number for the Hawaii stock of sei whales is 204 individuals. In the eastern North Pacific Ocean, the sei whale population is estimated at 311 individuals (CV=0.76) based on surveys in 2008 and 864 individuals (CV=0.4) based on surveys in 2014; the best estimate is the mean of these two estimates, or 519 individuals (CV=0.4; N_{min}=374 individuals; (Barlow 2016)). 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. The apparent increase in Eastern North Pacific stock of sei whales from 2008 through 2014 may be partially due to recovery from commercial whaling, but may also be due to distributional shifts (Barlow 2016).

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

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

The 2011 Final Recovery Plan for the sei whale (NMFS 2011b) lists recovery objectives for the species. The following recovery objectives are relevant to the impacts of the proposed actions:

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

Because no mortalities or effects on the abundance, distribution, and reproduction of sei whale populations are expected because the proposed actions, we do not anticipate the seismic survey

activities and the NMFS Permits Division's issuance of an IHA and possible renewal will impede the recovery objectives for sei whales. In conclusion, we believe the non-lethal effects associated with the proposed actions will not appreciably reduce the likelihood of survival and recovery of sei whales in the wild by reducing the reproduction, numbers, or distribution of the species.

12.5 Sperm Whale

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

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

The sperm whale is the most abundant of the large whale species, with total abundance estimates between 200,000 and 1,500,000. The most recent estimate indicated a global population of between 300,000 and 450,000 individuals (Whitehead 2009). The higher estimates may be approaching population sizes prior to commercial whaling, the reason for ESA-listing. It is estimated that well over 1,000,000 sperm whales were killed between the 1950's and 1999 (NMFS 2015b). There are six recognized sperm whale stocks in U.S. waters: Puerto Rico and U.S. Virgin Islands, Northern Gulf of Mexico, North Atlantic, North Pacific, California/Oregon/Washington, and Hawaii.

There are no reliable estimates for sperm whale abundance across the entire North Atlantic Ocean. The population estimate for Puerto Rico and U.S. Virgin Islands stock is unknown. The best population estimate for the Northern Gulf of Mexico stock is 1,180 individuals (CV=0.22) from 2017 and 2018 summer/fall surveys [N_{min}=983 individuals; (Garrison et al. 2020). For the North Atlantic stock, the best recent abundance estimate is 4,349 individuals (CV=0.28), which is the sum of abundance estimates from Central Florida to the lower Bay of Fundy in 2016 (N_{min}=3,451 individuals; (Garrison 2020); (Palka 2020). No trend analysis has been conducted for the North Atlantic stock. In the North Pacific Ocean, the abundance of sperm whales was estimated to be 1,260,000 individuals prior to commercial whaling. In 1997, population estimates in the northeastern temperate North Pacific Ocean were 26,300 individuals (CV=0.81) and 32,100 individuals (CV=0.36) based on visual and acoustic surveys, respectively (NMFS 2015b). In the eastern tropical Pacific Ocean, the abundance of sperm whales was estimated to be 22,700 individuals (95 percent CI=14,800 to 34,600 individuals) in 1993 (NMFS 2015b). There are

insufficient data to reliably estimate the population abundance of the North Pacific stock; however, N_{min} is estimated at 244 sperm whales in the Gulf of Alaska (Rone et al. 2017). The best population estimate for the California/Oregon/Washington stock is 1,997 individuals (CV=0.57) in 2014 (N_{min}=1,270 individuals; (Moore and Barlow 2014). The population estimate for the Hawaii stock is 5,707 individuals (CV=0.23) in 2017 (N_{min}=4,486 individuals; (Becker et al. 2021). There are currently no reliable population estimates for sperm whales in the South Pacific Ocean. There is insufficient data to evaluate trends in abundance and growth rates of sperm whale populations at this time. An attempt to determine trends for the Northern Gulf of Mexico stock showed no significant differences in abundance estimates between 2003 and 2018; however, there is little statistical power to detect a trend because of the relatively imprecise estimates and limited survey area (Garrison et al. 2020). Additionally, it has been reported that the California/Oregon/Washington stock abundance appeared stable, but the estimated growth rate include high uncertainty levels.

No reduction in the distribution of sperm whales from the Northwest Atlantic Ocean off North Carolina or changes to the geographic range of the species are expected because of the NSF and L-DEO's seismic survey activities and the NMFS Permits Division's issuance of an IHA and possible renewal.

No reduction in numbers is anticipated as part of the proposed actions. Therefore, no reduction in reproduction is expected because of the proposed actions. Non-lethal take of 406 individuals, adults, juveniles, and calves, is expected because of the seismic survey activities. We anticipate temporary behavioral responses (e.g., avoidance, discomfort, loss of foraging opportunities, loss of mating opportunities, masking, alteration of vocalizations, and stress) with some potential for TTS, with individuals returning to normal shortly after the exposure has ended, and thus do not anticipate any delay in reproduction as a result. Because we do not anticipate a reduction in numbers or reproduction of sperm whales due to the seismic survey activities and the NMFS Permits Division's issuance of an IHA and possible renewal, a reduction in the species' likelihood of survival is not expected.

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

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

Because no mortalities or effects on the abundance, distribution, and reproduction of sperm whale populations are expected because of the proposed actions, we do not anticipate the seismic survey activities and the NMFS Permits Division's issuance of an IHA and possible renewal will impede the recovery objectives for sperm whales. In conclusion, we believe the non-lethal effects associated with the proposed actions will not appreciably reduce the likelihood of

survival and recovery of sperm whales in the wild by reducing the reproduction, numbers, or distribution of the species.

12.6 Green Turtle – North Atlantic Distinct Population Segment

Adult, juvenile, and post-hatchling North Atlantic DPS of green turtles are present in the action area and are expected to be exposed to noise from the seismic survey activities. The severity of an animal's response to noise associated with the high-energy seismic survey will depend on the duration and severity of exposure.

Once abundant in tropical and subtropical waters, green turtles worldwide exist at a fraction of their historical abundance, as a result of over-exploitation for food and other products. Globally, egg harvest, the harvest of females on nesting beaches and directed hunting of sea turtles in foraging areas remain the three greatest threats to their recovery. In addition, bycatch in drift-net, long-line, set-net, pound-net, and trawl fisheries kill thousands of green turtles annually. Other threats include pollution, habitat loss through coastal development or stabilization, destruction of nesting habitat from storm events, artificial lighting, poaching, global climate change, natural predation, disease, cold-stunning events, and oil spills.

Historically, green turtles in the North Atlantic DPS were hunted for food, which was the principle cause of the population's decline. While the threats of pollution, habitat loss through coastal development, beachfront lighting, and fisheries bycatch continue, the North Atlantic DPS of green turtle appears to be somewhat resilient to future perturbations.

