Proposed Action	Issuance of Five Incidental Harassment Authorizations to Take Marine Mammals Incidental to Geophysical Surveys in the Atlantic Ocean
Type of Statement	Environmental Assessment
Lead Agency	U.S. Department of Commerce National Oceanic and Atmospheric Administration National Marine Fisheries Service
Responsible Official	Donna S. Wieting Director, Office of Protected Resources
For Further Information	Office of Protected Resources Permits and Conservation Division 1315 East West Highway Silver Spring, MD 20910 301-427-8401
Location	U.S. Atlantic Ocean, waters offshore Delaware to Florida
Abstract	This Environmental Assessment analyzes the environmental impacts of the National Marine Fisheries Service issuance of five incidental harassment authorizations to separate applicants for takes of marine mammals incidental to geophysical survey activities
Date	November 2018

TABLE OF CONTENTS

List of Acronyms and Abbreviations

µPa	microPascal
AOI	Area of Interest
BOEM	Bureau of Ocean Energy Management
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
COA	Conditions of Approval
CY	calendar year
CZMA	Coastal Zone Management Act
dB	decibel
EA	Environmental Assessment
ECS	Extended Continental Shelf
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
EO	Executive Order
FONSI	Finding of No Significant Impact
FR	Federal Register
Hz	Hertz
IHA	Incidental Harassment Authorization
kHz	kilohertz
km	kilometer
m	meter
MMPA	Marine Mammal Protection Act
MSFCMA	Magnuson-Stevens Fishery Conservation and Management Act
NAO	NOAA Administrative Order
NARW	North Atlantic right whale
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NMSA	National Marine Sanctuaries Act
NOAA	National Oceanic and Atmospheric Administration
OCSLA	Outer Continental Shelf Lands Act
OPR	Office of Protected Resources
OMB	Office of Management and Budget
PAM	passive acoustic monitoring
PEIS	Programmatic Environmental Impact Statement
PSO	protected species observer
PTS	permanent threshold shift
RMS	root mean square
SPL	sound pressure level
TTS	temporary threshold shift
UNCLOS	United Nations Convention on the Law of the Sea
USFWS	U.S. Fish and Wildlife Service

CHAPTER 1 INTRODUCTION AND PURPOSE AND NEED

1.0 General Overview

The National Marine Fisheries Service (NMFS) has statutory responsibility to authorize incidental take of marine mammals pursuant to the Marine Mammal Protection Act of 1972, as amended (MMPA; 16 U.S.C. 1361 et seq.) after receipt and review of an application if certain findings and determinations are made. In general, NMFS must issue incidental take authorizations (ITA) for small numbers of marine mammals to an applicant if the proposed take is: incidental to an otherwise lawful activity, limited to harassment, occurs within a specific geographic area, will have a negligible impact on affected marine mammal species, is subject to appropriate mitigation and monitoring, and is limited to one year.

NMFS received requests for authorization of marine mammal take from five companies proposing to conduct geophysical surveys in connection with geophysical survey activities identified in the Bureau of Ocean Energy Management's (BOEM) Final Programmatic Environmental Impact Statement (PEIS) (BOEM, 2014a). BOEM's Final PEIS presented a comprehensive review and analysis of the environmental impacts associated with multiple types of geological and geophysical (G&G) survey activities anticipated to occur in various locations along the Mid- and South Atlantic Outer Continental Shelf (OCS) over a period of nine years. Thus, NMFS anticipated receiving ITA requests from various applicants in relation to these activities.

In addition, the National Environmental Policy Act (NEPA; 42 United States Code (U.S.C.) 4321 et seq.), the Council on Environmental Quality (CEQ) Regulations (40 Code of Federal Regulations (CFR) Parts 1500 to 1508), and National Oceanic and Atmospheric Administration (NOAA) policy and procedures[1] for implementing NEPA require all proposals for major federal actions be reviewed with respect to environmental consequences on the human environment and encourage the use of programmatic NEPA documents to streamline decision-making[2].

BOEM prepared their PEIS at a programmatic level to establish a "tiered" environmental decision-making process. The PEIS includes a robust discussion and environmental analysis of impacts anticipated from various G&G activities with the expectation that project-level NEPA analysis would rely on and incorporate by reference relevant portions of the Final PEIS and focus on site-specific impacts and issues. NOAA served as a cooperating agency[3] during the development of this PEIS, and after independently reviewing the Final PEIS, determined it was adequate and properly addressed comments and concerns raised by NOAA as a cooperating agency. The Final PEIS also addressed NOAA's required components for adoption, as it meets relevant requirements under the CEQ regulations and NOAA policy and procedures. Subsequently, in accordance with 40 CFR 1506.3 and 1505.2, NMFS adopted BOEM's 2014 Final PEIS and issued a separate Record of Decision (ROD) with the intent to use BOEM's

[1] NOAA Administrative Order (NAO) 216-6A "*Compliance with the National Environmental Policy Act, Executive Orders 12114, Environmental Effects Abroad of Major Federal Actions; 11988 and 13690, Floodplain Management; and 11990, Protection of Wetlands*" issued April 22, 2016 and the Companion Manual for NAO 216-6A.

[2] The concept of "programmatic" NEPA analysis is included in the CEQ Regulations, which addresses analyses of "broad actions" and the "tiering" process (see 40 CFR §§1500.4(i), 1502.4 and 1502.20). Programmatic NEPA reviews add value and efficiency to the decision-making process when they inform the scope of decisions and subsequent tiered NEPA reviews. Programmatic NEPA analyses can facilitate decisions on agency actions that precede project-specific decisions and action. They also provide information and analysis that can be incorporated by reference in future, tiered NEPA reviews.

[3] NMFS served as the lead within NOAA under this cooperating agency agreement, and coordinated internally to address all resources of concern under NOAA's jurisdiction.

programmatic analysis as the basis for tiering when reviewing ITA requests and potentially issuing ITAs under the MMPA, on a case-by-case basis, as appropriate.

In the present case, for the ITA requests received since BOEM published their Final PEIS, NMFS determined that conducting NEPA review and preparing a tiered Environmental Assessment (EA) is appropriate to analyze environmental impacts associated with NMFS's issuance of separate incidental harassment authorizations (IHAs) to five different companies. NMFS further determined that the issuance of these five IHAs are "similar" but not "connected actions" per 40 C.F.R. 1508.25(a)(3) due to general commonalities in geography, timing, and type of activity, which provides a reasonable basis for evaluating them together in a single environmental analysis. This EA also incorporates relevant portions of BOEM's Final PEIS while focusing analysis on environmental issues specific to the five IHAs. BOEM's Final PEIS is available for review online at: *www.boem.gov/Atlantic-G-G-PEIS/*. Other relevant information and documentation are available online at: *www.fisheries.noaa.gov/action/incidental-take-authorization-oil-and-gas-industry-geophysical-survey-activity-atlantic*.

This Chapter presents a summary of NMFS's authority to authorize take of marine mammals incidental to specified activities other than commercial fishing (Section 1.1.1) and a summary of the applicants' requests and geophysical survey locations (Sections 1.1.2 and 1.1.3), and identifies NMFS's proposed action and purpose and need (Section 1.2). This Chapter also explains the environmental review process and background associated with the development of BOEM's PEIS and this EA (Section 1.3) and provides other information relevant to the analysis in this EA, such as public involvement (Section 1.4), compliance with other environmental laws (Section 1.5), and new information since the publication of BOEM's Final PEIS (Section 1.6). The remainder of this EA is organized as follows:

- Chapter 2 describes the applicants' activities and the alternatives carried forward for analysis as well as alternatives not carried forward for analysis.
- Chapter 3 describes the baseline conditions of the affected environment.
- Chapter 4 describes the direct, indirect, and cumulative impacts to the affected environment, specifically impacts to marine mammals and their habitat associated with NMFS's proposed action and alternatives. This chapter also summarizes the analysis in BOEM's Final PEIS with relevance to NMFS's proposed action and alternatives.
- Chapter 5 lists document preparers and agencies consulted and Chapter 6 lists references cited.

1.0.1 Marine Mammal Protection Act Overview

When the MMPA was enacted in 1972, Congress made several findings concerning the conservation of marine mammals, including, but not limited to, indicating that "certain species and population stocks of marine mammals are, or may be, in danger of extinction or depletion as a result of man's activities" (16 U.S.C. 1361(1)) [and] "such species and population stocks should not be permitted to diminish beyond the point at which they cease to be a significant functioning element in the ecosystem of which they are a part[…]" (16 U.S.C. 1361(2)) [and that] "marine mammals…[are] resources of great international significance… [that] should be protected and encouraged to develop to the greatest extent feasible commensurate with sound policies of resource management and that the primary objective of their management should be to maintain the health and stability of the marine ecosystem[….]" (16 U.S.C. 1361(6)). These and other findings in Section 2 of the MMPA speak to the need to maintain a broad scope in marine mammal protection that considers species- and ecosystem-level impacts.

To serve these broader goals, Section 101(a) of the MMPA prohibits the incidental taking of marine mammals. The incidental take[4] of a marine mammal falls under three categories: mortality, serious injury, or harassment (i.e., injury and/or disruption of behavioral patterns). Harassment[5] is any act of pursuit, torment, or annoyance that has the potential to injure a marine mammal or marine mammal stock in the wild (Level A harassment) or has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns (Level B harassment). Disruption of behavioral patterns includes, but is not limited to, migration, breathing, nursing, breeding, feeding or sheltering. However, Sections 101(a)(5)(A) and (D) of the MMPA provide exceptions to the prohibition on take, which give NMFS the authority to authorize the incidental but not intentional take of small numbers of marine mammals, provided certain determinations are made and statutory and regulatory procedures are met. ITAs may be issued as either (1) regulations and associated Letters of Authorization (LOA) or (2) IHAs, when a proposed action will not result in a potential for serious injury and/or mortality or where any such potential can be negated through required mitigation measures. IHAs may be issued for a maximum period of one year.

NMFS also promulgated regulations to implement the provisions of the MMPA governing the taking and importing of marine mammals (50 Code of Federal Regulations (CFR) Part 216) and produced Office of Management and Budget (OMB)-approved application instructions (OMB Number 0648-0151) that prescribe the procedures necessary to apply for permits. All applicants must comply with these regulations and application instructions in addition to the provisions of the MMPA.

1.0.2 Summary of Incidental Take Authorization Requests

In 2015 and 2016, NMFS received five complete applications requesting authorization for take of marine mammals incidental to conducting geophysical surveys. These included applications from Spectrum Geo Inc. (Spectrum), TGS-NOPEC Geophysical Company (TGS), ION GeoVentures (ION), WesternGeco, LLC (Western), and CGG (referred to herein as "applicants"). Spectrum submitted a modification to their survey plan in 2018. All five of these applicants propose to conduct geophysical survey activities using airgun arrays as an acoustic source, specifically two-dimensional (2D) deep penetration surveys to acquire data regarding oil and gas deposits beneath the seafloor. Airgun arrays are towed behind source vessels while an additional chase vessel typically accompanies the source vessel at some distance to monitor airguns for damage or provide other logistical support. Planned surveys vary between each company (e.g., characteristics of the airgun array, number of vessels, location and quantity of proposed survey tracklines). Airguns are active acoustic sources comprised of a steel cylinder charged with high-pressure air that releases compressed air into the water column, generating a signal that reflects and refracts off the seafloor or subsurface layers with acoustic impedance contrast. Firing of airguns releases a brief pulse of sound, with a return signal recorded by a listening device. Details and variations regarding each applicant's proposed survey are available in Chapter 2 of this EA.

1.0.3 Area of Interest Summary

Each applicant proposed to conduct geophysical surveys in various locations within BOEM's Mid- and South Atlantic OCS Planning Areas, which extend to approximately the limit of the

[4] The term "take" means "to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal." (16 U.S.C. §1362(3)(13))

[5] As defined in the MMPA for non-military readiness activities (Section 3(18)(A))

U.S. Exclusive Economic Zone (i.e., 200 nautical miles (nmi) from shore), as well as in areas out to 350 nmi (648 kilometers (km)) from shore. This Area of Interest (AOI; Figure 1) extends from Delaware to approximately Cape Canaveral, Florida, covering a total area of 854,779 km2. The seaward limit of the region is extended from BOEM's OCS planning area boundaries based on the maximum constraint line for the extended continental shelf (ECS), as defined under Article 76 of the United Nations Convention on the Law of the Sea (UNCLOS). Until the United States establishes an ECS, the region between the U.S. EEZ boundary and the ECS maximum constraint line (i.e., 200-350 nmi from shore) is part of the global commons, and BOEM determined it appropriate to include this area within the area of interest for geophysical survey activity. Since each of the applicants' specific survey areas will differ within the AOI, refer to maps provided in the individual applications, which are available for review online: *www.fisheries.noaa.gov/action/incidental-take-authorization-oil-and-gas-industry-geophysical-survey-activity-atlantic*.

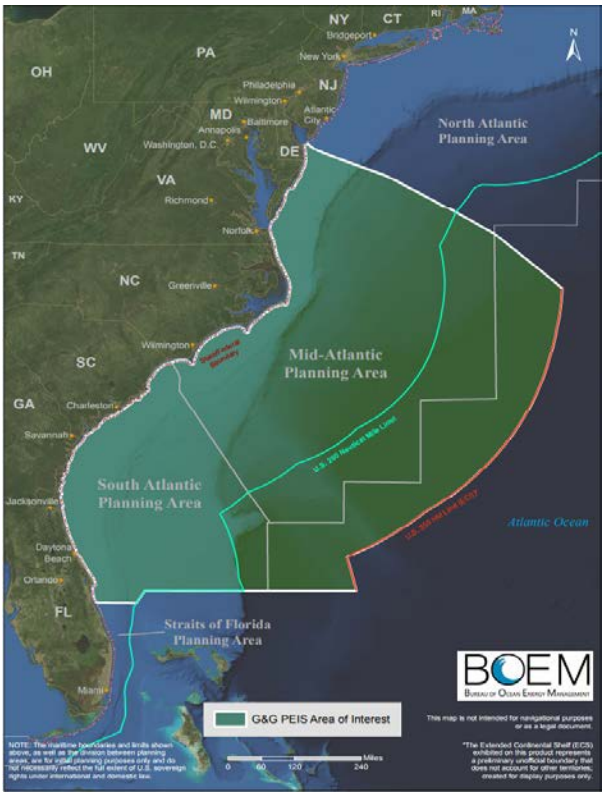

Figure 1. Area of Interest (Source: BOEM, 2014a)

1.1 Purpose and Need

1.1.1 Description of Proposed Action

NMFS's proposed action is the issuance of IHAs to each of the applicants pursuant to Section 101(a)(5)(D) of the MMPA and 50 CFR Part 216. The IHAs would be effective for a period of one year and would authorize takes of marine mammals, by harassment only (as defined by the MMPA), incidental to each applicant's proposed geophysical survey. Although each applicant requested IHAs covering the statutory maximum of one year, the expected extent of survey activity varies by company and may be subject to change due to inclement weather days, equipment maintenance and/or repair, transit to and from ports to survey locations, and other contingencies. Spectrum plans for a six-month data acquisition period with ~108 days dedicated

to geophysical survey operations. TGS plans for a 12-month data acquisition period with ~308 days dedicated to geophysical survey operations. ION plans for a six-month data acquisition period with ~70 days dedicated to geophysical survey operations. Western plans on a data acquisition period of 12-months with ~208 days dedicated to geophysical survey operations. CGG plans on a data acquisition period of six months with ~155 days dedicated to geophysical survey operations.

NMFS's proposed action is a direct outcome of each of these applicants' requests for authorization to take marine mammals incidental to conducting geophysical surveys. The proposed action is described in the notice of proposed IHAs published in the Federal Register (82 FR 26244; 6 June 2017), under "Summary of Requests" and "Description of Specified Activities", incorporated herein by reference, and the details and variations regarding each applicant are further explained in Chapter 2 of this EA.

1.1.2 Purpose

The purpose of NMFS's action is to authorize take of marine mammals incidental to the geophysical surveys proposed by the five companies, consistent with applicable legal requirements. Acoustic stimuli from use of airguns during geophysical surveys has the potential to cause harassment of marine mammals, and thus the applicants' survey activities warrant the issuance of IHAs from NMFS. The IHAs allow applicants to take small numbers of marine mammals within a specific geographic region incidental to a specified activity.

To authorize the incidental take of marine mammals, NMFS evaluates the best available scientific information to determine whether the take would have a negligible impact on marine mammal species or stocks and determines whether mitigation will achieve the least practicable adverse impact on species. NMFS also determines whether the activity would have an unmitigable impact on the availability of affected marine mammal species for subsistence use pursuant to the MMPA.