For the North Atlantic DPS of green turtle the available data indicate an increasing trend in nesting. There is no reliable estimates of population growth rate of the North Atlantic DPS as a whole, but estimates have been developed at a localized level. Apparent increases in nester abundance for the North Atlantic DPS of green turtle in recent years are encouraging, but must be viewed cautiously, as the datasets represent a fraction of green turtle generation, up to 50 years.

No reduction in the distribution of North Atlantic DPS of green turtles from the Northwest Atlantic Ocean off North Carolina or changes to the geographic range of the species are expected because of the NSF and L-DEO's seismic survey activities and the NMFS Permits Division's issuance of an IHA and possible renewal.

No reduction in numbers is anticipated as part of the proposed actions. Therefore, no reduction in reproduction is expected because of the proposed actions. Non-lethal take of 251 individuals, adults, juveniles, and post-hatchlings, is expected because of the seismic survey activities. Density data were not were not available to quantify the number of exposures for small sea turtles (less than 30 centimeters [11.8 inches]). Any small sea turtle found within an ensonified area of 1,417.5 square kilometers (413.3 square nautical miles) and 8,354.5 square kilometers (2,435.8 square nautical miles) are expected to be taken in the form of harassment in intermediate water depths and deep water depths, respectively. We anticipate temporary behavioral responses (e.g., temporary displacement and stress) with some potential for TTS, with

individuals returning to normal shortly after the exposure has ended, and thus do not anticipate any delay in reproduction as a result. Because we do not anticipate a reduction in numbers or reproduction of North Atlantic DPS of green turtles due to the seismic survey activities and the NMFS Permits Division's issuance of an IHA and possible renewal, a reduction in the species' likelihood of survival is not expected.

The Recovery Plan (NMFS 1991) for the U.S. Atlantic population of green turtle lists recovery objectives for the species. The following recovery objectives are relevant to the impacts of the proposed actions:

- Determine distribution and seasonal movements for all life stages in marine environment.
- Reduce threat to pollution and foraging habitat from marine pollution.

Because no mortalities or effects on the abundance, distribution, and reproduction of North Atlantic DPS of green turtles are expected because of the proposed actions, we do not anticipate the seismic survey activities and the NMFS Permits Division's issuance of an IHA and possible renewal will impede the recovery objectives for Kemp's ridley turtles. In conclusion, we believe the non-lethal effects associated with the proposed actions will not appreciably reduce the likelihood of survival and recovery of North Atlantic DPS of green turtles in the wild by reducing the reproduction, numbers, or distribution of the species.

12.7 Kemp's Ridley Turtle

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

Kemp's ridley turtles face many of the same threats as other sea turtle species, including destruction of nesting habitat from storm events, oceanic events such as cold-stunning, pollution (plastics, petroleum products, petrochemicals, etc.) ecosystem alterations (nesting beach development, beach nourishment and shoreline stabilization, vegetation changes, etc.), poaching, global climate change, fisheries interactions, natural predation, and disease.

The Kemp's ridley turtle was listed as endangered in response to a severe population decline, primarily the result of egg collection. In 1973, legal ordinances prohibited the harvest of sea turtles from May through August, and in 1990, the harvest of all sea turtles was prohibited by presidential decrees in Mexico. In 2002, Rancho Nuevo was declared a sanctuary. A successful head-start program resulted in re-establishment of nesting on Texas beaches. While fisheries bycatch remains a threat, the use of sea turtle excluder devices mitigates take. Fishery interactions and strandings, possibly due to forced submergence, appear to be the main threats to the species. The *Deepwater Horizon* oil spill event reduced nesting abundance and associated hatchling production as well as exposures to oil in the oceanic environment which has resulted in large losses of the population across various age classes, and likely had an important population-level effect on the species. We do not have an understanding of those impacts on the population

trajectory for the species into the future. The species' limited range and low global abundance make it vulnerable to new sources of mortality as well as demographic and environmental randomness, all of which are often difficult to predict with any certainty. Therefore, its resilience to future perturbation is low.

Of the sea turtle species in the world, the Kemp's ridley has declined to the lowest population level. Nesting aggregations at a single location (Rancho Nuevo, Mexico) were estimated at 40,000 females in 1947. By the mid-1980s, the population had declined to an estimated 300 nesting females. Nesting steadily increased through the 1990s, and then accelerated during the first decade of the 21st century. Following a significant, unexplained one-year decline in 2010, Kemp's ridley turtle nests in Mexico reached a record high of 21,797 in 2012 (NPS 2013). In 2013, there was a second significant decline with 16,385 nests recorded. In 2014, there were an estimated 10,987 nests and 519,000 hatchlings released from three primary nesting beaches in Mexico (NMFS and USFWS 2015). The number of nests in Padre Island, Texas has increased over the past two decades, with one nest observed in 1985, four in 1995, 50 in 2005, 197 in 2009, 209 in 2012, and 119 in 2014 (NMFS and USFWS 2015).

From 1980 through 2003, the number of nests at three primary nesting beaches (Rancho Nuevo, Tepehuajes, and Playa Dos) increased 15 percent annually (Heppell et al. 2005); however, due to recent declines in nest counts, decreased survival at other life stages, and updated population modeling, this rate is not expected to continue (NMFS and USFWS 2015). In fact, nest counts dropped by more than a third in 2010 and continue to remain below predictions (Caillouet et al. 2018). Kemp's ridley turtle nesting population was exponentially increasing (NMFS et al. 2011); however, since 2009 there has been concern over the slowing of recovery (Gallaway et al. 2016a; Gallaway et al. 2016b; Plotkin 2016).

No reduction in the distribution of Kemp's ridley turtles from the Northwest Atlantic Ocean off North Carolina or changes to the geographic range of the species are expected because of the NSF and L-DEO's seismic survey activities and the NMFS Permits Division's issuance of an IHA and possible renewal.

No reduction in numbers is anticipated as part of the proposed actions. Therefore, no reduction in reproduction is expected because of the proposed actions. Non-lethal take of three individuals, adults, juveniles, and post-hatchlings, is expected because of the seismic survey activities. Density data were not were not available to quantify the number of exposures for small sea turtles (less than 30 centimeters [11.8 inches]). Any small sea turtle found within an ensonified area of 1,417.5 square kilometers (413.3 square nautical miles) and 8,354.5 square kilometers (2,435.8 square nautical miles) are expected to be taken in the form of harassment in intermediate water depths and deep water depths, respectively. We anticipate temporary behavioral responses (e.g., temporary displacement and stress) with some potential for TTS, with individuals returning to normal shortly after the exposure has ended, and thus do not anticipate any delay in reproduction as a result. Because we do not anticipate a reduction in numbers or reproduction of Kemp's ridley turtles due to the seismic survey activities and the NMFS Permits

Division's issuance of an IHA and possible renewal, a reduction in the species' likelihood of survival is not expected.

The 2011 Final BI-National (U.S. and Mexico) Revised Recovery Plan (NMFS and USFWS 2011) for the population of Kemp's ridley turtle lists recovery objectives for the species. The following recovery objectives are relevant to the impacts of the proposed actions:

- Protect and manage nesting and marine habitats.
- Protect and manage populations on nesting beaches and in the marine environment.
- Maintain, promote awareness of and expand U.S. and Mexican laws.
- Enforce laws.

Because no mortalities or effects on the abundance, distribution, and reproduction of Kemp's ridley turtle populations are expected because of the proposed actions, we do not anticipate the seismic survey activities and the NMFS Permits Division's issuance of an IHA and possible renewal will impede the recovery objectives for Kemp's ridley turtles. In conclusion, we believe the non-lethal effects associated with the proposed actions will not appreciably reduce the likelihood of survival and recovery of Kemp's ridley turtles in the wild by reducing the reproduction, numbers, or distribution of the species.

12.8 Leatherback Turtle

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

The leatherback turtle is an endangered species whose once large nesting populations have experienced steep declines in recent decades. The status of the subpopulations in the Atlantic, Indian, and Pacific Oceans are generally declining, except for the subpopulation in the Southwest Atlantic Ocean, which is slightly increasing. Leatherback turtles show a lesser degree of nest site fidelity than occurs with hardshell sea turtle species.

The primary threats to leatherback turtles include fisheries interactions (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, vegetation changes, sand extraction, beach nourishment, shoreline stabilization, and natural disasters (e.g., storm events and tsunamis) as well as cold-stunning, vessel interaction, pollution (contaminants, marine debris and plastics, petroleum products, petrochemicals), ghost fishing gear, natural predation, parasites, and disease. Artificial lights on or adjacent to nesting beaches alter nesting adult female behavior and are often fatal to post-nesting females and emerging hatchlings as they are drawn to light sources and away from the sea. Ingestion of marine debris (plastic) is common in leatherback turtles and can block gastrointestinal tracts leading to death. Climate change may alter sex ratios (as temperature determines hatchling sex) and nest success, range (through

expansion of foraging habitat as well as alter spatial and temporal patterns), and habitat (through the loss of nesting beaches, because of sea-level rise and storms). Oceanographic regime shifts possibly impact foraging conditions that may affect nesting female size, clutch size, and egg size of populations. The species' resilience to additional perturbation is low.

Detailed population structure is unknown, but is likely dependent upon nesting beach location and influenced by physical barriers (i.e., land masses), current systems, and long migrations. The total index of nesting female abundance in the Northwest Atlantic Ocean is 20,659 females. Based on estimates calculated from nesting data, there are approximately 18,700 (10,000 to 31,000 nesting females) total adult leatherback turtles in the North Atlantic Ocean (TEWG 2007a). The total index of nesting female abundance in the Southwest Atlantic Ocean is approximately 27 females. The total index of nesting female abundance in the Southeast Atlantic Ocean is approximately 9,198 females. The total index of nesting female abundance in the Southwest Indian Ocean is approximately 149 females. The total index of nesting female abundance in the Northeast Indian Ocean is approximately 109 females. The total index of nesting female abundance in the West Pacific Ocean is approximately 1,277 females. The total index of nesting female abundance in the East Pacific Ocean is approximately 755 females. The total index of nesting female abundance is likely an underestimate because we did not have adequate data from many nesting beaches, which have the potential for being unmonitored or unidentified.

Population growth rates for leatherback turtles vary by ocean basin. Leatherback turtles in the Northwest Atlantic Ocean exhibit a decreasing nest trend at nesting beaches with the greatest known nesting female abundance. This decline has become more pronounced (2008 through 2017), and the available nest data reflect a steady decline for more than a decade (Eckert and Mitchell 2018). Leatherback turtles in the Southwest Atlantic Ocean exhibit an increasing, although variable, nest trend (nearly five percent average annual increase, with the largest increase occurring in the past decade). Leatherback turtles in the Southeast Atlantic Ocean exhibit a declining nest trend (8.6 percent annually) at the largest nesting aggregation (Gabon). Leatherback turtles in the Southwestern Indian Ocean exhibit a slightly decreasing nest trend at monitored nesting beaches (South Africa). Leatherback turtles in the Northeast Indian Ocean exhibit a drastic population decline with extirpation of its largest nesting aggregation in Malaysia. The overall nest trend has drastically decreased over the past several decades. Leatherback turtles in the West Pacific Ocean exhibit low hatching success and a declining nest and population trend. Leatherback turtles in the East Pacific Ocean exhibit a decreasing trend since monitoring began, with a 97.4 percent decline (depending on the nesting beach) since the 1980s or 1990s Wallace et al. (2013). Despite intense conservation efforts, the decline in nesting has not been reverse as of 2011 (Benson et al 2015).

No reduction in the distribution of leatherback turtles from the Northwest Atlantic Ocean off North Carolina or changes to the geographic range of the species are expected because of the

NSF and L-DEO's seismic survey activities and the NMFS Permits Division's issuance of an IHA and possible renewal.

No reduction in numbers is anticipated as part of the proposed actions. Therefore, no reduction in reproduction is expected because of the proposed actions. Non-lethal take of two individuals, adults, juveniles, and post-hatchlings, is expected because of the seismic survey activities. Density data were not were not available to quantify the number of exposures for small sea turtles (less than 30 centimeters [11.8 inches]). Any small sea turtle found within an ensonified area of 1,417.5 square kilometers (413.3 square nautical miles) and 8,354.5 square kilometers (2,435.8 square nautical miles) are expected to be taken in the form of harassment in intermediate water depths and deep water depths, respectively. We anticipate temporary behavioral responses (e.g., temporary displacement and stress) with some potential for TTS, with individuals returning to normal shortly after the exposure has ended, and thus do not anticipate any delay in reproduction as a result. Because we do not anticipate a reduction in numbers or reproduction of leatherback turtles due to the seismic survey activities and the NMFS Permits Division's issuance of an IHA and possible renewal, a reduction in the species' likelihood of survival is not expected.

The 1998 and 1991 Recovery Plans (NMFS 1998c) for the U.S. Caribbean, Gulf of Mexico, and Atlantic Ocean for the population of leatherback turtle lists recovery objectives for the species. The following recovery objectives are relevant to the impacts of the proposed actions:

- International cooperation.
- Monitoring and research.