NMFS cannot issue an IHA if it would result in more than a negligible impact on marine mammal species or stocks or would result in an unmitigable adverse impact on subsistence uses. We must prescribe the permissible methods of taking and other means of effecting the least practicable adverse impact on the species or stocks of marine mammals and their habitat, paying particular attention to rookeries, mating grounds, and other areas of similar significance. IHAs must also include requirements pertaining to monitoring and reporting.

1.1.3 Need

U.S. citizens seeking to obtain authorization for the incidental take of marine mammals under NMFS's jurisdiction must submit such a request (in the form of an application). Because the five companies submitted adequate and complete applications demonstrating the need and potential eligibility for an IHA under the MMPA, NMFS has a corresponding duty to determine whether and how to authorize take of marine mammals incidental to the activities described in their applications.

1.2 Environmental Review Process and Background

1.2.1 Bureau of Ocean Energy Management

In 2009, BOEM began preparing a PEIS to evaluate environmental impacts associated with G&G survey activities anticipated to occur in the AOI in support of BOEM's oil and gas, renewable energy, and marine minerals programs. G&G surveys provide information for

government and industry to evaluate the potential for offshore oil, gas or methane hydrate resources, non-energy marine mineral resources, and geologic hazards. These G&G survey activities are subject to permits, notices, authorizations, or conditions of approval from BOEM. Therefore, BOEM oversees G&G data acquisition and executes their permitting authority pursuant to 30 CFR parts 550, 551, 580 and 585, Section 11, Subsections 8(k) and 8(p) of the Outer Continental Shelf Lands Act (OCSLA) and Section 388(a) of the Energy Policy Act of 2005 (EPAct).

BOEM completed the PEIS in February 2014 and issued a Record of Decision (ROD) on July 11, 2014 (BOEM, 2014b). BOEM determined a programmatic approach was the most appropriate approach for several reasons, primarily because data obtained from G&G surveys supports multiple programs and G&G survey activities can occur over large geographical areas. Additional reasons included limitations in available information and uncertainty regarding the timing and location of actual surveys within the AOI and the specific type of G&G surveys to be conducted by future applicants. Therefore, the analysis in the Final PEIS supports BOEM's planning-level decisions associated with their oversight and permitting authority for G&G data acquisition and establishes the framework and parameters for subsequent analyses based on the programmatic review[6].

Using this programmatic approach, BOEM identified and prepared a qualitative analysis of environmental impacts (and where possible, a quantitative analysis) covering a range of various G&G activities planned to be conducted in support of the oil and gas, renewable energy, and marine minerals programs. Of particular importance, BOEM collaborated with NMFS (representing NOAA as a cooperating agency) to prepare a detailed evaluation of impacts of G&G activities, including the use of airguns, on marine mammals, conducted modeling of potential acoustic exposures, and developed standard mitigation to apply to individual permit requests submitted to BOEM. At the time of development, the PEIS included the best available scientific information regarding marine mammal density and distribution in the AOI, and regarding effects to marine mammals from noise produced by G&G activity. Information about BOEM's programmatic approach and requirements for further environmental review are found Volume I, Chapter 1.7.5 in BOEM's 2014 Final PEIS. In addition, a description of effects on marine mammals is found in Volume I, Chapters 2.2.3.2 and 4.3.2, and estimates of marine mammal acoustic exposures are found in Appendix E. Other information and analysis of impacts to protected resources is found in Volume I, Chapters 4.1-4.4 and Volume III, Appendices D, H, I, and J.

1.2.2 National Oceanic and Atmospheric Administration

In accordance with 40 CFR 1501.6, NOAA served as a cooperating agency and participated in the development of BOEM's PEIS, because the scope of BOEM's proposed action and alternatives included activities that have the potential to impact resources under NOAA's jurisdiction by law, and because of NOAA's subject matter expertise. NOAA, via NMFS, provided BOEM with technical assistance and input regarding the analysis of impacts to several resources, including: critical habitat and threatened and endangered species pursuant to the ESA, marine mammals pursuant to the MMPA, Essential Fish Habitat (EFH) and fishery resources pursuant to the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA), and National Marine Sanctuaries pursuant to the National Marine Sanctuaries Act (NMSA).

[6] BOEM planned to prepare sufficient "tiered" analyses for potential site-specific future actions, as appropriate.

In addition, BOEM and NMFS anticipated that certain permitted G&G activities may impact marine mammals and, therefore, collaborated to assess effects to marine mammals with the intention of establishing baseline programmatic environmental effects analysis that could be used to support NMFS's analyses under NEPA and MMPA for potential future ITAs for G&G activities.

Following BOEM's completion of the PEIS, NMFS determined after independent review that the Final PEIS satisfied NOAA's cooperating agency comments and suggestions offered during the NEPA process and that the Final PEIS met all the requirements for an EIS per CEQ regulations (40 CFR Part 1500-1508).

NMFS further determined any subsequent issuance of ITAs for covered G&G activities would likely be within the scope of the 2014 Final PEIS analysis, as the impacts of the alternatives evaluated by BOEM:

- occur over a much longer period of time (i.e., nine years) than is analyzed by NMFS for any given ITA;
- encompass many of the same factors considered by NMFS when reviewing ITAs for geophysical surveys or related activities (i.e., marine mammal exposures, intensity of acoustic exposure, monitoring and mitigation factors, etc.); and
- are substantially the same as the impacts of NMFS's issuance of any given ITA for take of marine mammals incidental to G&G survey activities.

However, at the time BOEM issued their ROD in 2014, NMFS had not received any applications requesting ITAs to conduct specific G&G activities analyzed in BOEM's 2014 Final PEIS. Project-specific requests for MMPA authorizations were thus not evaluated at that time.

1.2.3 Environmental Review for Current Incidental Take Authorization Requests

BOEM's programmatic approach to the PEIS ensured that they conducted an extensive analysis of a large scope of G&G activities and impacts in the AOI. The analysis in the Final PEIS considered environmental impacts over a nine-year period, a large geographic area, and considered impacts from a wide range of G&G activities (e.g., deep penetration airgun surveys, high resolution geophysical surveys, geotechnical surveys)—a scope and scale much larger than that relevant to NMFS's analysis of the issuance of five IHAs. Thus, relative to the issuance of five IHAs in the AOI, NMFS determined that BOEM's analysis was both comprehensive in scope and conservative in terms of the relative scale of impacts evaluated.

In this EA, NMFS builds off the Final PEIS analysis by considering environmental effects specific to our action (i.e., authorization of take of marine mammals incidental to five geophysical surveys) now that specific survey details are determined (i.e., specific survey plans described in the five IHA applications). Specific G&G survey activity details were unknown until NMFS began receiving applications from G&G companies. Furthermore, other information related to the MMPA analysis (e.g., new scientific information concerning acoustic effects and marine mammal densities) became available for consideration pursuant to NEPA. Therefore, NMFS determined that further environmental review is appropriate to address the new survey-specific information and scientific data, as well as the revised critical habitat designation for the North Atlantic right whale (NARW). NMFS also determined that preparing an EA analyzing five geophysical surveys as "similar actions" (i.e., versus individual NEPA analyses for each IHA) would provide administrative streamlining (i.e., allow us to reach a decision on the IHAs in the

most efficient and timely manner possible) and allow for environmental impacts to be reviewed in a more holistic, comprehensive manner through which we can assess the direct, indirect, and cumulative effects of issuance of five IHAs for geophysical surveys in relation to each other. For example, the geophysical survey activities by each company are similar and would be conducted in a similar manner affecting the same species and stocks in the same general action area.

In addition to participating as a cooperating agency during the development of BOEM's PEIS, NMFS, in accordance with CEQ Regulations and to the fullest extent possible, integrates the requirements of NEPA with other regulatory processes required by law or by agency practice so that all procedures run concurrently, rather than consecutively.

1.3 Public Involvement

During the development of BOEM's PEIS, the public had opportunities to participate in the NEPA process and comment on the PEIS during the initial scoping period (January-March 2009) and a second scoping period (April-May 2010)[7] and during the public comment periods for the Draft PEIS (March-July 2012)[8] and the Final PEIS (March-April 2014)[9]. NMFS participated in public meetings and assisted BOEM with addressing the public's and others' concerns associated with the analysis of impacts on marine mammals and other marine resources. Refer to Volume I, Chapters 5.1-5.6 in the Final PEIS for detailed descriptions of public involvement and public comments associated with the development of BOEM's PEIS.

In addition to the public process described above for development of BOEM's PEIS, during which NMFS acted as a cooperating agency, NMFS relied substantially on the public process pursuant to the MMPA to develop and evaluate environmental information relevant to an analysis under NEPA. NMFS made IHA applications available for public review and comment and, separately, published the proposed IHAs in the Federal Register (FR) (see list below regarding proposed IHA notices published in the FR). There, NMFS alerted the public it intended to use the MMPA public review process for the proposed IHAs to solicit relevant environmental information and provide the public an opportunity to submit comments. In addition, we indicated that we believed it was appropriate to adopt BOEM's 2014 Final PEIS in assessing impacts to the human environment associated with the issuance of the IHAs. Federal Register notices were published as follows:

- Notice of receipt and request for comments on IHA applications for geophysical surveys for 30 days (80 FR 45195; July 29, 2015)[10]
- Notice of proposed IHAs and request for public comments for 30 days (82 FR 26244; June 5, 2017)
- Notice of 15-day extension on public comment period on the proposed IHAs (82 FR 31048; July 5, 2017)

NMFS received over 117,000 public comments and over 99,000 petition signatures in response to the 45-day public comment period for the 2017 notice of proposed IHAs, including letters from the Marine Mammal Commission (MMC), state agencies, non-governmental organizations (NGOs), representatives and members of the oil and gas industry, and private citizens. The vast

[7] Scoping periods include public meetings held at multiple locations.
[8] The public review for the Draft PEIS began on March 30, 2012, for 60 days and was extended until July 2, 2012.
[9] The public review for the Final PEIS began on March 7, 2014, and concluded on April 7, 2014.
[10] Note: This notice and request for comments included three of the five companies for which NMFS is issuing IHAs; applications for the other two companies (which were substantially similar to the prior three) were included with the June 6, 2017, notice and request for comments.

majority of comments opposed issuance of the IHAs, though some were in support. Most of the opposition focused on the possibility of deleterious impacts to marine mammals, such as potential disruptions of behavioral patterns, including displacement, as well as other effects such as chronic stress and masking of acoustic signals. Other concerns indicated were that:

- NMFS was not using the best available science;
- NMFS did not meet its statutory obligations under the MMPA; and
- NMFS's proposed mitigation was not sufficient to achieve the least practicable adverse impact, in some cases stating that the efficacy of certain measures at reducing harm to marine mammals is untested or unproven.

Additionally, NMFS received many other comments in opposition on subjects not directly related to our action (i.e., issuance of five IHAs under the MMPA) versus that of BOEM (i.e., issuance of five permits to conduct the survey activities pursuant to OCSLA, as described in BOEM's Final PEIS)[11]. These unrelated subjects included impacts to tourism or to species not protected by the MMPA (e.g., sea turtles and commercial and recreational fisheries). We fully considered all comments received in response to the publication of the proposed IHAs and used these comments to inform our analysis in this EA and to develop mitigation, monitoring and other conditions for the final IHAs. NMFS's provides detailed responses and analyses, where applicable, to specific comments that can be reviewed on NMFS's website: *www.fisheries.noaa.gov/action/incidental-take-authorization-oil-and-gas-industry-geophysical-survey-activity-atlantic*.

1.4 Compliance with Other Environmental Laws or Consultations

NMFS must comply with all applicable federal environmental laws and regulations necessary to implement a proposed action. NMFS's evaluation of and compliance with environmental laws and regulations is based on the nature and location of an applicant's proposed activities and NMFS's proposed action. Therefore, this section only summarizes environmental laws applicable to NMFS's issuance of IHAs to the five applicants.

1.4.1 Coastal Zone Management Act

Section 307 of the Coastal Zone Management Act (CZMA) (16 U.S.C. § 1456) and NOAA's federal consistency regulations (15 C.F.R. part 930) require that federal actions within and outside of the coastal zone, which may have reasonably foreseeable effects on the uses or resources of the coastal zone of a state, be consistent with the enforceable policies of the state's federally-approved Coastal Management Program (CMP). Under this provision, if a federal activity is not listed in a state's CMP, the state can request approval from NOAA's Office for Coastal Management (OCM) to review the activity for federal consistency. NMFS's 2015 FR notice (80 FR 45195) afforded states the ability to request review related to NMFS's federal action for three applicants (TGS-NOPEC Geophysical Company (TGS), Spectrum Geo Inc. (Spectrum), and ION GeoVentures (ION)), but no state requested the opportunity to review. Then, in 2017, NMFS's FR notice of proposed IHAs (82 FR 26244) afforded states the opportunity to request review related to NMFS's federal action for the remaining applicants, CGG and Western. Delaware and Maryland were the only two states that requested consistency review related to CGG and WesternGeco's applications for IHAs. OCM found that neither state

[11] BOEM executes their permitting authority pursuant to 30 CFR parts 550, 551, 580 and 585, Section 11, Subsections 8(k) and 8(p) of the OCSLA and Section 388(a) of the EPAct of 2005. Although NMFS's authority to issue ITAs under the MMPA is not the same as BOEM's permitting authority under these other laws, NMFS's action to review and issue any given ITA coincides with BOEM's action to authorize and permit G&G activities under these other laws.

had demonstrated that there may be foreseeable effects from the issuance of an IHA on state coastal resources and uses, and therefore, denied their requests for CZMA review. All other states are outside the legal window (30 days of receiving notice of an application) to request unlisted activity consistency review from the time of notification, and therefore no other consistency reviews for the IHAs may be requested under the CZMA.

BOEM also underwent a similar review process related to their federal permitting action (also an unlisted activity for all Atlantic coastal states). In 2014, states along the East Coast from New York to Florida (excluding New Jersey and Virginia) requested that OCM grant permission for federal consistency review related to nine G&G permit applications BOEM received. After reviewing the state requests, OCM found reasonably foreseeable effects and granted reviews for six states. OCM denied New York's request, finding that the specified federal actions would not have reasonably foreseeable effects on the state's coastal resources or uses.

1.4.2 Endangered Species Act

The ESA establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the habitat they depend on. An endangered species is a species in danger of extinction throughout all or a significant portion of its range, and a threatened species is one that is likely to become endangered within the foreseeable future throughout all or in a significant portion of its range. The U.S. Fish and Wildlife Service (USFWS) and NMFS jointly administer the ESA and are responsible for listing a species as either threatened or endangered, as well as designating critical habitat where applicable, developing recovery plans for these species, and undertaking other conservation actions pursuant to the ESA. The ESA generally prohibits the "take" of an ESA-listed species unless an exception or exemption applies. The term "take" as defined in Section 3 of the ESA means to "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct."

Section 7(a)(2) of the ESA requires federal agencies to insure that their actions are not likely to jeopardize the continued existence of endangered or threatened species or adversely modify or destroy their designated critical habitat. Federal agencies must do so in consultation with NMFS (or the USFWS) for actions that may affect species listed as threatened or endangered or critical habitat designated for such species under Section 4 of the ESA (50 C.F.R. §402.14(a)). If a federal action agency determines that an action "may affect, but is not likely to adversely affect" endangered species, threatened species, or designated critical habitat and the consulting agency concurs with that determination, consultation concludes informally (50 C.F.R. §402.14(b)). The federal action agency, pursuant to Section 7(a)(4), shall confer with the consulting agency on any action which is likely to jeopardize the continued existence of any proposed species or result in the destruction or adverse modification of proposed critical habitat (50 C.F.R. §402.10). If requested by the federal agency and deemed appropriate, the conference may be conducted in accordance with the procedures for formal consultation in 50 C.F.R §402.14 (50 C.F.R §402.10(d)).

Section 7(b)(3) of the ESA requires that at the conclusion of consultation, the consulting agency provides an opinion stating whether the federal agency's action is likely to jeopardize ESA-listed species or destroy or adversely modify designated critical habitat. A similar opinion is included for proposed species or proposed critical habitat if either or both were part of the consultation. If the consulting agency determines that the action is likely to jeopardize ESA-listed species or destroy or adversely modify critical habitat, they then provide a reasonable and prudent alternative that allows the action to proceed in compliance with Section 7(a)(2) of the ESA. If

incidental take is expected and certain conditions are met, Section 7(b)(4) requires the consulting agency to provide an incidental take statement that specifies the impact of any incidental taking and includes mandatory reasonable and prudent measures to minimize such impacts and terms and conditions to implement the reasonable and prudent measures.