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

12.9 Loggerhead Turtle – Northwest Atlantic Ocean Distinct Population Segment

Adult, juvenile, and post-hatchling Northwest Atlantic Ocean DPS of loggerhead turtles are present in the action area and are expected to be exposed to noise from the seismic survey activities. The severity of an animal's response to noise associated with the high-energy seismic survey will depend on the duration and severity of exposure.

Based on the currently available information, the overall nesting trend of the Northwest Atlantic Ocean DPS of loggerhead turtle appears to be stable, neither increasing or decreasing, for over two decades (NMFS and USFWS 2023). Destruction and modification of terrestrial and marine habitats threaten the Northwest Atlantic Ocean DPS of loggerhead turtles. On beaches, threats and interfere with successful nesting, egg incubation, hatchling emergence, and transit to the sea

include erosion, erosion control, coastal development, artificial lighting, beach use, and beach debris (NMFS and USFWS 2023). In the marine environment, threats that interfere with foraging and movement include marine debris, oil spills and other pollutants, harmful algal blooms, and noise pollution (NMFS and USFWS 2023).

It is difficult to estimate the overall abundance for sea turtle populations because individuals spend most of their time in water, where they are difficult to count, especially considering their large range and use of many different and distance habitats. Females, however, converge on their natal beaches to lay eggs and nests are easily counted. The total number of annual U.S. nest counts for the Northwest Atlantic DPS of loggerhead turtles is over 110,000 (NMFS and USFWS 2023).

In water estimates of abundance include juvenile and adult life stages of loggerhead turtle males and females are difficult to perform on a wide scale. In the summer of 2010, NMFS' Northeast Fisheries Science Center and Southeast Fisheries Science Center estimated the abundance of juvenile and adult loggerhead turtles along the continental shelf between Cape Canaveral, Florida and the mouth of the Gulf of St. Lawrence, Canada, based on the Atlantic Marine Assessment Program for Protected Species aerial line-transect sighting survey and satellite tagged loggerhead turtles (NMFS 2011d). They provided a preliminary regional abundance estimate of 588,000 individuals (approximate inter-quartile range of 382,000 to 817,000 individuals) based on positively identified loggerhead turtle sightings (NMFS 2011). A separate, smaller aerial survey, conducted in the southern portion of the Mid-Atlantic Bight and Chesapeake Bay in 2011 and 2012, demonstrated uncorrected loggerhead turtle abundance ranging from a spring high of 27,508 to a fall low of 3,005 loggerhead turtles (NMFS and USFWS 2023). We are not aware of any current rangewide in-water estimates for the Northwest Atlantic Ocean DPS of loggerhead turtle.

Nesting data are the best current indicator of population trends in sea turtles, but in-water data also provide some insight. In-water research suggests the abundance of neritic juveniles is steady or increasing. Although Ehrhart et al. (2007) found no significant regression-line trend in a long-term dataset, researchers have observed notable increases in catch per unit effort (Arendt et al. 2009; Ehrhart et al. 2007; Epperly et al. 2007b). Researchers believe that this increase in catch per unit effort is likely linked to an increase in abundance of juveniles. Although it is unclear whether this increase in abundance represents a true population increase among juveniles or merely a shift in spatial occurrence. Bjorndal et al. (2005) caution about extrapolating localized in-water trends to the broader population and relating localized trends in neritic sites to population trends at nesting beaches. The apparent overall increase in the abundance of the largest oceanic/neritic juveniles (historically referred to as small benthic juveniles), which could indicate a relatively large number of individuals around the same age may mature in the near future (TEWG 2009). However, in-water studies throughout the eastern U.S. indicate a substantial decrease in abundance of the smallest oceanic/neritic juvenile loggerhead turtles, a pattern corroborated by stranding data (TEWG 2009).

No reduction in the distribution of Northwest Atlantic Ocean DPS of loggerhead turtles from the Northwest Atlantic Ocean off North Carolina or changes to the geographic range of the species are expected because of the NSF and L-DEO's seismic survey activities and the NMFS Permits Division's issuance of an IHA and possible renewal.

No reduction in numbers is anticipated as part of the proposed actions. Therefore, no reduction in reproduction is expected because of the proposed actions. Non-lethal take of 1,047 individuals, adults, juveniles, and post-hatchlings, is expected because of the seismic survey activities. Density data were not were not available to quantify the number of exposures for small sea turtles (less than 30 centimeters [11.8 inches]). Any small sea turtle found within an ensonified area of 1,417.5 square kilometers (413.3 square nautical miles) and 8,354.5 square kilometers (2,435.8 square nautical miles) are expected to be taken in the form of harassment in intermediate water depths and deep water depths, respectively. We anticipate temporary behavioral responses (e.g., temporary displacement and stress) with some potential for TTS, with individuals returning to normal shortly after the exposure has ended, and thus do not anticipate any delay in reproduction as a result. Because we do not anticipate a reduction in numbers or reproduction of Northwest Atlantic Ocean DPS of loggerhead turtles due to the seismic survey activities and the NMFS Permits Division's issuance of an IHA and possible renewal, a reduction in the species' likelihood of survival is not expected.

The 2009 Final Recovery Plan (NMFS 2008) for the Northwest Atlantic Population of loggerhead turtle lists recovery objectives for the species. The following recovery objectives are relevant to the impacts of the proposed actions:

- Ensure the in-water abundance of juveniles in both neritic and oceanic habitats is increasing and is increasing at a greater rate than strandings of similar age classes.
- Manage sufficient feeding, migratory, and interesting marine habitats to ensure successful growth and reproduction.
- Develop and implement local, state, Federal, and international legislation to ensure long-term protection of loggerhead turtles and their terrestrial and marine habitats.
- Minimize trophic changes from fishery harvest and habitat alteration.
- Minimize marine debris ingestion and entanglement.
- Minimize vessel strike mortality.

Because no mortalities or effects on the abundance, distribution, and reproduction of Northwest Atlantic Ocean DPS of loggerhead turtle populations are expected because of the proposed actions, we do not anticipate the seismic survey activities and the NMFS Permits Division's issuance of an IHA and possible renewal will impede the recovery objectives for Northwest Atlantic Ocean DPS of loggerhead turtles. In conclusion, we believe the non-lethal effects associated with the proposed actions will not appreciably reduce the likelihood of survival and recovery of Northwest Atlantic Ocean DPS Of loggerhead turtles in the wild by reducing the reproduction, numbers, or distribution of the species.

13 CONCLUSION

After reviewing the current status of the ESA-listed species, the environmental baseline within the action area, the effects of the proposed actions, and cumulative effects, it is NMFS' biological opinion that the proposed actions are not likely to jeopardize the continued existence or recovery of the blue whale, fin whale, sei whale, sperm whale, North Atlantic DPS of green turtle, Kemp's ridley turtle, leatherback turtle, and Northwest Atlantic Ocean DPS of loggerhead turtle.

It is also NMFS' biological opinion that the proposed actions are not likely to adversely affect the hawksbill turtle, Carolina DPS of Atlantic sturgeon, Chesapeake DPS of Atlantic sturgeon, Gulf of Maine DPS of Atlantic sturgeon, New York Bight DPS of Atlantic sturgeon, South Atlantic DPS of Atlantic sturgeon, giant manta ray, oceanic whitetip shark, and shortnose sturgeon. Also, the proposed actions will not adversely affect the designated critical habitat of Northwest Atlantic Ocean DPS of loggerhead turtle.

14 INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of threatened and endangered species, respectively, without a special exemption. "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct (16 U.S.C. §1532(19)). "Harm" is further defined by regulation to include significant habitat modification or degradation that results in death or injury to ESA-listed species by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding, or sheltering (50 C.F.R. §222.102). NMFS has not yet defined "harass" under the ESA in regulation. On December 21, 2016, NMFS issued interim guidance on the term "harass," defining it as to "create the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering," For purposes of this consultation, we relied on NMFS' interim definition of harassment to evaluate when the seismic survey activities are likely to harass ESA-listed marine mammals (cetaceans).

Section 9 take prohibitions do not apply to threatened species without section 4(d) rules as specified in section 9(a)(1)(g). The ESA does not prohibit the take of threatened species unless special regulations have been promulgated, pursuant to section 4(d), to promote the conservation of the species. ESA section 4(d) rules have been promulgated for North Atlantic DPS of green turtles and Northwest Atlantic Ocean DPS of loggerhead turtles; therefore, section 9 take prohibitions apply to these two species as well as all other ESA-listed marine mammals and sea turtles that are likely to be adversely affected by the proposed actions. This incidental take statement includes numeric limits on the take of these species because specific amounts of take were analyzed in our jeopardy analysis. These numeric limits provide guidance to the action agency on its requirements to reinitiate consultation if the amount of take estimated in the

jeopardy analysis of this opinion is exceeded. This incidental take statement includes reasonable and prudent measures and terms and conditions designed to minimize and monitor take of these threatened species.

Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity (50 C.F.R. §402.02). 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.

ESA section 7(b)(4) states that take of ESA-listed marine mammals (cetaceans) must be authorized under MMPA section 101(a)(5) before the Secretary can issue an incidental take statement for ESA-listed marine mammals. NMFS' implementing regulations for MMPA section 101(a)(5)(D) specify that an IHA 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 IHA for the tentative period of April 2023 through April 2024 (valid for a period of one year from the date of issuance), under the MMPA, the incidental take of ESA-listed marine mammals is exempt from the ESA take prohibitions as stated in this incidental take statement pursuant to section 7(b)(4) and 7(o)(2).

14.1 Amount or Extent of Take

Section 7(b)(4) and its implementing regulations require NMFS to specify the impact of any incidental take of threatened or endangered species; that is, the amount or extent, of such incidental taking on the species (50 C.F.R. §402.14(i)(1)(i)).

We anticipate the high-energy seismic survey in the Northwest Atlantic Ocean off North Carolina is likely to result in the incidental take of ESA-listed marine mammals by harassment (Table 30). Behavioral harassment is expected to occur at received levels at or above 160 dB re: one µPa (rms) for airgun array operations for ESA-listed marine mammals and at received levels at or above 175 dB re: one µPa (rms) for ESA-listed sea turtles. For all species of ESA-listed marine mammals and sea turtles, this incidental take will result from exposure to acoustic energy during airgun array operations and will be in the form of ESA harassment, and is not expected to result in the death or injury of any individuals that will be exposed.

Table 30. Estimated amount of incidental take of Endangered Species Act-listed marine mammals anticipated because of the proposed actions in the Northwest Atlantic Ocean off North Carolina.

Species	Anticipated Incidental Take by Harassment (Potential Temporary Threshold Shift and Behavioral) by Seismic Survey Activities
Marine Mammals – Cetaceans	
Blue Whale	1

Species	Anticipated Incidental Take by Harassment (Potential Temporary Threshold Shift and Behavioral) by Seismic Survey Activities
Fin Whale	4
Sei Whale	8
Sperm Whale	406
Marine Reptiles – Sea Turtles	
Green Turtle – North Atlantic DPS	251
Kemp's Ridley Turtle	2
Leatherback Turtle	2
Loggerhead Turtle – Northwest Atlantic Ocean DPS	1,047

DPS=distinct population segment

14.2 Reasonable and Prudent Measures

"Reasonable and prudent measures" are measures that are necessary or appropriate to minimize the amount or extent of incidental take (50 C.F.R. §402.02). The measures described below must be undertaken by the NSF and the NMFS Permits Division so that they become binding conditions for the exemption in section 7(o)(2) to apply. Section 7(b)(4) of the ESA requires that when a proposed agency action is found to be consistent with section 7(a)(2) of the ESA and the proposed action may incidentally take individuals of ESA-listed species, we will issue a statement that specifies the impact of any incidental taking of threatened or endangered species. To minimize such impacts, reasonable and prudent measures, and term and conditions to implement the measures, must be provided. Only incidental take resulting from the agency actions and any specified reasonable and prudent measures and terms and conditions identified in the incidental take statement are exempt from the taking prohibition of section 9(a), pursuant to section 7(o) of the ESA.

We believe the reasonable and prudent measures described below are necessary and appropriate to minimize the impacts of incidental take on threatened and endangered species:

- The NSF, with L-DEO must implement a program to minimize and report the potential effects of seismic survey activities as well as the effectiveness of conservation measures for the incidental taking of marine mammals (blue whales, fin whales, sei whales, and sperm whales) and sea turtles (North Atlantic DPS of green turtles, Kemp's ridley turtles, leatherback turtles, and Northwest Atlantic Ocean DPS of loggerhead turtles).
- The NMFS Permits Division must ensure that the NSF and L-DEO implement a program to minimize and report the potential effects of seismic survey activities as well as the effectiveness of conservation measures incorporated as part of the proposed IHA and possible renewal for the incidental taking of marine mammals (blue whales, fin whales,

sei whales, and sperm whales) pursuant to section 101(a)(5)(D) of the MMPA. In addition, the NMFS Permits Division must ensure that the provisions of the IHA and possible renewal are carried out, and to inform us if take is exceeded.