There are five marine mammal species under NMFS's jurisdiction listed as threatened or endangered under the ESA with confirmed or possible occurrence in the AOI, including North Atlantic right whales (NARW), fin whales, sei whales, sperm whales, and blue whales. NMFS's issuance of IHAs to the five companies is subject to the requirements of Section 7 of the ESA. Therefore, NMFS's Office of Protected Resources (OPR), Permits and Conservation Division requested initiation of a formal consultation with the NMFS OPR, ESA Interagency Cooperation Division on the proposed issuance of IHAs on June 5, 2017; formal consultation was initiated on June 28, 2017. The formal consultation concluded and a final Biological Opinion (BiOp) was issued in November 2018. The BiOp found that NMFS's proposed action is not likely to jeopardize the continued existence or recovery of blue whales, fin whales, NARW, sei whales, or sperm whales. This determination was made based on review of the status of the ESA-listed species, the environmental baseline within the action area, and the effects of the proposed action as well as effects of interrelated and interdependent actions and cumulative effects. Furthermore, NMFS OPR, ESA Interagency Cooperation Division found that the proposed action is also not likely to adversely affect designated critical habitat for NARW; thus, no destruction or adverse modification of designated critical habitat for these species is anticipated.

Separately, on July 19, 2013, NMFS OPR, ESA Interagency Cooperation Division issued a BiOp to BOEM and the Bureau of Safety and Environmental Enforcement (BSEE) analyzing BOEM's proposed permitting activities in support of its oil and gas, renewable energy, and marine minerals programs, before NMFS had received any applications for IHAs[12]. On October 16, 2015, BOEM requested reinitiation of consultation since there were a number of species proposed and listed and critical habitat proposed and designated since issuance of the opinion in 2013. Because new information on marine mammal occurrence had also become available, the reinitiated consultation would also consider the relevance of the new information for marine mammal species affected by activities associated with implementation of BOEM's oil and gas, renewable energy, and marine minerals programs in the Mid- and South Atlantic OCS Planning Areas. This 2013 reinitiation of consultation is still ongoing with BOEM and BSEE. However, it is important to note that while the programmatic consultation is ongoing, NMFS's 2018 BiOp applies to both BOEM's issuance of five permits and NMFS's issuance of five associated IHAs.

1.4.3 Magnuson-Stevens Fishery Conservation and Management Act

Under the MSFCMA, federal agencies are required to consult with the Secretary of Commerce with respect to any action authorized, funded, or undertaken, or proposed to be authorized by such agency that may adversely affect EFH identified under the MSFCMA. Authorizing the take of marine mammals through the issuance of the five IHAs is unlikely to affect the ability of the water column or substrate to provide necessary spawning, feeding, breeding or growth to maturity functions for managed fish. Likewise, authorizing the take of marine mammals is not likely to reduce (directly or indirectly) the quantity or quality of EFH by affecting the physical, biological or chemical parameters of EFH. Marine mammals were not identified as a prey component of EFH for managed fish species in the AOI, so authorizing the incidental take of

[12] At the time of publication of the 2014 Final PEIS and 2013 BiOp, there were six ESA-listed marine mammal species occurring in the AOI (North Atlantic right whale, blue whale, sei whale, fin whale, sperm whale, and humpback whales). Since publication, NMFS divided the formerly globally listed humpback whale into 14 Distinct Population Segments (DPSs) under the ESA (81 FR 62259; September 8, 2016). The only humpback whale DPS occurring in the AOI (West Indies DPS) has been delisted.

marine mammals will likely not reduce the quantity and/or quality of EFH. Finally, none of the required mitigation or monitoring elements in the five IHAs have the ability to affect EFH. Therefore, pursuant to 2017 NMFS Office of Habitat Conservation guidance on EFH and ITAs, NMFS OPR determined that the issuance of the five IHAs will not result in adverse impacts to EFH and that a separate consultation per Section 305(B)(2) of the MSFCMA as amended by the Sustainable Fisheries Act of 1996 (Public Law 104-267) is not required.

Separately, BOEM consulted with NMFS during the development of the PEIS and based on this initial consultation, NMFS determined that a Programmatic EFH Consultation was not appropriate. Therefore, BOEM determined they will consult with NMFS regarding potential effects to EFH on an activity-specific basis upon receiving applications for permits. Refer to Chapter 1.6.8 in BOEM's Final PEIS for more information.

1.4.4 National Marine Sanctuaries Act

Under Title III of the Marine Protection, Research, and Sanctuaries Act of 1972 (also known as the National Marine Sanctuaries Act (NMSA) (16 U.S.C. §§ 1431 et seq.)), NOAA can establish as national marine sanctuaries (NMS) areas of the marine environment with special conservation, recreational, ecological, historical, cultural, archaeological, scientific, educational, or aesthetic qualities. Sanctuary regulations prohibit destroying, causing the loss of, or injuring any sanctuary resource managed under the law or regulations for that sanctuary (15 CFR part 922). NMS are managed on a site-specific basis, and each sanctuary has site-specific regulations. Section 304(d) of the NMSA requires federal agencies to consult with NOAA's Office of National Marine Sanctuaries (ONMS) whenever their proposed activity is "likely to destroy, cause the loss of, or injure a sanctuary resource." Based on coordination and discussion between BOEM and ONMS, BOEM would avoid the potential for injury to sanctuary resources by conditioning permits such that all surveys must maintain a minimum buffer of 15 km around the boundaries of the sanctuaries in the AOI (Gray's Reef and Monitor NMS). Gray's Reef NMS is located approximately 26 km off the Georgia coast and protects 57 km2 (46 FR 7942). The Monitor NMS is located approximately 26 km off the North Carolina coast and protects the wreck of the USS Monitor (81 FR 879). Because this precludes the possibility of impacts to sanctuary resources, NMFS did not need to consult with ONMS regarding its action of issuing the IHAs.

1.5 Document Scope

NMFS prepared this EA in accordance with NEPA (42 USC 4321, et seq.), CEQ Regulations (40 CFR 1500-1508), and NOAA policy and procedures (NAO 216-6A and the Companion Manual for the NAO 216-6A). The analysis in this EA addresses potential direct, indirect, and cumulative impacts to marine mammals and their habitat, resulting from NMFS's proposed action to authorize incidental take associated with geophysical survey activities proposed by the five applicants. However, the scope of this analysis is limited to the decision for which we are responsible (i.e., whether to issue the IHAs to each applicant). Therefore, this EA provides focused information on the primary impacts of environmental concern specific to authorizing take of marine mammals and the mitigation and monitoring measures to minimize the effects of that take. This EA also addresses new information and data (see Section 1.6.2.) concerning marine mammals that was not available for analysis at the time BOEM completed their Final PEIS in 2014.

In addition to providing focused information based on the applications received and addressing new information concerning potential marine mammal impacts, NMFS determined BOEM's evaluation of the direct, indirect, and cumulative impacts on the human environment, including some aspects of marine mammal and ESA-listed species impacts, is adequate and relevant to the

analysis in this EA. Therefore, NMFS relied on the analysis in BOEM's Final PEIS, incorporating certain material by reference,[13] and did not provide a detailed evaluation of effects to the human environment for all elements listed in Table 1 for reasons explained below.
In the Final PEIS, BOEM presented the baseline environmental conditions for affected resources in the AOI along with potential impacts to these resources that may result from conducting the various types of G&G activities projected to occur over a nine-year period. The affected environment and environmental consequences are explained discussed in Volume I, Chapter 4, within subsections arranged by resource type. The analysis in the Final PEIS describes and specifically addresses the following key issues and environmental concerns in detail:

- impacts of underwater noise on marine mammals, sea turtles, fishes, birds, and other marine life from active acoustic sources (airguns and electromechanical sources);
- impacts of underwater noise on commercial and recreational fishing;
- impacts of vessel traffic (including risk of ship strikes) on marine mammals and sea turtles, birds, and threatened and endangered fish species;
- impacts of vessel traffic on fishing, shipping, and other marine uses;
- impacts of aircraft traffic and noise on marine mammals, sea turtles, birds, and other marine uses;
- impacts of seafloor-disturbing activities on sensitive benthic communities including coral and hard/live bottom communities, chemosynthetic communities, and deepwater canyon benthos;
- impacts of seafloor-disturbing activities on EFH, Habitat Areas of Particular Concern (HAPC), and Marine Protected Areas (MPAs);
- impacts of seafloor-disturbing activities on archaeological resources including historic shipwrecks and prehistoric archaeological sites;
- impacts of vessel exclusion zones on commercial and recreational fishing, shipping, recreational resources, and other marine uses;
- impacts of marine trash and debris on benthic communities, marine mammals, sea turtles, birds, endangered or threatened fish species, and recreational resources;
- impacts of accidental spills on benthic communities, marine mammals, sea turtles, birds, fishes and EFH, archaeological resources, recreational resources, MPAs, other marine uses, and human resources and land use.

The Marine Mammals subsections in Volume I, Chapter 4 of BOEM's Final PEIS contain the majority of the analysis that relates to NMFS's action of issuing these five IHAs. The supporting technical documents in the appendices contain additional information on marine mammals and the modeling used by BOEM to quantitatively and qualitatively evaluate potential impacts to marine mammals, including descriptions of the potential acoustic impacts and acoustic thresholds used to indicate at what received sound levels marine mammals will experience certain effects (equivalent to regulatory definitions of harassment pursuant to the MMPA). Other subsections in Chapter 4 contain analyses related to potential impacts on marine mammal habitat along with the potential for cumulatively significant impacts to marine mammals, all of which supports this analysis for issuance of IHAs to the five applicants.

Table 1. Elements of the Environment Not Carried Forward for Analysis

[13] Per 40 CFR 1502.21

Biological	Physical	Socioeconomic/Cultural
Humans	Air Quality	Commercial Fishing
Fisheries Resources and EFH	Farmland Geography	Historic and Cultural Resources
Invertebrates	Geology/sediments	Indigenous Cultural Resources
Invasive Species	Land Use	Low Income Populations
Marine and Coastal Birds	Oceanography	Military Activities
Sea Turtles	State Marine Protected Areas	Minority Populations
Threatened and Endangered Fishes	Federal Marine Protected Areas	National Historic Preservation Sites
Benthic Communities	National Estuarine Research Reserves	Other Marine Uses: Military activities, Shipping and marine transportation, and Boating
	National Marine Sanctuaries	Recreational Fishing
	National Wildlife Refuges	Public Health and Safety
	Park Land	
	Water Quality	
	Wetlands	
	Wild and Scenic Rivers	

1.5.1 Best Available Data and Information

In accordance with NEPA and the Administrative Procedure Act of 1946 (5 U.S.C. §§ 551-559), NMFS used the best available data and information to compile and assess the environmental baseline and impacts evaluated in this document. Literature reviews of journals, books, periodicals or technical reports, and previous analyses were conducted to support the analysis of potential impacts to marine mammals associated with acoustic sources and for the identification and evaluation of mitigation measures. We evaluated all sources, including websites, identified in this EA were evaluated for credibility of the source, quality of the information, and relevance of the content to ensure use of the best available information.

1.5.2 New and Updated Information and Data Considered

Since BOEM issued the Final PEIS and ROD in 2014, NMFS recognized that new scientific information (e.g., new marine mammal density models representing the best available science) or regulatory determinations (e.g., critical habitat designation) warrant additional environmental review and consideration, and hence give reason for preparing an EA. A summary of the applicable new information is below, and details of its application in the IHAs is in Chapter 4 of this EA.

Revised North Atlantic Right Whale Critical Habitat

In January 2016, NMFS revised the existing critical habitat designation for the NARW (81 FR 4837, 27 January 2016). The Southeast critical habitat area now extends from the Cape Fear, North Carolina region to 27 nautical miles (nm) south of Cape Canaveral, Florida and is intended to protect NARW calving habitat. The previous NARW critical habitat designation in the southeast included pocket areas adjacent to coastal Georgia and the east coast of Florida. To account for the revised critical habitat designation as well as the best available information regarding NARW occurrence in the AOI, the Final IHAs include larger time-area restrictions and buffer zones, which is more conservative than those assessed in BOEM's Final PEIS.

New Marine Mammal Density Data

New marine mammal density models have been published (Roberts et al., 2016) since publication of the PEIS, which now represent the best available science relating to cetacean abundance and occurrence patterns. In addition, after publication of the proposed IHAs, NMFS became aware of efforts by Roberts et al. to update NARW density model outputs. These outputs expanded the original dataset used to inform density modeling by including information from the Atlantic Marine Assessment Program for Protected Species (AMAPPS), as well as aerial surveys conducted by several organizations in the Southeast. The number of right whale sightings used in this model in the AOI increased by roughly 2,500 sightings (Roberts et al., 2017). The models also now incorporated several improvements to minimize biases, an improved seasonal definition that more closely aligns with right whale biology, and showed a strong relationship between right whale abundance in the action area and distance to shore to approximately 80 km (Roberts et al., 2017), which was approximately 50 km in the previous model (Roberts et al., 2016). Thus, using this new information, estimates of Level B harassment for NARW were updated and NMFS's time-area restrictions were modified to appropriately reflect the new information.

The PEIS based density estimates on the U.S. Navy Operating Area Density Estimates (NODEs), which were derived from vessel and aerial survey data collected by NMFS from 1998-2005 during broad-scale abundance surveys. This was the best available information about marine mammal occurrence at the time BOEM developed the Final PEIS.

Updated Acoustic Guidance

In 2016, NMFS published Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing ("new guidance") (NOAA Technical Memorandum NMFS-OPR-55). This new guidance identified the received levels, or acoustic thresholds, above which marine mammals are predicted to experience changes in hearing sensitivity for acute, incidental exposure to anthropogenic sound sources. More specifically, it identifies thresholds for the onset of permanent threshold shift (PTS) for impulsive (e.g., airguns) and non-impulsive sound sources, based on the formation of marine mammal hearing groups (e.g., low-, mid-, and high-frequency cetaceans). The new thresholds and auditory weighting functions for three cetacean hearing groups provided in the guidance replaced the historical acoustic exposure threshold for auditory injury (previously based solely on a received sound pressure level (SPL) of 180 dB root

mean square (rms) for all cetacean species), which the best available science has since shown to be inaccurate (see Figure 1). Furthermore, NMFS revised Southall et al. (2007)'s recommendations for marine mammals to be divided into functional hearing groups, now describing generalized hearing ranges for various marine mammal groups (Figure 1). Because the new guidance represented the best available information and was finalized after publication of BOEM's Final PEIS, NMFS incorporated that information in the IHAs as the basis to evaluate potential auditory injury for different marine mammal hearing groups (see Chapter 4 of this EA). The guidance was revised in 2018, and NMFS's analyses reflect this revised version of the guidance.

Hearing Group	Generalized Hearing Range*
Low-frequency (LF) cetaceans (baleen whales)	7 Hz to 35 kHz
Mid-frequency (MF) cetaceans (dolphins, toothed whales, beaked whales, bottlenose whales)	150 Hz to 160 kHz
High-frequency (HF) cetaceans (true porpoises, *Kogia*, river dolphins, cephalorhynchid, *Lagenorhynchus cruciger* & *L. australis*)	275 Hz to 160 kHz
Phocid pinnipeds (PW) (underwater) (true seals)	50 Hz to 86 kHz
Otariid pinnipeds (OW) (underwater) (sea lions and fur seals)	60 Hz to 39 kHz

* Represents the generalized hearing range for the entire group as a composite (i.e., all species within the group), where individual species' hearing ranges are typically not as broad. Generalized hearing range chosen based on ~65 dB threshold from normalized composite audiogram, with the exception for lower limits for LF cetaceans (Southall et al. 2007) and PW pinniped (approximation).

Figure 1. Marine Mammal Hearing Groups (NMFS, 2018)

Modeling

Sound Field Modeling—BOEM provided sound field modeling, including isopleth distances to certain received level thresholds (described in detail in Volume III, Appendix D of the Final PEIS). In brief, BOEM generated a three-dimensional acoustic propagation field as a function of output characteristics of a representative 5,400 in^3 airgun array, within 21 distinct propagation scenarios, reflecting varying water depths, water temperatures, and bottom types (i.e., sand and clay). The scenarios varied by season as a result of different sound speed profiles (Zykov and Carr, 2014). Two acoustic models were employed to estimate the acoustic field radiated by the sound sources. Directional source levels from an airgun array were modeled using the Airgun Array Source Model (AASM) based on specifications of the source such as the arrangement and volume of the guns, firing pressure, and depth below the sea surface. A version of JASCO Applied Science's Marine Operations Noise Model (MONM), based on the Range-dependent Acoustic Model (RAM) parabolic-equation model, MONM-RAM, was used to model the resulting sound fields based on the AASM outputs.

Marine Mammal Acoustic Exposure Estimates—BOEM's sound field modeling was used with the NODEs data to produce their acoustic exposure estimates. In summary, region-specific density estimates, corresponding with the 21 acoustic modeling regions, were created using NODEs seasonal distribution density information. Density for marine mammals outside of 200 nmi was extrapolated using density information at the edge of the area modeled by NODEs. Results of the acoustic modeling and region-specific density estimates were input into Marine

Acoustics Inc.'s Acoustic Integration Model (AIM), a software package that simulated marine animals (i.e., animats) behaving in specific ways. Animat positions relative to the acoustic source (i.e., range, bearing, and depth) were used to extract received sound exposure level (SEL) estimates. Received levels were expressed as root mean square (rms) sound pressure levels (SPLs) with units of dB re 1μ Pa, which were then converted back to intensity summed over the duration of an exercise to generate an integrated energy level expressed in either dB re 1 μPa2-sec or dB SEL. The numbers of animats per species that exceeded the pre-determined received level criteria were then determined using a seeded density of animats, with the results then scaled using the real-world density estimates. In doing so, BOEM produced their own exposure estimates for marine mammal species for each year of activity covered in the PEIS, reflective of the representative airgun array used in their sound field modeling (as well as for other non-airgun G&G survey activities).

In the IHA applications, three of the geophysical companies—TGS, CGG, and Western—used the acoustic modeling from BOEM's PEIS to inform their acoustic exposure modeling. ION and Spectrum performed their own acoustic modeling, using similar procedures to those described above, but made additional changes, such as limiting the acoustic analysis to specific seasons. See Appendix D in BOEM's PEIS (BOEM, 2014a), the "Sound Field Modeling" section in the notice of proposed IHAs (82 FR 26244), and the five applications on NMFS's website for more information: *www.fisheries.noaa.gov/action/incidental-take-authorization-oil-and-gas-industry-geophysical-survey-activity-atlantic*. Since publication of the proposed IHAs, NMFS has revised exposure estimates for NARW using the more recent density model described above (i.e., Roberts et al., 2017), and revised estimates for additional species by accounting for planned time-area restrictions on survey effort. See Chapter 4 of this EA for more information.

New Scientific Information

NMFS also incorporated other scientific information into its IHAs and this analysis that was either published after publication of the PEIS or not included in the PEIS. This includes, but is not limited to: (1) information on recommended or required mitigation protocols (e.g., IAGC, 2015; BOEM, 2016; Nowacek and Southall, 2016); (2) information on impacts from airgun noise to marine mammals and their prey (e.g., Blackwell et al., 2015; Finneran et al., 2015; Erbe et al., 2016; Gailey et al., 2016; Popov et al., 2016; Dunlop et al., 2017; McCauley et al., 2017; Paxton et al., 2017; Videsen et al., 2017); (3) information on marine mammal abundance and distribution (e.g., Baird et al., 2015; LaBrecque et al., 2015; Frasier et al., 2016; Waring et al., 2016; Oedekoven et al., 2015; Roberts et al., 2016; Salisbury et al., 2016; Davis et al., 2017; Stanistreet et al., 2018).

CHAPTER 2 ALTERNATIVES

2.0 Introduction

As indicated in Chapter 1 of this EA, NMFS's Proposed Action is to issue IHAs to authorize the take of small numbers of marine mammals incidental to each of the five companies' proposed geophysical survey activities. NMFS's Proposed Action is triggered by these applicants' requests for an IHA per the MMPA of 1972, as amended (16 U.S.C. 1361 et seq.). In accordance with the NEPA and CEQ Regulations, NMFS is required to consider a reasonable range of alternatives to a Proposed Action, as well as a No Action Alternative. Reasonable alternatives are viable options for meeting the purpose and need for the proposed action. The evaluation of alternatives under NEPA assists NMFS with understanding, and as appropriate minimizing, impacts through an assessment of alternative ways to achieve the purpose and need for our Proposed Action. Reasonable alternatives are carried forward for detailed evaluation under NEPA. Alternatives considered but determined not to meet the purpose and need are not carried forward. For the purposes of this EA, an alternative will only meet the purpose and need if it satisfies the requirements of Section 101(a)(5)(D) of the MMPA. Therefore, NMFS applied the screening criteria and considerations outlined in Section 2.1 below to the alternatives to identify which alternatives to carry forward for analysis. Accordingly, an alternative must meet these criteria to be considered "reasonable."

2.1 Considerations for Selecting Alternatives

Under Section 101(a)(5)(D) of the MMPA, NMFS must set forth the permissible methods of taking pursuant to such activity, and other means of effecting the least practicable impact on such species or stock and its habitat, paying particular attention to rookeries, mating grounds, and areas of similar significance, and on the availability of such species or stock for taking for certain subsistence uses ("least practicable adverse impact"). Consideration of the availability of marine mammal species or stocks for taking for subsistence uses pertains only to Alaska, and is therefore not relevant here. NMFS does not have a regulatory definition for "least practicable adverse impact." NMFS's implementing 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 such activity or other means of effecting the least practicable adverse impact upon the affected species or stocks and their habitat" (50 CFR 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, we carefully consider two primary factors:

(1) The manner in which, and the degree to which, implementation of the measure(s) is expected to reduce impacts to marine mammal species or stocks, their habitat, and their availability for subsistence uses (when relevant). This analysis will consider such things as the nature of the potential adverse impact (such as likelihood, scope, and range), the likelihood that the measure will be effective if implemented, and the likelihood of successful implementation.

(2) The practicability of the measure for applicant implementation. The analysis may consider such things as cost, impact on operations, personnel safety, and practicality of implementation.

While the language of the least practicable adverse impact standard calls for minimizing impacts to affected species or stocks, we recognize that the reduction of impacts to those species or stocks accrues through the application of mitigation measures that limit impacts to individual

animals. Accordingly, our analysis focuses on measures designed to avoid or minimize impacts on marine mammals from activities that are likely to increase the probability or severity of population-level effects, including auditory injury or disruption of important behaviors, such as foraging, breeding, or mother/calf interactions.

In the evaluation of specific measures, the details of the specified activity will necessarily inform each of the two primary factors discussed above (expected reduction of impacts and practicability), and will be carefully considered to determine the types of mitigation that are appropriate under the least practicable adverse impact standard. Analysis of how a potential mitigation measure may reduce adverse impacts on a marine mammal stock or species and practicability of implementation are not issues that can be meaningfully evaluated through a yes/no lens. The manner in which, and the degree to which, implementation of a measure is expected to reduce impacts, as well as its practicability in terms of these considerations, can vary widely. For example, a time/area restriction could be of very high value for decreasing population-level impacts (e.g., avoiding disturbance of feeding females in an area of established biological importance) or it could be of lower value (e.g., decreased disturbance in an area of high productivity but of less firmly established biological importance). Regarding practicability, a measure might involve operational restrictions that completely impede the operator's ability to acquire necessary data (higher impact), or it could mean additional incremental delays that increase operational costs but still allow the activity to be conducted (lower impact). Expected effects of the activity and of the mitigation as well as status of the stock all weigh into these considerations. Accordingly, the greater the likelihood that a measure will contribute to reducing the probability or severity of adverse impacts to the species or stock, the greater the weight that measure is given when considered in combination with practicability to determine the appropriateness of the mitigation measure, and vice versa.

2.2 Description of Activities

From 2015 through 2016, NMFS received five separate complete requests for IHAs related to planned geophysical surveys in the AOI. The following section summarizes the planned activity by each company. See Table 2, the notice of proposed IHAs, and the original applications on NMFS's website for more specific information about each survey: *www.fisheries.noaa.gov/action/incidental-take-authorization-oil-and-gas-industry-geophysical-survey-activity-atlantic*.

- CGG: CGG's survey is planned to occur from Virginia to Georgia (see Figure 3 of CGG's application), and consists of ~28,670 km of survey line. The acoustic source planned for deployment is a 36-airgun array with a total volume of 5,400 in^3. The array would consist of airguns ranging in volume from 40 in^3 to 380 in^3. The airguns would be configured as four identical strings (see Figure 2 of CGG's application). The four airgun strings would be towed at 7-m depth, and would fire every 25 m or 10 s, depending on exact vessel speed. More detail regarding CGG's acoustic source and modeling related to CGG's application is provided in CGG's application.

- ION: ION's survey is planned to occur from Delaware to northern Florida (~38.5ºN to ~27.9ºN) (see Figure 1 of ION's application), and consists of ~13,062 km of survey line. The acoustic source planned for deployment is a 36-airgun array with a total volume of 6,420 in^3. The array would consist of airguns ranging in volume from 40 in^3 to 380 in^3. The airguns would be configured as four identical linear arrays or "strings" (see Figure 3 of ION's application). The four airgun strings would be towed at 10-m depth, and would

fire every 50 m or 20-24 s, depending on exact vessel speed. ION provided modeling results for their array, including notional source signatures, 1/3-octave band source levels as a function of azimuth angle, and received sound levels as a function of distance and direction at 16 representative sites in the proposed survey area. For more detail, please see Figures 4-6 and Appendix A of ION's application.

- Spectrum: Spectrum's survey was initially planned to occur from Delaware to northern Florida (see Figure 1 of Spectrum's application), consisting of ~21,635 km of survey line. In June 2018, Spectrum notified NMFS of a requested modification to their survey plan. The modified survey plan occurs roughly within the same survey "footprint," and consists of ~13,766 km of survey line (see Figure provided on p. 2 of Spectrum's letter notifying us of their intent to modify their survey plan). Therefore, the modified survey plan represents an approximate 34 percent decrease in total survey line. The changes to the survey plan, in summary, include the following: (1) rotated the survey grid by approximately 5 degrees; (2) trimmed lines from most time-area restrictions; (3) removed certain lines; and (4) shifted certain lines. Spectrum's letter modifying their survey plan shows an overlay of the modified survey plan (red lines) with the previously proposed survey plan (black lines). Spectrum's letter can be found on-line at *www.fisheries.noaa.gov/action/incidental-take-authorization-oil-and-gas-industry-geophysical-survey-activity-atlantic*.

  The acoustic source planned for deployment is a 32-airgun array with a total volume of 4,920 in^3. The array would consist of airguns ranging in volume from 50 in^3 to 250 in^3. The airguns would be configured as four subarrays, each with eight to ten airguns (see Figure 2 in Appendix A of Spectrum's application). The four airgun strings would be towed at 6 to 10-m depth, and would fire every 25 m or 10 s, depending on exact vessel speed. Spectrum provided modeling results for their array, including notional source signatures, 1/3-octave band source levels as a function of azimuth angle, and received sound levels as a function of distance and direction at 16 representative sites in the proposed survey area. For more detail, please see Appendix A of Spectrum's application.

- TGS: TGS's survey is planned to occur from Delaware to northern Florida (see Figure 1-1 of TGS's application), and consists of ~58,300 km of survey line. The survey plan consists of two contiguous survey grids with differently spaced lines (see Figures 1-1 to 1-4 of TGS's application), and would involve use of two source vessels operating independently of one another at a minimum of 100 km separation distance. The acoustic sources planned for deployment are 40-airgun arrays with a total volume of 4,808 in^3. The array would consist of airguns ranging in volume from 22 in^3 to 250 in^3. The airguns would be configured as four identical strings (see Figure 3 in Appendix B of TGS's application). The four airgun strings would be towed at 7-m depth, and would fire every 25 m or 10 s, depending on exact vessel speed. More detail regarding TGS's acoustic source and modeling related to TGS's application is provided in Appendix B of TGS's application.

- Western: Western's survey is planned to occur from Maryland to northern Florida (see Figure 1-1 of Western's application), and consists of ~27,330 km of survey line. The survey plan consists of a survey grid with differently spaced lines (see Figures 1-1 to 1-4 of Western's application). The acoustic source planned for deployment is a 24-airgun array with a total volume of 5,085 in^3. The airguns would be configured as three identical

strings. The three airgun strings would be towed at 10-m depth, and would fire every 37.5 m (approximately every 16 s, depending on vessel speed). More detail regarding Western's acoustic source and modeling related to Western's application is provided in Appendix B of Western's application.

Table 2. Survey and Airgun Array Characteristics

Company	Total planned survey km	Total volume (in^3)	# guns	# strings	Nominal source output (downward)[1]			Shot interval (m)	Tow depth (m)
					0-pk	pk-pk	rms		
ION	13,062	6,420	36	4	257	263	247[4]	50	10
Spectrum	13,766	4,920	32	4	266	272	243	25	6-10
TGS	58,300	4,808	40	4	255	-[3]	240	25	7
Western	27,330	5,085	24	3	-[3]	262	235	37.5	10
CGG	28,670	5,400	36	4	-[3]	259	243[3,4]	25	7
BOEM[2]	n/a	5,400	18	3	247	-[3]	233	n/a	6.5

[1] See "Description of Active Acoustic Sound Sources" in the notice of proposed IHAs for discussion of these concepts.
[2] Notional array characteristics modeled and source characterization outputs from BOEM's PEIS (2014a) provided for comparison.
[3] Values not given; however, SPL (pk-pk) is usually considered to be approximately 6 dB higher than SPL (0-pk) (Greene, 1997).
[4] Value decreased from modeled 0-pk value by minimum 10 dB (Greene, 1997).

2.3 Alternative 1 (No Action Alternative)

In accordance with NOAA's implementing procedures, the Companion Manual for NAO 216-6A, Section 6.B.i ,NMFS is defining the No Action alternative as not authorizing the requested incidental take of marine mammals under Section 101(a)(5)(D) of the MMPA. This is consistent with our statutory obligation under the MMPA to either: (1) deny the requested authorization or (2) grant the requested authorization and prescribe mitigation, monitoring, and reporting requirements. Under the No Action Alternative, NMFS would not issue the IHAs to the applicants, in which case we assume the applicants would not proceed with their proposed geophysical survey activities as described in the applications. The requested take would not occur and mitigation, monitoring, and reporting for marine mammals would not be implemented. Although the No Action Alternative would not meet the purpose and need to allow incidental takes of marine mammals under certain conditions (i.e., when the statutory requirements are satisfied), the CEQ Regulations require consideration and analysis of a No Action Alternative for the purposes of presenting a comparative analysis to the action alternatives. The No Action Alternative, consistent with CEQ Guidance and the Companion Manual for NAO 216-6A, serves as a baseline against which the impacts of the Preferred Alternative will be compared and contrasted.

2.4 Alternative 2 – Issuance of Authorizations with Additional Mitigation Measures (Preferred Alternative)

Under this alternative, NMFS would issue IHAs to each of the five companies allowing the incidental take, by harassment only, of marine mammals consistent with the activities described in Section 2.2 and more thoroughly in the notice of proposed IHAs, subject to additional mitigation requirements prescribed by NMFS (see Sections 2.4.2 and 4.4.4 in this EA). This Alternative includes mandatory requirements, including monitoring and reporting, for each of the applicants to achieve the MMPA standard of effecting the least practicable adverse impact on the

affected species or stocks of marine mammals and their habitat, paying particular attention to rookeries, mating grounds, and other areas of similar significance.

2.4.1 Mitigation Measures

NMFS has reviewed the best scientific information in consideration of additional mitigation specific to our actions and pursuant to Section 101(a)(5)(D) of the MMPA. In development of mitigation measures under the Preferred Alternative, NMFS reviewed and considered mitigation evaluated by BOEM in the PEIS, as well as mitigation measures proposed by the applicant companies in their applications for IHAs. While NMFS is carrying forward a single action alternative, it in essence considered sub-alternatives as it evaluated the effectiveness of different levels and types of mitigation, summarized in Table 3 and Table 5 in this EA. For example, NMFS considered the option of carrying forward the same mitigation measures identified in BOEM's preferred alternative and described in their ROD. NMFS also considered limiting mitigation measures to those proposed by the applicants (which largely follow those identified in BOEM's preferred alternative). However, NMFS determined that neither option would be sufficient to meet the MMPA's least practicable adverse impact standard, and therefore would not satisfy the Purpose and Need described herein. Based on this review, NMFS's mitigation included in the Preferred Alternative described in this analysis differs from that identified in BOEM's preferred alternative and described in their ROD and from the various suites of mitigation measures proposed by the applicants. That evaluation is explained in this section and Section 2.5. NMFS assessed how such measures could benefit the affected marine mammal species or stocks and their habitat. NMFS believes our suite of mitigation measures, which incorporated the best available information as indicated in Chapter 1 of this EA, fulfill our statutory obligations under the MMPA, and reflect specific survey information detailed in the five applications. For a full description of mitigation measures considered by BOEM in their PEIS relevant to deep penetration airgun surveys, please see Volume I, Chapter 2.2 and "Attachment 1: Seismic Airgun Survey Protocol" in Volume III, Appendix C of BOEM's Final PEIS. Further, please see BOEM's ROD for a full description of the mitigation measures that we assume would be carried forward as permit conditions when implementing their Preferred Alternative in the future. However, it is important to note that in BOEM's final permits, they could alter or change some of the mitigation measures described in the PEIS to reflect best available science and details specific to applications submitted to BOEM; for the purposes of this analysis under NEPA, NMFS only compares its mitigation to that discussed in BOEM's PEIS and ROD.