14.3 Terms and Conditions

To be exempt from the prohibitions of section 9 of the ESA and regulations issued pursuant to section 4(d), the Federal action agency (i.e., NSF and NMFS Permits Division) must comply (or must ensure that any applicant complies) with the following terms and conditions. These include the take minimization, monitoring and reporting measures required by the section 7 regulations (50 C.F.R. §402.14(i)).

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

1. To implement the first reasonable and prudent measure, the NSF must provide a copy of the draft comprehensive report on all seismic survey activities and monitoring results must be provided to the NMFS ESA Interagency Cooperation Division within 90 days of the completion of the high-energy seismic survey, or expiration of the IHA, whichever comes sooner.
2. To implement the second reasonable and prudent measure, any reports of injured or dead ESA-listed species must be provided by the NSF to the chief of the NMFS ESA Interagency Cooperation Division immediately to by e-mail at nmfs.hq.esa.consultations@noaa.gov. The subject line of the e-mail should include "report of injured or dead ESA-listed species" and consultation tracking number OPR-2022-02837.

15 Conservation Recommendations

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

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

1. We recommend that the NSF and L-DEO promote and fund research examining the potential effects of seismic surveys on ESA-listed marine mammal, sea turtle, and fish species.

2. We recommend that the NSF and L-DEO develop a more robust propagation model that incorporates environmental variables into estimates of how far sound levels reach from airgun arrays.
3. We recommend that the NSF and L-DEO model potential impacts to ESA-listed species, validate assumptions, through refinements of current models and use of other relevant models, validate assumptions used in effects analyses, and seek information and high quality data for use in such efforts.
4. We recommend that the NSF and L-DEO 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 shutdown zones prior to starting seismic survey activities.
5. We recommend that the NMFS Permits Division develops a flow chart with decision points for conservation measures to be included in future MMPA incidental take authorizations for seismic surveys.
6. We recommend the NSF and L-DEO use (and NMFS Permits Division require in MMPA incidental take authorizations) thermal imaging cameras, in addition to reticled binoculars (Big-Eye and handheld) and the naked eye, for use during daytime and nighttime visual observations and test their effectiveness at detecting ESA-listed species.
7. We recommend the NSF and L-DEO use (and NMFS Permits Division require in MMPA incidental take authorizations) clinometers or geometers, such as those described in Hansen et al. 2020, to accurately measure lateral distances from the research vessel to ESA-listed species for potential implementation of conservation measures (e.g., shutdown procedure) during daytime and nighttime visual observations.
8. We recommend the NSF and L-DEO (and NMFS Permits Division require in MMPA incidental take authorizations) limit the shifts of acoustic and visual PSOs to no more than two consecutive hours followed by at least an hour break to prevent fatigue and increase effectiveness at detecting marine mammals and other ESA-listed species.
9. We recommend the NSF and L-DEO use the Marine Mammal Commission's recommended method for estimating the number of cetaceans near seismic surveys based on the number of groups detected for post-seismic survey activities take analysis and use in monitoring reports.
10. We recommend the NSF, L-DEO, and NMFS Permits Division work to make the data collected as part of the required monitoring and reporting available to the public and scientific community in an easily accessible online database that can be queried to aggregate data across PSO reports. Access to such data, which may include sightings as well as responses to seismic survey activities, will not only help us understand the biology of ESA-listed species (e.g., their range), it will inform future consultations and incidental take authorizations/permits by providing information on the effectiveness of the conservation measures and the impact of seismic survey activities on ESA-listed species.

11. We recommend the NSF and L-DEO utilize real-time visual sighting and acoustic detection services such as the WhaleAlert application (http://www.whalealert.org/) or southeast whale alert system for marine mammals or the Ocean Alert mobile application (https://www.boem.gov/boem-harnessing-citizen-science-new-ocean-alert-mobile-app) for marine megafauna (e.g., sea turtles, sharks, and marine mammals). We recognize that the research vessel may not have reliable internet access during operations offshore, but nearshore, where many of the ESA-listed species considered in this consultation are likely found in greater numbers, we anticipate internet access may be better. Monitoring such systems will help plan seismic survey activities and transits to avoid locations with recent ESA-listed species sightings, and may also be valuable during other activities to alert others of ESA-listed species within the area, which they can then avoid.
12. We recommend the NSF and L-DEO submit their monitoring data (i.e., visual sightings) by PSOs to the Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations online database so that it can be added to the aggregate marine mammal, seabird, sea turtle, and fish observation data from around the world.
13. We recommend the research vessel operator and other relevant vessel personnel (e.g., crewmembers) 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 PSOs.
14. We recommend NSF and L-DEO attempt to maintain a distance of 45 meters (147.6 feet) or greater whenever possible from the R/V *Marcus G. Langseth*, when ESA-listed sea turtles and fish are visually sighted, as a vessel strike avoidance measure.
15. We recommend the NSF, L-DEO, and NMFS Permits Division implement a program to mitigate, monitor, and report any potential effects and interactions between seismic survey activities as well as any effectiveness of conservation measures on ESA-listed species of marine mammals, sea turtles, and fish.
16. We recommend the NSF and L-DEO's seismic survey activities actively avoid *Sargassum* mats or patches in designated critical habitat for the Northwest Atlantic Ocean DPS of loggerhead turtle.
17. We recommend the NSF and L-DEO coordinate with government agencies (e.g. Bureau of Ocean Energy Management, NMFS, Northeast Fisheries Science Center, U.S. Navy), academic institutions (e.g., Duke University, Woods Hole Oceanographic Institution), and/or the private sector that may be conducting long-term passive acoustic monitoring and/or tagging studies to potentially determine received sound levels and responses of protected species and their prey from the seismic survey activities in the action area.
18. We recommend the NSF and L-DEO measure ambient noise levels in the survey area to help better understand the total ensonified area from acoustic sources (e.g., vessel noise, airgun array operations) from the high-energy seismic survey to determine the extent of the action area in future ESA section 7 consultations.

19. We recommend the NSF and L-DEO consider port locations to reduce transits and the potential for effects (e.g., vessel strikes) on ESA-listed species (e.g., North Atlantic right whales) and designated critical habitat in the action area.