Our evaluation of mitigation measures for the issuance of these five IHAs included consideration of the following factors related to marine mammals, as well as characteristics of the specific surveys and practicability of implementation for the applicants. For marine mammals, NMFS carefully considered the status of species and stocks (i.e., giving particular consideration to ESA-listed species or those facing significant additional stressors); distribution and abundance throughout the AOI (i.e., considering time-area restrictions for species with site fidelity towards specific bathymetric or dynamic oceanographic features); sensitivity to the acoustic sound source and potential effects from exposure (e.g., for some low-frequency cetaceans whose best hearing overlaps with the frequency ranges of airguns, for some species with particular behavioral sensitivity to acoustic exposure), and other information detailed in Chapter 4 of this EA. We considered this in the context of the activities planned by the applicants, such as survey duration and planned areas of operation within the AOI.

Viewing this information collectively, NMFS developed mitigation that sometimes varies from what BOEM identified in their preferred alternative. The most notable differences are: (1) spatiotemporal mitigation measures, including four time-area restrictions, a 30-km year-round coastal closure, and a 90-km seasonal restriction for NARW (or comparable protection achieved through implementation of a NMFS-approved mitigation and monitoring plan at distances between 47-80 km offshore), as well as (2) various shutdowns for specific species or guilds at greater distance from the acoustic source, given species' status or particular sensitivity to the acoustic source (see Tables 3 and 4).

Table 3 provides a summary description of mitigation described by BOEM in their Final PEIS's preferred alternative (as identified in their ROD) as well as the mitigation identified by NMFS as appropriate for inclusion in final IHAs, following consideration of public comment received. The table also explains where and how these sets of mitigation requirements differ. Additional information is provided below where appropriate. For a full description of mitigation measures proposed for requirement by BOEM, please refer to Volume I, Chapter 2.2 and Volume III, Appendix C, Attachment 1 of BOEM's Final PEIS, as well as BOEM's ROD.

Table 3. Summary of Mitigation Required by NMFS and Described by BOEM

Mitigation Measure	Brief Description of the Mitigation Measure	Included in BOEM's Preferred Alternative	Included in NMFS's IHAs	Differences between BOEM's and NMFS's Requirements[1]
Exclusion Zone	A 500-m zone monitored by protected species observers (PSOs) prior to, during, and after use of the airgun array. If marine mammals are seen within this zone, the acoustic source must be shut down (see "Shutdowns" later in this table).	Yes	Yes	BOEM's PEIS describes a requirement for PSOs to monitor the exclusion zone 60 minutes prior to ramp-up of the acoustic source and continue until operations cease or sighting conditions do not allow observation of the sea surface. NMFS differs from BOEM only in the set times for monitoring the exclusion zone before and after surveys. NMFS is requiring visual monitoring 30 minutes prior to ramp-up (i.e., not 60), continuing for one hour after use of the acoustic source or 30 minutes past sunset.
Buffer Zone (see "Clearance Watch" later in this table)	PSOs are to watch for occurrence of marine mammals within a 1,000-m zone (i.e., 500-m exclusion zone plus 500-m buffer) prior to ramp-up and, during operations, communicate to the operator to prepare for shut-down in	No	Yes	The buffer zone provides additional precaution for marine mammals in the immediate vicinity of the source vessel when beginning airgun firing, and a larger area within which PSOs may focus observational effort to heighten awareness of marine mammal presence.

Mitigation Measure	Brief Description of the Mitigation Measure	Included in BOEM's Preferred Alternative	Included in NMFS's IHAs	Differences between BOEM's and NMFS's Requirements[1]
	advance of animals entering the shutdown zone; surveys cannot recommence until animals have cleared the buffer zone for specific times.			
Geographic Distance Separation	A 40-km minimum distance between simultaneously operating surveys within the AOI. The intent is to provide a corridor for animals to pass between surveys with minimal exposure to sound from the acoustic source.	Yes[2]	N	NMFS has determined that there is no information supporting the efficacy of this measure. In turn, NMFS deems the potential benefit of such a measure too speculative to impose this burden on applicants, particularly since operators typically maintain their own minimum separation distances. BOEM is not programmatically requiring this for all surveys, but considering it on a case-by-case basis.
Mitigation Source	A separate or individual airgun often used when the full array is not being used to allow for ramp-ups during poor visibility.	No	No	N/A
North Atlantic Right Whale-Specific Mitigation	Additional mitigation measures have been proposed specific to the species, including prohibitions on surveys in critical habitat and other designations when in effect.	Yes	Yes	NMFS expanded on BOEM's described closures for North Atlantic right whales. This includes a 90 km restriction on survey activity from the coastline from November through April (or comparable protection achieved through implementation of a NMFS-approved mitigation and monitoring plan at distances between 47-80 km offshore), 10 km buffer distances around Dynamic Management Areas (DMAs), shutdowns, and other changes. See below for more information.
Passive Acoustic	PAM is to be used continuously during	Yes	Yes	NMFS has provided more specific requirements than BOEM

Mitigation Measure	Brief Description of the Mitigation Measure	Included in BOEM's Preferred Alternative	Included in NMFS's IHAs	Differences between BOEM's and NMFS's Requirements[1]
Monitoring (PAM)	surveys to detect marine mammals prior to and during surveys.			described in regards to requirements for PAM, such as that PAM must begin 30 minutes prior to activation of the acoustic source. See "Passive Acoustic Monitoring" below for more specific information.
Clearance Watch	This specifies a duration of time for which the exclusion zone must be free of marine mammals before activity can begin at the start of activity (or resume after a shutdown).	Yes	Yes	BOEM describes a 60-minute clearance watch at the start of new survey activity or after shutdowns, meaning that no animals may have been seen entering or transiting within the exclusion zone before commencing ramp-up or start of activity. NMFS is instead requiring clearance for 30 minutes. If activity shutdown is required and animals are not observed exiting the exclusion zone, the zone must be clear of marine mammals for 60 minutes under BOEM's description, and 15 or 30 minutes for NMFS, depending on species.
Ramp-Up	A gradual incremental increase in the acoustic source before reaching maximum source levels, intended to signal to marine mammals to leave the area.	Yes	Yes	NMFS has adopted a procedure recommended by IAGC (2015); BOEM describes a requirement to gradually ramp-up for at least 20 minutes, but no more than 40 minutes, to reach maximum source levels.
Shutdowns	Following observations of a marine mammal in the exclusion zone, PSOs must call for shutdowns of the acoustic source. Operations cannot recommence until animals have cleared the exclusion zone for set time limits.	Yes	Yes	Both BOEM and NMFS are requiring shutdown of the acoustic source upon observation of any marine mammal, with exceptions for delphinids. BOEM describes an exception for all "bowriding" dolphins; NMFS is instead requiring no action when species of the following genera enter the exclusion zone: *Steno*, *Tursiops*, *Stenella*, *Delphinus*, *Lagenodelphis*, and *Lagenorhynchus*.

Mitigation Measure	Brief Description of the Mitigation Measure	Included in BOEM's Preferred Alternative	Included in NMFS's IHAs	Differences between BOEM's and NMFS's Requirements[1]
				NMFS is also requiring shutdowns for specific species or scenarios; please see below.
Time-Area Restrictions	Specific areas where airgun activity is prohibited or otherwise restricted to protect specific species (including closures for NARWs as described above).	Yes	Yes	NMFS is requiring several additional time-area restrictions compared with BOEM, which described only a NARW closure within designated critical habitat and seasonal management areas (SMAs), and within a 20-nmi coastal strip through the AOI during designated time periods. NMFS has also expanded these as described below.
Vessel Strike Avoidance	There are multiple requirements for vessel strike avoidance, including maintaining vigilant watch for all marine mammals to avoid strikes while in transit. Vessel operators should reduce speeds to 10 knots or less when within designated critical habitat, SMAs, or DMAs for NARWs, or when mother/calf pairs or groups of whales are observed nearby. Vessels should keep a minimum distance of 500 m from any NARW, 100 m from other whale species, and 50 m from all other marine mammals.	Yes	Yes	Vessel strike avoidance protocols are similar between the two agencies.

[1] It is important to note that BOEM, in some instances, could alter or add to some of the requirements described here in their final permits to the applicants. These descriptions are based off their PEIS and ROD.
[2] Under the Preferred Alternative in the PEIS, a 40-km geographic separation distance between concurrent sources would be required. However, BOEM's ROD states that this mitigation measure may be required, and will be evaluated on a "case-by-case basis."

The following descriptions elaborate on mitigation included in NMFS's final IHAs that was not fully evaluated in BOEM's PEIS:

Mitigation Specific to North Atlantic Right Whales

BOEM's preferred alternative describes a requirement for deep penetration airgun surveys to avoid NARW critical habitat between November 15 through April 15 (note that this requirement reflects the boundaries for NARW critical habitat as designated at the time BOEM's PEIS was published—see Chapter 3 of this EA for more information). Furthermore, BOEM describes a closure within a 20-nmi coastal strip encompassing NARW SMAs. This prohibition would be in effect from November 1 to April 30 between the Delaware Bay and Brunswick, Georgia portion and from November 15 through April 15 for the portion south of Brunswick, GA. BOEM also called for vessel operators to avoid DMAs.

NMFS's mitigation measures specific to NARW expand on what is described in BOEM's preferred alternative, on the basis of the best available scientific information regarding NARW seasonal distribution. No survey effort is allowed to occur within 90 km of the coastline from November 1 through April 30, which encompasses critical habitat and any SMAs. This 90 km distance consists of an 80 km closure extending from the coastline in order to encompass the expected occurrence of most NARW, and includes a 10 km buffer expected to contain received sound levels exceeding 160 dB rms under a wide variety of conditions (as modeled in BOEM, 2014a). This expands the geographic area closed to the surveys, and is expected to avoid effects to the vast majority of NARW occurring in the AOI during this time period.

As stated above, we require that source vessels maintain a minimum coastal standoff distance of 90 km (80 km closure area plus 10-km buffer distance) from November through April. However, in lieu of this requirement, applicants may develop and submit a monitoring and mitigation plan for NMFS's approval that would be sufficient to achieve comparable protection for North Atlantic right whales. If approved, applicants would be required to maintain a minimum coastal standoff distance of 47 km from November through April while operating in adherence with the approved plan from 47 through 80 km offshore (10-km buffer would be protected by the plan).

Finally, NMFS is requiring shutdowns of the acoustic source upon visual observation or acoustic detection of NARW when observed at extended distance beyond the exclusion and buffer zones (i.e., 1.5 km).

Passive Acoustic Monitoring

Like BOEM, NMFS is requiring acoustic monitoring via a towed PAM system during use of the acoustic source with additional and more specific requirements. First, NMFS has specified that observers must begin monitoring the PAM system at 30 minutes prior to ramp-up. Furthermore, NMFS also set specific information collection, software, and operator requirements, as described in the proposed IHAs and incorporated by reference here. Both NMFS and BOEM are allowing ramp-up and survey activity during periods of low visibility where visual monitoring is not possible if PAM is being used and monitored.

Shutdown Requirements

NMFS and BOEM would both require shutdowns of the acoustic source when a marine mammal is detected within or entering the acoustic exclusion zone. However, NMFS is also requiring shut downs at extended distance (i.e., 1.5 km) for the following species: North Atlantic right whales, any large whale (i.e., any baleen whale or sperm whale) with calf, any beaked whales or Kogia spp., any aggregation of large whales.

Time-Area Restrictions

Coastal Closure for Bottlenose Dolphins

NMFS is requiring a year-round coastal closure, with survey activity allowed within 30 km of the coast (see Table 4). This measure is intended to protect bottlenose dolphins, of which all coastal stocks in the Mid- and South Atlantic Planning Areas are designated as depleted under the MMPA. Furthermore, an Unusual Mortality Event (UME) affected bottlenose dolphins along the Atlantic coast from New York to Florida from 2013 to 2015. Coastal bottlenose dolphins are typically expected to occur within 20 km of the coast. An additional 10 km buffer is added to encompass the areas where sound exceeding 160 dB rms could be reasonably expected to occur. Other specific time-area restrictions are described below:

Areas #1-4
These restrictions are targeted towards protection of sperm whales, beaked whales, and pilot whales in particular, all of which have moderate to high exposure estimates (see Table 4) and are considered to be more sensitive to noise from airguns because of specific sensitivity to airgun noise, behavioral sensitivity to noise exposure generally, and because of additional population stressors, respectively. It is also expected these closures will have subsidiary benefits to other species. The closure areas include (see Table 3 in the notice of proposed IHAs for specific longitudinal and latitudinal points of defined areas):

- Areas #1-3: These areas would be closed year-round to the acoustic source. Area #1, located in deeper waters off Cape Hatteras, is expected to particularly benefit beaked whales. Areas #2-3 are expected to be particularly beneficial for both beaked whales and sperm whales. Area #1 encompasses the Hatteras Transverse Canyon (HTC), Area #2 is centered on Hatteras Canyon and borders Area #4, and Area #3 is centered on a large, deepwater valley system at the northern edge of the AOI.
- Area #4: This restricts use of the acoustic source in the vicinity of the shelf break off Cape Hatteras and to the north, including slope waters around "The Point." This closure is expected to benefit a diverse range of species, but be particularly beneficial to beaked whales, sperm whales, and pilot whales. It will be closed to use of the acoustic source from January through March.

Table 4. Summary of Restriction Areas[1]

Closure[3]	**Closure Area**	**Duration**	**Target Species**
Coastal closure	30 km of coastline throughout AOI	Year-round	Bottlenose dolphins
North Atlantic right whale closure	Within 90 km of coastline throughout AOI[4]	November through April	North Atlantic right whales

Area #1	Areas surrounding Hatteras Transverse Canyon; see Figure 4 in Proposed IHAs[2]	Year-round	Beaked whales
Area #2	Centered around Hatteras Canyon; see Figure 4 in Proposed IHAs[2]	Year-round	Beaked whales and sperm whales
Area #3	Centered around deepwater valley system in the northern AOI; see Figure 4 in notice of proposed IHAs[2]	Year-round	Beaked whales and sperm whales
Area #4	See Figure 4 in Proposed IHAs[2]	January through March	Beaked whales, sperm whales, and pilot whales

[1] Note: This summary table only includes restrictions established by NMFS pursuant to the MMPA. It does not include other closures that may be required pursuant to other statutes.
[2] Note: Figure 4 in the notice of proposed IHAs contains an additional closure area that NMFS considered but eliminated (former Area #1 that was intended to protect Atlantic spotted dolphins). The temporal extent for Areas #2-5 on the map still apply, but are now re-numbered (i.e., former Area #2 is now Area #1, former Area #3 is now Area #2, and so on).
[3] All mitigation described in this table is required for all five companies.
[4] In lieu of this requirement, applicants may develop and submit a monitoring and mitigation plan for NMFS's approval that would be sufficient to achieve comparable protection for North Atlantic right whales. If approved, applicants would be required to maintain a minimum coastal standoff distance of 47 km from November through April while operating in adherence with the approved plan from 47 through 80 km offshore (10-km buffer would be protected by the plan).

2.4.2 Monitoring and Reporting

NMFS is required to include monitoring and reporting pursuant to Section 101(a)(5)(D) of the MMPA and 50 CFR 216.104 (a)(13) of NMFS's MMPA implementing regulations. In order to meet applicable requirements, NMFS's reporting requirements differ somewhat from those described in BOEM's preferred alternative (see "Monitoring and Reporting" section of the notice of proposed IHAs). For example, NMFS requires additional information regarding observations of animal behaviors and requires reports at different intervals than BOEM. Furthermore, applicants must submit comprehensive draft reports within 30 days of concluding activity. Finally, NMFS includes more specific requirements for PSOs regarding training, background requirements, and procedural duties.

2.5 Alternatives Considered but Eliminated from Further Consideration

In developing the Proposed Action, NMFS identified variations of the Preferred Alternative. The primary variations under consideration were different mitigation and monitoring in order to meet the Purpose and Need of this proposed action. Specifically, variations of the Preferred Alternative included issuing IHAs with only mitigation measures proposed by applicants, issuing IHAs based on mitigation described by BOEM as part of their preferred alternative and identified in their ROD, and issuing IHAs based on a combination of mitigation evaluated by BOEM, proposed by the applicants, and identified by the public. Reasons for eliminating variations of suites of mitigation measures vary, but are generally because (1) they will not have a reasonably anticipated benefit for either individual marine mammals or marine mammal species and stocks

and/or their habitat and/or (2) could create significant practicability concerns for the applicants without offsetting benefit to individual marine mammals or species and stocks—the result being that the prescribed mitigation would not achieve the least practicable adverse impact. Below, NMFS discusses mitigation and monitoring measures that were considered from four main stakeholders—BOEM, the applicants, NMFS, and the public—and provides explanation for those not carried forward.

BOEM—In the Final PEIS, BOEM evaluated several different approaches to mitigating the effects of G&G activities, and for some of these NMFS determined it appropriate to take a different approach in considering the most appropriate protective measures for marine mammals. First, as described above, NMFS has expanded on BOEM's time-area restriction for NARW (i.e., a prohibition on survey activity within designated critical habitat from November 15 to April 15, prohibition on survey activity within SMAs in designated time closures, either avoidance of DMAs or reducing speeds to 10 kn or less when transiting DMAs[14], and ensuring sound from surveys outside of these areas does not exceed 160 dB rms at the boundaries of these restrictions). NMFS expanded that closure based on the best available information concerning whale presence in the AOI (Roberts et al., 2017) to avoid to the maximum extent practicable any impacts of the activities on NARW. Secondly, BOEM proposed a 60-minute pre-clearance watch. NMFS considered this and determined it more appropriate to proceed with a 30-minute watch period. NMFS found that a lengthier clearance period would not appreciably increase the likelihood of detecting deep-diving animals prior to activation of the acoustic source. Some deep-diving species can stay submerged for periods up to an hour, but it is unlikely they would do so while remaining within close proximity of the moving vessel, thereby continuing to experience potential adverse effects from the acoustic exposure. Next, on a case-by-case basis, BOEM may require a 40-km minimum geographic separation distance between vessels (BOEM, 2014a,b). The intent is to create a sound-free corridor in the marine environment where animals may swim through rather than circumvent a sound source; there is, however, no information supporting the efficacy of this measure, and participants in a 2012 workshop held by NMFS and BOEM indicated skepticism regarding the efficacy of this measure (unpublished workshop report, 2012). In any case, NMFS also recognizes that operators typically maintain a minimum separation distance between concurrent surveys to avoid interference (BOEM, 2014a) (see Table 5).

Applicants—All five companies proposed mitigation and monitoring requirements in their applications for IHAs. NMFS considered these measures in development of its suite of required mitigation and monitoring, but in some cases eliminated or altered certain proposed measures. Notable differences are described in brief below, followed by NMFS's rationale for altering or not including these measures (see Table 5).

Table 5. Comparison of Applicants' Proposed Mitigation with NMFS's Requirements

Applicant[1]	Proposed Minimum Separation Distance	Proposed Exclusion Zone	Proposed Power Down/Mitigation Source[2]	Proposed Ramp-Up	Proposed Area Closures
CGG	Yes—17.5-km distance between vessels	Proposed 907 m exclusion	Power down to a single 70-in[3]	Same as NMFS	None proposed by the applicant

[14] The PEIS states that seismic surveys would not be allowed in DMAs, whereas the ROD states that vessel operators may be required to avoid DMAs or reduce speeds to 10 kn or less when transiting DMAs.

Applicant[1]	Proposed Minimum Separation Distance	Proposed Exclusion Zone	Proposed Power Down/Mitigation Source[2]	Proposed Ramp-Up	Proposed Area Closures
		zone for "whales"[3]	airgun for dolphins		
ION	No	See below[4]	Power down to a single 40-in^3 airgun for all species	Same as NMFS	None proposed by the applicant
Spectrum	Yes—40-km distance between vessels*	500-m exclusion zone	No	Proposed visual monitoring prior to ramp-up for 60 minutes*	Applicant proposed NARW restrictions following those described by BOEM*
TGS	No	Proposed 904 m exclusion zone[5]	Yes—See below[5,6]	Proposed visual monitoring prior to ramp-up for 60 minutes*	Applicant proposed NARW restrictions following those described by BOEM*
Western	No	Proposed 904 m exclusion zone[7]	Yes—See below[7,8]	Proposed visual monitoring prior to ramp-up for 60 minutes*	Applicant proposed NARW restrictions following those described by BOEM*
NMFS	No minimum separation distance required	500 m exclusion zone (with additional shutdowns for certain species; see above at Section 2.4)	No use of a "mitigation source" allowed	Visual monitoring for 30 minutes prior to ramp-up	30 km coastal restriction for bottlenose dolphin, 90 km seasonal closures for right whales (which is expected to encompass SMAs or DMAs), four time-area closures (see above at Section 2.4)[9]

* Asterisk denotes that mitigation measure proposed by the applicant is the same as described in the PEIS.

[1] See NMFS's website for access to the companies' applications, including detailed descriptions of their proposed mitigation: *www.fisheries.noaa.gov/action/incidental-take-authorization-oil-and-gas-industry-geophysical-survey-activity-atlantic*

[2] All applicants proposed that no mitigation action be required for dolphins determined to be voluntarily approaching the vessel, i.e., "bow riding." NMFS does not require that any action be taken upon detection of small delphinids within the exclusion zone.
[3]The 907 m (2,975 ft) mitigation zone was established by estimating the distance from the proposed 5,400 in^3 seismic acoustic source at which sound pressure levels exceed 180 dB re 1 μPa rms.
[4] ION proposed exclusion zones of different sizes depending on water depth and season to the modeled distance for which sound pressure levels could exceed 180 dB re 1 μPa rms. When animals enter these zones, a power down (rather than shutdown) would be effected. Shutdown would occur if a marine mammal approaches within 150 m of the single airgun used in the power down procedure.
[5] TGS proposed an exclusion zone of 904 m for an 4,808 in^3 array, resulting in a power down to the 126-m exclusion zone of the mitigation seismic source; if marine mammals occur within or closely approach this 904 m zone, a full power down would not be required if delphinids voluntarily approach the vessel or the vessels towed equipment. A full power down would be done if a non-delphinid cetacean occurs within this 126-m zone.
[6] TGS will use a 90 in^3 seismic source during turns and transits; if turns and transits will take longer than three hours, the mitigation source will be turned off.
[7] WesternGeco proposed an exclusion zone of 904 m for an 5,085 in^3 array, resulting in a power down to the 126-m exclusion zone of the mitigation seismic source; if marine mammals occur within or closely approach this 904 m zone, a full power down would not be required if delphinids voluntarily approach the vessel or the vessels towed equipment. A full power down would be done if a non-delphinid cetacean occurs within this 126-m zone.
[8] WesternGeco will use a 105 in^3 mitigation source during turns and transits; if turns and transits will take longer than three hours, the mitigation source will be turned off.
[9] For right whales, applicants may develop and submit a monitoring and mitigation plan for NMFS's approval that would be sufficient to achieve comparable protection for North Atlantic right whales. If approved, applicants would be required to maintain a minimum coastal standoff distance of 47 km from November through April while operating in adherence with the approved plan from 47 through 80 km offshore (10-km buffer would be protected by the plan).

As shown in this table, there are several areas where the applicants' proposed mitigations differ from NMFS's requirements. NMFS is requiring a standard 500-m exclusion zone; requires shutdowns when marine mammals enter the exclusion zone other than as described for the dolphin exception; is not allowing power down or use of a mitigation gun; is requiring a 30-minute pre-clearance watch prior to ramp-up; and has imposed multiple time-area restrictions and an extended NARW closure compared with what any applicant proposed. NMFS does not believe that use of a mitigation source is appropriate, as this involves release of unnecessary sound energy into the marine environment, with the purpose of causing aversive behavior. When used for extended periods of time, this likely results in unnecessary behavioral disturbance of marine mammals. NMFS is requiring a more conservative approach to mitigation than proposed by the applicants, as necessary in order to meet the least practicable adverse impact standard, particularly through time-area restrictions and shutdowns. See Sections 2.4 and 4.4 of this EA for more information regarding NMFS's determinations on these mitigation measures.

NMFS—In the proposed IHAs, NMFS included several mitigation measures that have since been removed from further analysis or consideration:

- Time-area restriction for Atlantic spotted dolphins: In the notice of proposed IHAs, NMFS proposed to require a seasonal closure extending from northern South Carolina into Florida from the coastline to 100 km offshore. This closure was intended to reduce expected acoustic exposure of Atlantic spotted dolphins. NMFS, however, has decided on the basis of public comment that given the stable and healthy population status of Atlantic spotted dolphins, the fact that the majority of projected exposures would not

occur within the proposed restriction area, and that a substantial portion of this closure will be superseded by the year-round restriction for bottlenose dolphins (as well as the other area closures), that this measure would not have the intended effect and is therefore unnecessary.

- Shutdowns for diving sperm whales: On the basis of public comment, NMFS found there was not enough scientific evidence to support the potential efficacy of this requirement, and that it would place unnecessary burden on the applicants while not providing a meaningful benefit to the species. Furthermore, prolonging survey duration for this shutdown could potentially re-expose a sperm whale when it surfaces after diving.

- Shutdowns at any distance for fin whales—TGS: NMFS proposed this additional shutdown requirement for TGS only on the basis of relatively higher estimated acoustic exposures of fin whales. The measure was intended to reduce the duration and/or intensity of acoustic exposure of fin whales. In consideration of public comment, NMFS found this requirement places undue burden on one specific company, without having a meaningful reduction of acoustic exposures.

- Shutdowns for non-traveling aggregations of marine mammals: NMFS originally proposed requiring shutdowns at any distance for aggregations of marine mammals (defined here as 6+ individuals) for any behavior except for when they appeared to be traveling. NMFS has revised this shutdown to apply to all aggregations of whales only (baleen whales and sperm whales), regardless of behavior (i.e., including traveling or stationary) in response to comments received. The initial proposal was not intended to encompass commonly occurring large groups of dolphins, which would be expected to result in an impracticable amount of shutdowns.

Public—As described above, NMFS received a large volume of comments from the public. Some of these comments suggested new mitigation measures or time-area restrictions, or variations of the requirements described in the notice of proposed IHAs; some key topics are addressed below. Please see Section 4.4 of this EA for detailed explanations of NMFS's mitigation and monitoring requirements.

- Buffer and exclusion zones: Some members of the public proposed different distances for extending the exclusion zone. For example, some suggested that NMFS expand the standard exclusion zone, including to a "single-shot auditory injury distance of 1,585 m" or to a standard 2,000 m distance. Others requested that NMFS reduce the size of the buffer zone or eliminate use of a buffer zone. NMFS considered these comments but elected to maintain the exclusion zone at 500 m, as it is expected to contain sound exceeding peak pressure injury criteria for all hearing groups other than high-frequency cetaceans (see Chapter 4 of this EA for a discussion on high-frequency cetaceans and additional mitigation for Kogia spp.). Furthermore, a 500-m zone also provides a consistent and reliably observable zone for PSOs to detect marine mammals by the naked eye under normal conditions. Use of the full 1 km zone (500 m exclusion zone plus 500 m buffer) in ramp-up is also appropriately cautionary without placing meaningful extra burden on the applicants, and NMFS finds that given the scope of the activity, it is warranted for inclusion.

- PAM: One group requested that PAM be optional, while others agreed that it should be required during use of the acoustic source. NMFS has reviewed all comments related to PAM and notes that NMFS's PAM requirements in the proposed IHAs mirror PAM requirements in other similar surveys, as well as those described in BOEM's preferred alternative. NMFS recognizes that PAM is not always effective at detecting marine mammals, but finds it is the best method to implement monitoring in low visibility conditions, and that it is the most effective measure for monitoring of species that are cryptic or deep diving but vocal (e.g., beaked whales, sperm whales). Some commenters recommended that NMFS require acoustic monitoring at various locations and bathymetric depths throughout the sound field in the AOI to monitor potential increases in sound; however, we do not believe that this would provide specifically useful information, given the nature of the planned tracklines (very long and widely spaced) and that the surveys would likely only pass by any acoustic sensor at most a few times, and the fact that multiple surveys are not expected to be in close enough proximity to be measured by a given sensor simultaneously.

- Number of surveys: Many commenters stated that NMFS should limit the number of surveys as the most effective way to reduce impacts on marine mammals, typically stating that the multiple surveys are duplicative and/or citing the potential for cumulative impacts. NMFS does not have the statutory authority under the MMPA to limit the number of surveys; rather, NMFS shall authorize marine mammal take if the necessary findings are made and appropriate mitigation and monitoring prescribed. It is similarly not within NMFS's jurisdiction to select which companies may be able to proceed or not with proposed surveys, or to make determinations regarding whether surveys are or are not "duplicative."

- Time-Area restrictions: NMFS recognizes that the AOI contains important habitat areas for many species with authorized take, and that many species have a broad distribution across the entire survey area. However, NMFS is required to prescribe effective mitigation for marine mammals and their habitat while also considering practicability for applicants. Reflecting this, NMFS has determined that the prescribed spatiotemporal restrictions, which are designated on the basis of the best available scientific information, are appropriate. Several groups said NMFS should institute a year-round closure area off Cape Hatteras given the diverse assemblage of species and year-round residency for some species. Regarding Cape Hatteras, NMFS has closed the most important areas and bathymetric features during the period with the highest number of sperm whale detections (Stanistreet et al., 2018) (note that information regarding the best timing of a restriction for other species is not available). Others suggested NMFS should consider time-area restrictions for additional mysticete whales (i.e., humpback, sei, fin, and blue whales). Two of the four whales are considered "rare species" in the AOI, and all have broad distributions throughout the region, with no identified biologically important areas. Furthermore, NMFS believes its time-area restrictions and shutdowns at extended distances for large whales with calf will provide subsidiary benefits to these species. Please see Chapter 4 of this EA for more information.

CHAPTER 3 AFFECTED ENVIRONMENT

3.0 Introduction

NMFS reviewed all relevant environmental, cultural, historical, social, and economic resources based on the specific geographic region associated with NMFS's proposed action, alternatives, and the applicant's request for an IHA (i.e., the AOI). Based on this review, this section describes the affected environment and existing (baseline) conditions for select resource categories (e.g., marine environment). As explained in Chapter 1, certain resource categories were not carried forward for further consideration or evaluation in this EA (see Section 1.5) and where appropriate, the analysis in BOEM's Final PEIS related to baseline conditions and select resource categories carried forward is incorporated by reference. Chapter 4 provides an analysis and description of environmental impacts associated with the affected environment.

3.1 Physical Environment

The AOI covers a broad area of the U.S. Atlantic coast, ranging from the shoreline to continental shelf and slope waters. As described in Volume I, Chapter 4.2.1 in BOEM's Final PEIS, the AOI includes two main ecoregions: The Mid-Atlantic Bight (MAB), which extends from roughly Cape Cod, Massachusetts to Cape Hatteras, North Carolina, and the South Atlantic Bight (SAB), which extends from Cape Hatteras to Cape Canaveral, Florida. These are considered temperate and subtropical regions, divided by the Gulf Stream as it heads eastwards offshore of Cape Hatteras (Wiebe et al., 1987, as cited in BOEM, 2014a). The Hatteras Middle Slope, which breaks these two regions, is one of the steepest slope environments along the U.S. East Coast, and is characterized by complex interactions of ocean fronts, Gulf stream eddies and meanders, and more, leading to unique benthic communities and fauna (Diaz et al., 1993, Blake and Grassle, 1994).

The continental shelf in the MAB gives way to the continental slope at roughly 200 to 2,000 m depths, characterized by a steep depth gradient. It is a heterogeneous physical environment, dotted by hills and valleys that have patchy distributions of soft sediments and benthic communities (Boesch, 1979). The seafloor in the MAB consists of soft sediment, mostly sand but moving to silt and clay in deeper waters (Boesch, 1979 and Wigley and Theroux, 1981). Hard bottom habitat is relatively sparse over the SAB. Conversely, hard bottom comprises much of the deepwater and canyons in the SAB. The nearshore environment of the South Atlantic Bight consists of barrier islands, sounds, and meandering tidal marshes. The nearshore area is relatively shallow and wide, characterized by sandy bottom. This gives way to several prominent physical features (i.e., Charleston Bump).

3.1.1 Ambient Sound Overview

Sound is a key modality for marine mammal communication and behavior, in which they produce or listen for sound as part of their key life history strategies, including foraging, mating, avoiding predators, reproducing or socializing. Thus, the surrounding soundscape is a key component of marine mammal habitat, and can be considered their "acoustic habitat" (Clark et al., 2009).

Ambient sound levels in a certain environment are the product of numerous natural processes and anthropogenic sounds, the latter of which can propagate over large distances and vary considerably on differing spatiotemporal scales (Hildebrand, 2009). These ambient sounds contribute to the ocean soundscape at frequencies from a few hundred hertz (Hz) to 200 kilohertz

(kHz) (NRC, 2003). Low-frequency sounds (e.g., shipping) have longer wavelengths than higher frequency sounds, and generally propagate further than higher frequency sounds (e.g., some acoustic deterrent devices).

Anthropogenic sound inputs into the marine environment include shipping and other vessel traffic, military activity, marine construction, geophysical surveys, and more. Of these, shipping has traditionally dominated the anthropogenic low-frequency spectrum, but offshore oil and gas exploration has become more widespread in recent decades (Hildebrand, 2009). Recent studies show that low-frequency ambient noise levels have increased relative to recordings in the 1960s (Ross 1993; Andrew et al., 2002; McDonald et al., 2006).

Biological sounds arise from a variety of sources (e.g., marine mammals, fish, and shellfish) and range from approximately 12 Hz to over 100 kHz. The relative strength of biological sounds varies greatly; depending on the situation, biological sound can be nearly absent to dominant over narrow or broad frequency ranges (Richardson et al., 1995). The main natural sources of underwater sound are wind and wave activity, precipitation, and biological sounds (e.g., fish, snapping shrimp).