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

16 REINITIATION NOTICE

This concludes formal consultation for the NSF and L-DEO's high-energy marine seismic survey by the R/V *Marcus G. Langseth* in the Northwest Atlantic Ocean off North Carolina and NMFS Permits Division's issuance and possible renewal of an IHA for the proposed high-energy marine seismic survey pursuant to section 101(a)(5)(D) of the MMPA. Consistent with 50 C.F.R. §402.16, reinitiation of formal consultation is required and shall be requested by the Federal agency or by NMFS, where discretionary Federal agency involvement or control over the action has been retained or is authorized by law and:

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

If the amount of tracklines, location of tracklines, number of seismic survey days, acoustic characteristics of the airgun arrays, timing of the high-energy seismic survey, or any other aspect of the proposed action changes in such a way (e.g., increased beyond the 25 percent contingency, greater estimates of sound propagation, increases in the airgun array sound source levels) that the incidental take of ESA-listed species can be greater than estimated in the incidental take statement of this opinion, then one or more of the reinitiation triggers above may be met and reinitiation of consultation may be necessary.

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18 APPENDICES

18.1 Appendix A – Proposed Incidental Harassment Authorization and Possible Renewal for the National Science Foundation and Lamont-Doherty Earth Observatory's High-Energy Seismic Survey in the Northwest Atlantic Ocean off North Carolina

The text below was taken directly from the proposed IHA provided to us in the consultation initiation package from the NMFS Permits Division, in the notice of proposed IHA and request for comments and possible renewal published in the *Federal Register* on March 23, 2023 (88 FR 17646 to 17677), as well as from revisions after the public comment period. The final IHA may have minor changes that will not affect this opinion.

INCIDENTAL HARASSMENT AUTHORIZATION

The Lamont-Doherty Earth Observatory of Columbia University (L-DEO) is hereby authorized under section 101(a)(5)(D) of the Marine Mammal Protection Act (MMPA; 16 U.S.C. 1371(a)(5)(D)) to incidentally harass marine mammals, under the following conditions:

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

2. This IHA is valid only for geophysical survey activity in the Cape Fear submarine slide complex, off North Carolina in the Northwest Atlantic Ocean, as specified in L-DEO's IHA application.

3. <u>General Conditions</u>

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

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

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

(e) L-DEO must ensure that relevant vessel personnel and the PSO team participate in a joint onboard briefing led by the vessel operator and lead PSO to ensure that responsibilities, communication procedures, marine mammal monitoring protocols, operational procedures, and IHA requirements are clearly understood.

(f) L-DEO must notify the NOAA Southeast Regional Office (SERO) on the start and end date of seismic operations in the survey area via email (nmfs.ser.research.notification@noaa.gov).

4. Mitigation Requirements

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

a. No use of airguns is allowed from November 1 through April 30 for North Atlantic right whale migration. If any activities (non-seismic) are conducted between November 1 and April 30, daily PSO logs must be sent to Kara Shervanick at SERO (kara.shervanick@noaa.gov).

b. L-DEO must use independent, dedicated, trained visual and acoustic PSOs, meaning that the PSOs must be employed by a third-party observer provider, must not have tasks other than to conduct observational effort, collect data, and communicate with and instruct relevant vessel crew with regard to the presence of marine mammals and mitigation requirements (including brief alerts regarding maritime hazards), and must have successfully completed an approved PSO training course appropriate for their designated task (visual or acoustic). Individual PSOs may perform acoustic and visual PSO duties (though not at the same time).

c. At least one visual and two acoustic PSOs must have a minimum of 90 days at-sea experience working in those roles, respectively, during a deep penetration seismic

survey, with no more than 18 months elapsed since the conclusion of the at-sea experience.

d. Visual Observation

i. During survey operations (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 PSOs must be on duty and conducting visual observations at all times during daylight hours (i.e., from 30 minutes prior to sunrise through 30 minutes following sunset) and 30 minutes prior to and during ramp-up of the airgun array.

ii. Visual monitoring of the shutdown 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.

iii. Visual PSOs must coordinate to ensure 360° visual coverage around the vessel from the most appropriate observation posts, and must conduct visual observations using binoculars and the naked eye while free from distractions and in a consistent, systematic, and diligent manner. Estimated harassment zones are provided in Table 2 and 3 for reference.

iv. 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.

v. During good conditions (e.g., daylight hours; Beaufort sea state (BSS) 3 or less), visual PSOs must 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.

vi. 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.

e. 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 airgun array.

ii. When both visual and acoustic PSOs are on duty, all detections must be immediately communicated to the remainder of the on-duty PSO team for

potential verification of visual observations by the acoustic PSO or of acoustic detections by visual PSOs.

iii. Acoustic PSOs may be on watch for a maximum of four consecutive hours followed by a break of at least one hour between watches and may conduct a maximum of 12 hours of observation per 24-hour period. Combined observational duties may not exceed 12 hours per 24-hour period for any individual PSO.

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

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

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

3. 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

4. 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.

f. Shutdown zones and buffer zones

i. Except as provided in 4(f)(ii) and 4(f)(iii), the PSOs must establish and monitor a 500-m shutdown zone and additional 500-m buffer zone (total 1000 m). The 1000-m zone must serve to focus observational effort but not limit such effort; observations of marine mammals beyond this distance shall also be recorded as described in 5(d) below and/or trigger shutdown as described in 4(g)(iv) below, as appropriate. The shutdown zone encompasses the area at and below the sea surface out to a radius of 500 m from the edges of the airgun array (rather than being based on the center of the array or around the vessel itself) (0–500 m). The buffer zone encompasses the area at and below the sea surface from the edge of the shutdown zone, out to a radius of 1000 meters from the edges of the airgun array (500–1000 m). During use of the acoustic source, occurrence of marine mammals within the buffer zone (but outside the shutdown zone) must be communicated to the operator to prepare for the potential shutdown of the acoustic source. PSOs must monitor the shutdown zone and buffer zone for a minimum of 30 minutes prior to ramp-up (i.e., pre-start clearance).

ii. An extended 1500 m shutdown zone must be established for all beaked whales, dwarf and pygmy sperm whales, a large whale with a calf, and groups of six or more large whales. No buffer zone is required.

iii. The acoustic source must be shut down upon detection (visual or acoustic) of a North Atlantic right whale at any distance.

g. Pre-start clearance and Ramp-up

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

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

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. The operator must provide information to the PSO documenting that appropriate procedures were followed.

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

v. Where operational planning cannot reasonably avoid such circumstances 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. Acoustic source activation may only occur at times of poor visibility where operational planning cannot reasonably avoid such circumstances.

vi. If the acoustic source is shut down for brief periods (i.e., less than 30 minutes) for reasons other than that described for shutdown (e.g., mechanical difficulty), it may be activated again without ramp-up if PSOs have maintained constant visual and/or acoustic observation and no visual or acoustic detections of marine mammals have occurred within the applicable shutdown zone. For any longer shutdown, pre-start clearance observation and ramp-up are required. For any shutdown at night or in periods of poor visibility (e.g., BSS 4 or greater), ramp-up is required, but if the shutdown

period was brief and constant observation was maintained, pre-start clearance watch is not required.