The contribution of these sources to background sound levels differs with their spectral components and local propagation characteristics (e.g., water depth, temperature, salinity, and ocean bottom conditions). In deep water, low-frequency ambient sound from 1-10 Hz mainly comprises turbulent pressure fluctuations from surface waves and the motion of water at the air-water interface. At these infrasonic frequencies, sound levels depend only slightly on wind speed. Between 20-300 Hz, distant anthropogenic sound (ship transiting, etc.) dominates wind-related sounds. Above 300 Hz, the ambient sound level depends on weather conditions, with wind- and wave-related effects mostly dominating the soundscape.

Ambient noise levels at any one location in the AOI vary based on a range of environmental factors (e.g., wind speed, precipitation), physical factors (e.g., depth, bottom type), and the type of noise input. Various records have been collected throughout areas of the Atlantic Ocean that measured sound levels at specific points of time or across longer time periods (e.g., Hatch et al., 2008; Hatch et al. 2012; Nieukirk et al., 2012; Parks et al., 2008). One study investigated noise levels in three areas of North Atlantic right whale habitat (i.e., the Bay of Fundy, Cape Cod Bay, and off the coast of Georgia) from 2004 to 2007 (Parks et al., 2008). The coastal location off the Bay of Fundy and Georgia had the lower noise levels out of the three locations, with peak frequency averaging between ~<50 Hz and 50 and 75 Hz, respectively (Parks et al., 2008). In the Atlantic, existing anthropogenic noise inputs include shipping and vessel traffic, pile driving for various activities, geophysical surveys for research and other purposes, fisheries, and military activity. Sounds generated from airguns are broadband sounds, meaning they span a range of frequencies, but are typically low-frequency (with typical dominant frequency components ranging from 2-188 Hz at the source), of short-duration (<0.1s), and of high amplitude (216–261 dB p-p re 1 lPa @ 1 m) (Richardson et al., 1995). They are typically considered transient sounds (Richardson et al., 1995; McDonald et al., 1995), but in some instances, have become constant components of ambient noise levels in specific areas (Nieukirk et al., 2012). Understanding the existing acoustic habitat is critical to be able to assess the impacts of geophysical surveys on marine mammals.

3.2 Biological Environment

The primary component of the biological environment that could be impacted by NMFS's action in issuing the IHAs to the five companies would be marine mammals, which could be directly impacted by sound and other activities associated with geophysical surveys.

3.2.1 Marine Mammals

Waters of the Mid- and South Atlantic consist of a diverse assemblage of marine mammal species. As noted in the IHAs, 34 species (including 39 managed stocks) listed in Table 6 could potentially overlap with authorized activities.

BOEM's Final PEIS (see Volume I, Chapter 4.4.2), the five applications, and the proposed IHAs (for some species) include descriptions of the marine mammal species in the AOI. We incorporate those by reference, and do not reiterate species descriptions here. For more information, we defer the reader to Stock Assessment Reports on each of the 34 species on NMFS's website: *www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-stock-assessments*. New information not included in these previous documents on the 34 species that is relevant to NMFS's NEPA analysis and issuance of IHAs under the MMPA is discussed in Chapter 4 of this EA.

Table 6. Marine Mammals Potentially Present in the Vicinity of Survey Activities

Common name	Scientific name	Stock	ESA/ MMPA status; Strategic (Y/N)[1]	NMFS stock abundance (CV, N_{min}, most recent abundance survey)[2]	Predicted mean (CV)/ maximum abundance[3]	Predicted abundance outside EEZ[4]	PBR	Annual M/SI (CV)[5]
Order Cetartiodactyla – Cetacea – Superfamily Mysticeti (baleen whales)								
Family Balaenidae								
North Atlantic right whale	*Eubalaena glacialis*	Western North Atlantic (WNA)	E/D; Y	451 (n/a; 445; n/a)	394 (0.07)*	1	1.4	5.56
Family Balaenopteridae (rorquals)								
Humpback whale	*Megaptera novaeangliae novaeangliae*	Gulf of Maine	-; N	896 (n/a; 896; 2015)	1,637 (0.07)*/ 1,994	8	14.6	9.8
Minke whale	*Balaenoptera acutorostrata acutorostrata*	Canadian East Coast	-; N	2,591 (0.81; 1,425; 2011)	2,112 (0.05)*/ 2,431	929	14	7.5
Bryde's whale	*B. edeni brydei*	None defined[6]	-; n/a	n/a	7 (0.58)/ n/a	7	n/a	n/a
Sei whale	*B. borealis borealis*	Nova Scotia	E/D; Y	357 (0.52; 236; 2011)	717 (0.30)*/ 1,519	46	0.5	0.6
Fin whale	*B. physalus physalus*	WNA	E/D; Y	1,618 (0.33; 1,234; 2011)	4,633 (0.08)/ 6,538	44	2.5	2.5
Blue whale	*B. musculus musculus*	WNA	E/D; Y	Unknown (n/a; 440; n/a)	11 (0.41)/n/a	4	0.9	Unk
Superfamily Odontoceti (toothed whales, dolphins, and porpoises)								
Family Physeteridae								
Sperm whale	*Physeter macrocephalus*	North Atlantic	E/D; Y	2,288 (0.28; 1,815; 2011)	5,353 (0.12)/ 7,193	2,456	3.6	0.8
Family Kogiidae								
Pygmy sperm whale	*Kogia breviceps*	WNA	-; N	3,785 (0.47; 2,598; 2011)[7]	678 (0.23)/ n/a[7]	428	21	3.5 (1.0)

Common name	Scientific name	Stock	ESA/ MMPA status; Strategic (Y/N)[1]	NMFS stock abundance (CV, N_{min}, most recent abundance survey)[2]	Predicted mean (CV)/ maximum abundance[3]	Predicted abundance outside EEZ[4]	PBR	Annual M/SI (CV)[5]
Dwarf sperm whale	*K. sima*	WNA	-; N					
Family Ziphiidae (beaked whales)								
Cuvier's beaked whale	*Ziphius cavirostris*	WNA	-; N	6,532 (0.32; 5,021; 2011)	14,491 (0.17)/ 16,635[7]	9,426	50	0.4
Gervais beaked whale	*Mesoplodon europaeus*	WNA	-; N	7,092 (0.54; 4,632; 2011)[7]			46	0.2
Blainville's beaked whale	*M. densirostris*	WNA	-; N					
Sowerby's beaked whale	*M. bidens*	WNA	-; N					
True's beaked whale	*M. mirus*	WNA	-; N					
Northern bottlenose whale	*Hyperoodon ampullatus*	WNA	-; N	Unknown	90 (0.63)/ n/a	11	Und.	0
Family Delphinidae								
Rough-toothed dolphin	*Steno bredanensis*	WNA	-; N	136 (1.0; 67; 2016)	532 (0.36)/ n/a	313	0.7	0
Common bottlenose dolphin	*Tursiops truncatus truncatus*	WNA Offshore	-; N	77,532 (0.40; 56,053; 2011)	97,476 (0.06)/ 144,505[7]	5,280	561	39.4 (0.29)
		WNA Coastal, Northern Migratory	D; Y	6,639 (0.41; 4,759; 2016)			48	6.1 (0.32)-13.2 (0.22)
		WNA Coastal, Southern Migratory	D; Y	3,751 (0.60; 2,353; 2016)			23	0-14.3 (0.31)
		WNA Coastal, South Carolina/ Georgia	D; Y	6,027 (0.34; 4,569; 2016)			46	1.4-1.6
		WNA Coastal, Northern Florida	D; Y	877 (0.49; 595; 2016)			6	0.6
		WNA Coastal, Central Florida	D; Y	1,218 (0.35; 913; 2016)			9.1	0.4
Clymene dolphin	*Stenella clymene*	WNA	-; N	6,086 (0.93; 3,132; 1998)[8]	12,515 (0.56)/n/a	11,503	Und.	0
Atlantic spotted dolphin	*S. frontalis*	WNA	-; N	44,715 (0.43; 31,610; 2011)	55,436 (0.32)/ 137,795	7,339	316	0

Common name	Scientific name	Stock	ESA/ MMPA status; Strategic (Y/N)[1]	NMFS stock abundance (CV, N_{min}, most recent abundance survey)[2]	Predicted mean (CV)/ maximum abundance[3]	Predicted abundance outside EEZ[4]	PBR	Annual M/SI (CV)[5]
Pantropical spotted dolphin	*S. attenuata attenuata*	WNA	-; N	3,333 (0.91; 1,733; 2011)	4,436 (0.33)/n/a	2,781	17	0
Spinner dolphin	*S. longirostris longirostris*	WNA	-; N	Unknown	262 (0.93)/ n/a	184	Und.	0
Striped dolphin	*S. coeruleoalba*	WNA	-; N	54,807 (0.3; 42,804; 2011)	75,657 (0.21)/ 172,158	15,166	428	0
Common dolphin	*Delphinus delphis delphis*	WNA	-; N	70,184 (0.28; 55,690; 2011)	86,098 (0.12)/ 129,977	3,154	557	437 (0.10)
Fraser's dolphin	*Lagenodelphis hosei*	WNA	-; N	Unknown	492 (0.76)/ n/a	474	Und.	0
Atlantic white-sided dolphin	*Lagenorhynchus acutus*	WNA	-; N	48,819 (0.61; 30,403; 2011)	37,180 (0.07)/ 59,008	368	304	57 (0.15)
Risso's dolphin	*Grampus griseus*	WNA	-; N	18,250 (0.46; 12,619; 2011)	7,732 (0.09)/ 18,377	1,060	126	49.9 (0.24)
Melon-headed whale	*Peponocephala electra*	WNA	-; N	Unknown	1,175 (0.50)/n/a	1,095	Und.	0
Pygmy killer whale	*Feresa attenuata*	WNA	-; N	Unknown	n/a	n/a	Und.	0
False killer whale	*Pseudorca crassidens*	WNA	-; Y	442 (1.06; 212; 2011)	95 (0.84)/ n/a	35	2.1	Unk
Killer whale	*Orcinus orca*	WNA	-; N	Unknown	11 (0.82)/ n/a	4	Und.	0
Short-finned pilot whale	*Globicephala macrorhynchus*	WNA	-; Y	28,924 (0.24; 23,637; 2016)	18,977 (0.11)/ 35,715[6]	2,258	236	168 (0.13)
Long-finned pilot whale	*G. melas melas*	WNA	-; Y	5,636 (0.63; 3,464; 2011)			35	27 (0.18)
Family Phocoenidae (porpoises)								
Harbor porpoise	*Phocoena phocoena phocoena*	Gulf of Maine/Bay of Fundy	-; N	79,833 (0.32; 61,415; 2011)	45,089 (0.12)*/ 50,315	91	706	255 (0.18)

[1] Endangered Species Act (ESA) status: Endangered (E), Threatened (T)/MMPA status: Depleted (D). A dash (-) indicates that the species is not listed under the ESA or designated as depleted under the MMPA. Under the MMPA, a strategic stock is one for which the level of direct human-caused mortality exceeds PBR or which is determined to be declining and likely to be listed under the ESA within the foreseeable future. Any species or stock listed under the ESA is automatically designated under the MMPA as depleted and as a strategic stock.

[2] NMFS marine mammal stock assessment reports online at: *www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-stock-assessments*. CV is coefficient of variation; N_{min} is the minimum estimate of stock abundance. In some cases, CV is not applicable. For the right whale, the best abundance value represents modeling related to a count of individually identifiable animals. The minimum estimate of 440 blue whales represents recognizable photo-identified individuals.

[3] This information represents species- or guild-specific abundance predicted by habitat-based cetacean density models (Roberts et al., 2016). For the North Atlantic right whale, we report the outputs of a more recently updates model (Roberts et al., 2017). These models provide the best available scientific information regarding predicted density patterns of cetaceans in the U.S. Atlantic Ocean, and we provide the corresponding mean annual and maximum monthly abundance predictions. Total abundance estimates were produced by computing the mean density of all pixels in the modeled area and multiplying by its area. Roberts et

al. (2016) did not produce a density model for pygmy killer whales off the east coast. For those species marked with an asterisk, the available information supported development of either two or four seasonal models; each model has an associated abundance prediction. Here, we report the maximum predicted seasonal abundance.

[4] The density models used to predict acoustic exposures (e.g., Roberts et al., 2016) provide abundance predictions for the area within the U.S. EEZ. However, the model outputs were also extrapolated to the portion of the specific geographic region outside the EEZ in order to predict acoustic exposures in that area (i.e., from 200 nmi to 350 nmi offshore). Therefore, we calculated corresponding seasonal abundance estimates for this region. The maximum seasonal abundance estimate is reported.

[5] These values, found in NMFS's SARs, represent annual levels of human-caused mortality plus serious injury from all sources combined (e.g., commercial fisheries, ship strike). Annual M/SI often cannot be determined precisely and is in some cases presented as a minimum value or range. A CV associated with estimated mortality due to commercial fisheries is presented in some cases.

[6] Bryde's whales are occasionally reported off the southeastern U.S. and southern West Indies. NMFS defines and manages a stock of Bryde's whales that is resident in the northern Gulf of Mexico, but does not define a separate stock in the Atlantic Ocean.

[7] Abundance estimates are in some cases reported for a guild or group of species when those species are difficult to differentiate at sea. Similarly, the habitat-based cetacean density models produced by Roberts et al. (2016) are based in part on available observational data which, in some cases, is limited to genus or guild in terms of taxonomic definition. NMFS's SARs present pooled abundance estimates for *Kogia* spp. and *Mesoplodon* spp., while Roberts et al. (2016) produced density models to genus level for *Kogia* spp. and *Globicephala* spp. and as a guild for most beaked whales (*Ziphius cavirostris* and *Mesoplodon* spp.). Finally, Roberts et al. (2016) produced a density model for bottlenose dolphins that does not differentiate between offshore and coastal stocks.

[8] NMFS's abundance estimates for the Clymene dolphin is greater than eight years old and not considered current. PBR is therefore considered undetermined for this stock, as there is no current minimum abundance estimate for use in calculation. We nevertheless present the most recent abundance estimate.

3.2.2 North Atlantic Right Whale Critical Habitat

Critical habitat for North Atlantic right whales is the only critical habitat designated for marine mammals within the AOI. On January 27, 2016, NMFS published a final rule establishing revised critical habitat areas for the NARW (81 FR 4837), replacing a previous critical habitat designation established in 1994 and revised in 2006. The new critical habitat designation includes two units on which physical and biological features essential to the conservation of North Atlantic right whales are based, pursuant to Section 3 of the ESA. Unit 1 is designated on the basis of being essential to NARW foraging habitat, and extends from Maine to Massachusetts and along the U.S.-Canadian border. Unit 2 is essential calving habitat. It includes all marine waters from Cape Fear, North Carolina southward to 27 nm below Cape Canaveral, Florida (Figure 3). See the final critical habitat rule for specific spatial extent of this habitat (81 FR 4837, 27 January 2016): *www.federalregister.gov/documents/2016/01/27/2016-01633/endangered-and-threatened-species-critical-habitat-for-endangered-north-atlantic-right-whale*. Unit 2 overlaps with the permitted survey activity, and we have set forth mitigation specific to this critical habitat designation as described in Chapter 2 of this EA.