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

h. Shutdown requirements

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

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

iii. When the airgun array is active (i.e., anytime one or more airguns is active, including during ramp-up) and (1) a marine mammal (excluding delphinids of the species described in 4(h)(iv)) appears within or enters the shutdown zone and/or (2) a marine mammal is detected acoustically and localized within the shutdown zone, the airgun array must be shut down. When shutdown is called for by a PSO, the airgun array must be immediately deactivated. Any dispute regarding a PSO shutdown must be resolved after deactivation.

iv. The shutdown requirement described in 4(h)(iii) shall be waived for small dolphins of the following genera: *Delphinus, Lagenodelphis, Stenella, Steno, and Tursiops.*

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

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

v. Upon implementation of shutdown, the source may be reactivated after the marine mammal(s) has been observed exiting the applicable shutdown 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 30 minutes for mysticetes and all other odontocetes) with no further observation of the marine mammal(s).

vi. Shutdown of the array is required upon observation of a species for which authorization has not been granted, or a species for which authorization has been granted but the authorized number of takes has been met, approaching or observed within any harassment zone.

i. Vessel strike avoidance

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

ii. All survey vessels, regardless of size, must observe a 10-kn speed restriction in specific areas designated by NMFS for the protection of North Atlantic right whales from vessel strikes. These include all Seasonal Management Areas (SMA) established under 50 CFR 224.105 (when in effect), any dynamic management areas (DMA) (when in effect), and Slow Zones. See *www.fisheries.noaa.gov/national/endangered-species-conservation/reducing-ship-strikes-north-atlantic-right-whales* for specific detail regarding these areas.

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

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

v. The vessel must maintain a minimum separation distance of 100 m from sperm whales and all other baleen whales.

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

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

viii. These requirements do not apply in any case where compliance would create an imminent and serious threat to a person or vessel or to the extent that a vessel is restricted in its ability to maneuver and, because of the restriction, cannot comply.

5. Monitoring Requirements

Monitoring must be conducted in accordance with the following requirements:

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

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

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

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

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

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

v. Compass (plus backup)

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

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

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

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

ii. NMFS must review and approve PSO resumes.

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

iv. One visual PSO with experience as shown in 4(c) shall be designated as the lead for the PSO team. The lead must coordinate duty schedules and roles for the PSO team and serve as primary point of contact for the vessel operator. (Note that the responsibility of coordinating duty schedules and roles may instead be assigned to a shore-based, third-party monitoring coordinator.) To the maximum extent practicable, the lead PSO must devise the duty schedule such that experienced PSOs are on duty with those PSOs with appropriate training but who have not yet gained relevant experience.

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

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

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

d. Data Collection

i. PSOs must use standardized data collection forms, whether hard copy or electronic. PSOs must record detailed information about any implementation of mitigation requirements, including the distance of animals to the acoustic source and description of specific actions that ensued, the behavior of the animal(s), any observed changes in behavior before and after implementation of mitigation, and if shutdown was implemented, the length of time before any subsequent ramp-up of the acoustic source. If required mitigation was not implemented, PSOs should record a description of the circumstances.

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

1. Vessel name and call sign;

2. PSO names and affiliations;

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

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

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

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

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

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

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

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

iii. Upon visual observation of any marine mammals, the following information must be recorded:

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

2. PSO who sighted the animal;

3. Time of sighting;

4. Vessel location at time of sighting;

5. Water depth;

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

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

8. Pace of the animal;

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

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

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

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

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

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

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

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

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

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

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

2. Date and time when first and last heard;

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

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

6. Reporting

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

(i) Summary of all activities conducted and sightings of marine mammals near the activities;

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

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

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

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

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

(vii) Raw observational data.

(b) Reporting Injured or Dead Marine Mammals

(i) Discovery of Injured or Dead Marine Mammal – In the event that personnel involved in the survey activities covered by the authorization discover an injured or dead marine mammal, L-DEO must report the incident to the Office of Protected Resources (OPR) (301-427-8401), NMFS and the NMFS Southeast Regional Stranding Coordinator (305-361-4586) as soon as feasible. The report must include the following information:

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

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

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

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

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

6. General circumstances under which the animal was discovered.

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

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

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

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

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

5. Status of all sound sources in use;

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

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

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

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

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

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

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

(c) Reporting Species of Concern

(i) If a North Atlantic right whale is observed at any time by PSOs or personnel on any project vessels, during surveys or during vessel transit, L-DEO must immediately report sighting information to the NMFS North Atlantic Right Whale Sighting Advisory System: 877-WHALE-HELP (877-942-5343). North Atlantic right whale sightings in any location must also be reported to the U.S. Coast Guard via channel 16 and through the WhaleAlert app (http://www.whalealert.org/).

7. Actions to minimize additional harm to live-stranded (or milling) marine mammals – In the event of a live stranding (or near-shore atypical milling) event within 50 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:

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

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

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

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

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

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

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

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

9. Renewals

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

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

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

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

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

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

will remain the same and appropriate, and the findings made in support of this IHA remain valid.

_____ _____

Kimberly Damon-Randall, Date

Director, Office of Protected Resources,

National Marine Fisheries Service.

Table 1. Authorized take numbers, by species

Species	Authorized Take	
	Level B	Level A
Humpback whale	2	0
Fin whale	4	0
Sei whale	8	0
Minke whale	10	0
Blue whale	1	0
Sperm whale	406	0
Kogia spp.	678	31
Cuvier's beaked whale	396	0
Mesoplodont Beaked whales	420	0
Pilot whales	385	0
Rough-toothed dolphin	82	0
Bottlenose dolphin	1,477	0
Atlantic white-sided dolphin	14	0
Pantropical spotted dolphin	114	0
Atlantic spotted dolphin	1,237	0
Spinner dolphin	41	0
Clymene dolphin	79	0
Striped dolphin	45	0
Fraser’s dolphin	163	0
Risso’s dolphin	189	0
Common dolphin	56	0
Melon-headed whale	83	0
Pygmy killer whale	6	0
False killer whale	6	0

Killer whale	4	0
Harbor porpoise	3	0

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

Airgun Configuration	Threshold	Level A harassment zone (m)		
		LF Cetaceans	MF Cetaceans	HF Cetaceans
18 airgun array (3300 in^3)	SELcum	101.9	0	0.5
	Peak	23.3	11.2	116.9

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

Airgun Configuration	Water Depth (m)	Level B harassment zone (m)
18 airgun array (3300 in^3)	>1000m	2,886
	100-1000m	4,329