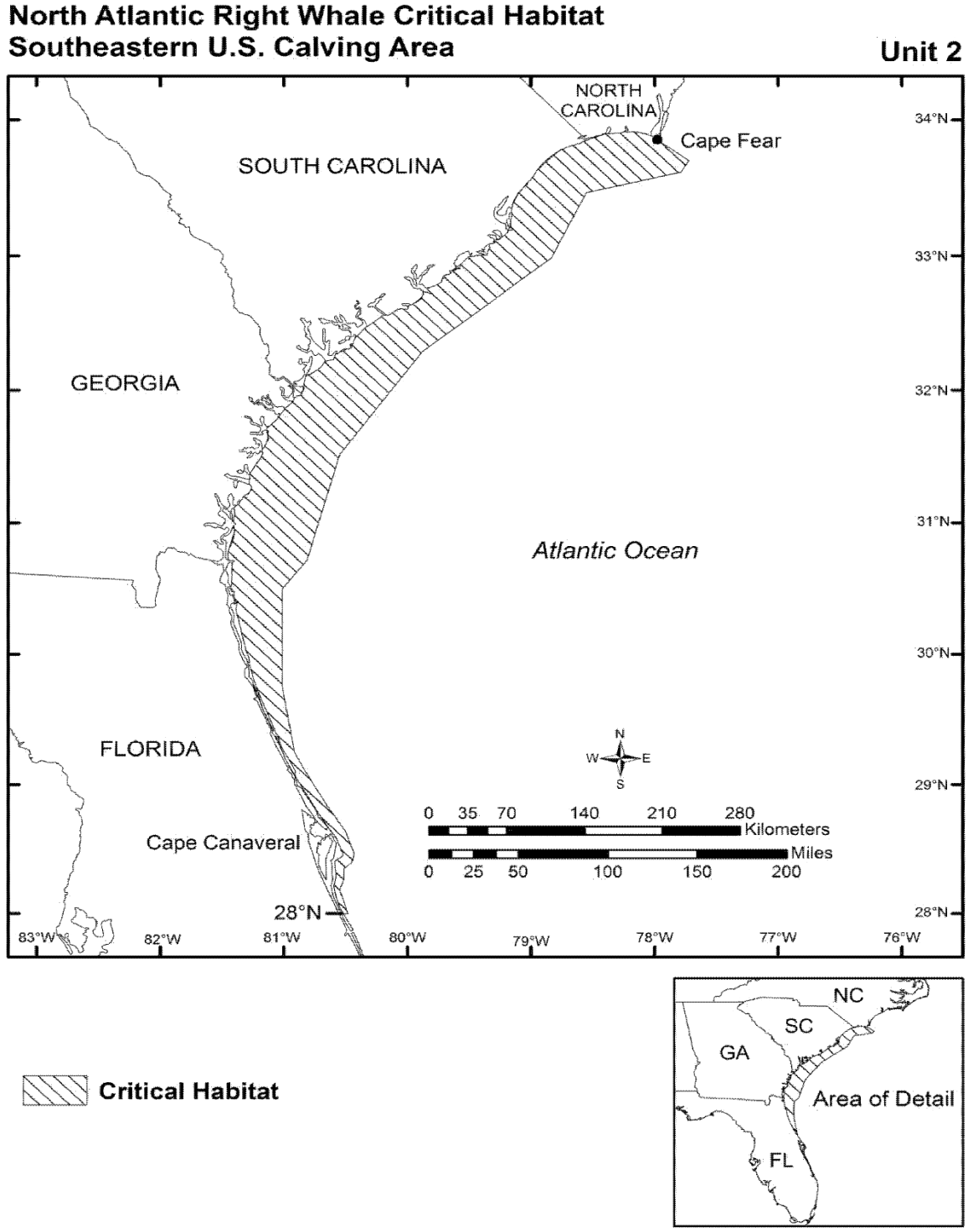

Figure 3. North Atlantic right whale critical habitat, Unit 2 (81 FR 4837)

In addition to critical habitat, two SMAs exist for NARW. The Mid-Atlantic SMA contains areas extending from 20 nmi from the entrance to certain ports from Delaware to Georgia. Those within the AOI include the entrance to Delaware Bay, the entrance to the Chesapeake Bay, the ports of Morehead City and Beaufort, NC, and Wilmington, NC to Brunswick, GA. This SMA is intended to protect right whales on their migratory route. The southeast SMA extends from

roughly Brunswick, GA to St. Augustine, FL to 25 miles offshore, specifically bounded to the north by 31°27′ N., to the south by 29°45′ N., and to the east by 80°51′36″ W. The southeast SMA is intended to protect NARW calving and nursery ground.

Several biologically important areas (BIAs) have been described for NARW. BIAs are region, species, and time-specific areas important for reproduction, feeding, and migratory behavior. The southeast right whale critical habitat designation encompasses calving habitat and thus constitutes a BIA. LaBrecque et al. (2015) further described BIAs for North Atlantic right whales. This includes waters out to the 25-m isobaths from Cape Canaveral to Cape Lookout from mid-November to mid-April.

NMFS also designates an additional type of habitat protection with applicable restrictions for North Atlantic right whales: dynamic management areas (DMA). These areas reflect real-time right whale observations in areas where they may be aggregating higher numbers or utilizing habitat outside of pre-established protective area (i.e., critical habitat or SMAs). DMAs are necessary because right whales can congregate in areas outside of where they are known to predictably occur and thus outside of areas of existing closures. NMFS establishes these DMAs by surveying right whale habitat, and creating a temporary closure zone based on these aggregations.

3.2.3 Essential Fish Habitat and Marine Mammal Prey

Marine mammals consume a wide variety of prey, including fish, cephalopods, shrimp, plankton, crustaceans, other marine mammals, and other species. Prey species for marine mammals in the North Atlantic generally fall into three broad categories: fish, squid, and zooplankton (Kenney et al., 1995). Zooplankton is a considerable component of mysticete prey consumption (Kenney et al., 1995), though preference varies by species. Odontocetes typically feed on fish or squid (Mintzer et al., 2008). For example, studies on stomach contents of short-finned pilot whales revealed that various cephalopod species formed the majority of diet, though fish (Scopelogadus beanie) was also a part of their diet (Mintzer et al., 2008). Beaked whales and sperm whales are known to primarily consume cephalopods at depth and distributions related to oceanographic conditions (Clarke, 1980; Waring et al., 2001; Whitehead, 2003). In stranded dolphins in North Carolina, Atlantic croaker comprised the majority of the diet of estuarine-stranded dolphins, while weakfish and squid was more commonly consumed by ocean-stranded dolphins (Gannon and Waples, 2004). Different prey species are distributed throughout the AOI.

It is estimated that 600 fish species occur in the AOI (Ray et al., 1997; Smith-Vaniz et al., 1999). Essential fish habitat exists for numerous species within the AOI, including for hard and soft bottom species, coastal pelagic species, highly migratory fish, and shark species. For the entire list of species with EFH within the AOI, see Tables 4-20 to 4-26 in BOEM's PEIS.

3.3 Socioeconomic Resources

The Mid- and South Atlantic supports a wide variety of commercial and recreational activities that support economies along the East Coast. Volume I, Chapter 4 of BOEM's PEIS (2014a) describes those resources and activities in detail, and it is incorporated by reference.

Subsistence—There are no subsistence harvests for marine mammals in this area of the Atlantic Ocean.

Fisheries—Upwelling along the shelf break created by the western edge of the Gulf Stream makes the Atlantic Coast, particularly from Cape Cod to Cape Hatteras, one of the most

productive areas in the world. A variety of commercial and recreational fisheries operate in the area, using a number of gear types, including pots/traps, dredges, trawls, longlines, gillnets, purse seines, and pound nets. In 2012, commercial landings in Virginia generated the most revenue out of states in the AOI, followed by Maryland, North Carolina, Florida's East Coast, South Carolina, Georgia, and Delaware. Increased vessel traffic from geophysical surveys present a risk of interaction with fisheries, particularly for dredges, otter trawls, longlines, and purse seines, but given the large distances, separation distances between the surveys, and relatively short time periods, these impacts and not expected to be significant.

Ecotourism/Tourism—Coastal tourism is vital to many state economies along the Atlantic seaboard. In some states in the AOI, marine and coastal tourism-related jobs contribute tens to hundreds of thousands of jobs. Additionally, various types of ecotourism operations exist along the Atlantic seaboard, including SCUBA diving companies, kayaking and other water sports, animal watching, and sailing.

Military Activity—Much of the AOI overlaps with Military Use Areas, which include air-to-air, air-to-surface, and surface-to-surface naval fleet training, submarine and antisubmarine training, and Air Force exercises. Naval vessels and aircraft that conduct operations not compatible with commercial or recreational activity are confined to designated range complexes with associated Operating Areas (OPAREAs) and Special Use Airspace. Comprehensive summaries of the Navy's activities can be found in recent Navy Environmental Impact Statements (e.g., Atlantic Fleet Training and Testing (AFTT) Study Area final EIS/OEIS, published in September 2018: *www.aftteis.com*) and other documents related to previous phases of the Navy's activities in the AFTT Study Area on NMFS's website: *www.fisheries.noaa.gov/national/marine-mammal-protection/incidental-take-authorizations-military-readiness-activities*.

Four military-related Range Complexes exist within the AOI from the Chesapeake Bay to Jacksonville, Florida. The AFTT Study Area includes: the Virginia Capes (VACAPES) Range Complex, which extends along the coastline of Delaware to North Carolina; the Navy Cherry Point Range Complex off the coast of North Carolina and South Carolina; the Jacksonville Range Complex along the coast from North Carolina to Florida, and the Key West Range Complex. Within these Range Complexes, there are a number of other "danger zones" (i.e., warning areas, testing ranges, and restricted areas) and OPAREAs within the Range Complexes.

Shipping and Marine Transportation—Six commercial deepwater ports are found along the AOI: Norfolk, Virginia; Wilmington, North Carolina; Charleston, South Carolina; Savannah, Georgia; Brunswick, Georgia; and Jacksonville, Florida. Cargo ships, tankers, and container ships use these ports to transport goods throughout the U.S., though military vessels, commercial and recreational vessels (e.g., cruise ships), research vessels, and personal vessels also use these ports.

CHAPTER 4 ENVIRONMENTAL CONSEQUENCES

4.0 Introduction

NMFS has reviewed all relevant direct, indirect, cumulative, short-term, and long-term impacts to marine mammals and their habitat associated with our action and alternatives. This chapter describes NMFS's review process and analyses, and then describes the potential environmental consequences for the affected resources described in Chapter 3 of this EA for each alternative. Furthermore, this chapter also summarizes analyses provided by BOEM in the PEIS that are relevant to NMFS's action (i.e., the authorization of marine mammal take), and incorporates some of the analysis by reference. This includes the prescribed mitigation and monitoring for BOEM's Preferred Alternative (Alternative B) from Volume 1, Chapter 2.2; the explanations from Volume I, Chapter 3 regarding BOEM's proposed action scenarios and the impact-producing factors (IPFs) in general and specific to the geophysical surveys that constitute the specified activities that are considered in the proposed IHAs; and explanations from Volume 1, Chapter 4 regarding BOEM's characterization of environmental impacts and the analysis of impacts specific to marine mammals and the marine environment. Finally, Volume III, Appendix D provides details on BOEM's acoustic modeling, and Volume III, Appendix E provides a summary of acoustic exposure estimates.

4.1 Overview of Bureau of Ocean Energy Management Impact Analysis and Methodology

As described in earlier chapters of this EA, BOEM's Final PEIS analyzes a broad scope of program areas (i.e., marine minerals and renewable energy in addition to oil and gas) and types of effects (e.g., effects to resources other than marine mammals) over a long timeframe (i.e., nine years). For example, BOEM's analysis includes impacts to sea turtles and coastal birds from different activity types, while NMFS's action is specific to the authorization of marine mammal take and associated effects to marine mammal habitat incidental to five 2D deep penetration airgun surveys occurring over a period of one year.

BOEM evaluated impacts to resources by assigning a four-level scale of environmental impacts to IPFs, or components of survey-related activities that could impact aspects of the human environment. IPFs include: active acoustic sound sources (airguns and electromechanical sources); vessel and equipment noise; vessel traffic; aircraft traffic and noise; vessel exclusion zones; trash and debris; seafloor disturbance; drilling discharges; onshore support activities; and accidental fuel spills. Out of all possible IPFs, BOEM acknowledges the following five IPFs as having the ability to affect marine mammals: (1) active acoustic sound sources (e.g., airguns), (2) vessel and equipment noise (from survey and support vessels), (3) vessel traffic (e.g., physical disturbance to and risk of collisions with marine mammals), (4) aircraft traffic and noise (identified in the PEIS but not relevant to NMFS's action), (5) trash and debris, and (6) accidental fuel spills. Then, based on these IPFs, BOEM evaluated and assigned a level of environmental impact caused by the IPFs. These four levels include:

- **Negligible:** Little or no measurable impacts observed or expected, including no expected mortality or injury or disruption of behavioral patterns (note that this is not related to the definition of "negligible impact" under the MMPA);

- **Minor:** Impacts are detectable, short-term, extensive or localized, but less than severe. This could include minor auditory discomfort, temporary disruption of communication

and/or echolocation, behavioral disruptions of individual or localized groups of marine mammals, and limited, localized, and short-term displacement of individuals of any species from the area of impact;

- **Moderate:** Impacts are detectable, short-term, extensive, and severe; or impacts are detectable, short-term or long-lasting, localized, and severe; or impacts are detectable, long-lasting, extensive or localized, but less than severe. This could include injury, but in numbers low enough such that annual rates of recruitment and survival of populations and stocks are not affected, and temporary displacement of individuals from preferred habitats. Although individual animals may be meaningfully impacted, no meaningful effects would be expected to populations or stocks;

- **Major:** Impacts are detectable, long-lasting, extensive, and severe. This could include injury and/or long-term behavioral disruptions sufficient to impact populations or stocks through adverse effects on annual rates of recruitment or survival, as well as permanent or long-term displacement of a sufficient number of individuals from preferred habitat

BOEM modeled the sound field from a representative airgun array within different acoustic propagation regions which, in conjunction with the best available information at the time regarding marine mammal occurrence, was used to produce acoustic exposure estimates. In order to build a comprehensive impact analysis, BOEM considered these acoustic exposure estimates, as well as the best available information concerning marine mammal occurrence and habitat use, the potential effects of noise on marine mammals, and a review of the best available information on mitigation. BOEM's quantitative exposure analysis and qualitative analysis of relevant literature and other context-specific information informed an evaluation of various IPFs on the basis of the environmental impact characterization identified above.

BOEM's modeling resulted in estimates of auditory injury for some species using the historical 180-dB rms criterion and the Southall et al. (2007) criteria. Disruption of behavioral patterns was predicted for all 34 species.

Based on scientific literature and exposure estimates, BOEM concluded it likely that airgun-related noise could affect individuals and groups of marine mammals. However, BOEM wrote that these types of surveys are expected to occur in the open ocean where cetaceans may move freely away from the sound source. Furthermore, BOEM wrote that the surveys are designed to avoid entrapment of marine mammals between a sound source and shore, that the mitigation measures are intended to reduce effects on marine mammal individuals and populations, and that given the slow-moving and transitory nature of the surveys, it is expected that elevated sound will be somewhat localized and temporary in duration. With this information, and incorporating exposure estimates, BOEM assessed the overall impacts from airgun surveys on marine mammals as "moderate." Brief descriptions of impact ratings for each IPF possibly affecting marine mammals are summarized below (see also Table 7).

Vessel and Equipment Noise—Based on closures of specifically designated areas at times with expected increased occurrence of right whales, the low expected volume of vessel traffic associated with G&G activities, and the fact that individuals or groups of marine mammals within the AOI may be familiar with various and common vessel-related noises, BOEM assessed impacts to marine mammals from vessel and equipment noise as negligible to minor.

Vessel Strike—BOEM also evaluated potential impacts to marine mammals from vessel strike. Noting that working survey vessels travel at slow speeds, and based on required guidance for ship strike avoidance, including ship speed restrictions, additional visual monitoring requirements, and the aforementioned closures of specifically designated areas at times with expected increased occurrence of right whales, BOEM found that the likelihood of a collision between G&G-related vessels and marine mammals within the AOI is considered low. Therefore, BOEM found that impacts to marine mammals from vessel strike would be negligible.

Debris Entanglement and Ingestion—BOEM anticipates insignificant amounts of trash and debris associated with G&G surveys to be released into the marine environment, and if any occurred, most would be from onboard food service operations. Furthermore, entanglement records for marine mammals is most common as bycatch in fishing activity, rather than from G&G surveys. Therefore, BOEM assessed debris entanglement and ingestion impacts on marine mammals as negligible.

Accidental Fuel Spill—BOEM developed an accidental fuel spill scenario based on U.S. Coast Guard statistics (see explanation in Volume I, Chapter 3.5.2.1 of the Final PEIS). BOEM acknowledges that marine mammals could be affected by accidental fuel spills from survey-associated vessels, but stated that the likelihood is low and that the impacts depend on the size, location, and meteorological conditions at the time of the spill. Accordingly, BOEM rated impacts of an accidental fuel spill as negligible to minor.

BOEM also assessed cumulative impacts to marine mammals from the range of activities considered in the PEIS alongside ongoing activity in the AOI (e.g., fisheries, military activity). To do so, they developed a cumulative impacts scenario, which includes 10 different foreseeable activities within the AOI: oil and gas development, renewable energy development, marine minerals use, geosequestration, liquefied natural gas terminals, commercial and recreational fishing, military range complexes and civilian space program use, shipping and marine transportation (including research vessels), dredged material disposal, and new cable infrastructure. BOEM grouped these into broad cumulative impact sources: (1) climate change, (2) cumulative ocean noise, and (3) cumulative vessel activity. To feed into the cumulative impact scenario, BOEM identified six impact-causing sources: underwater noise, vessel and equipment noise, vessel traffic and collisions, aircraft traffic and noise, trash and debris, and accidental fuel spills. They also assigned the same four levels of environmental impact (i.e. negligible to minor) described above to each of these major impact types in its cumulative impact analysis.

In their cumulative impacts analysis, BOEM provides a comparison of predicted impacts from Navy training and testing operations in the Atlantic alongside G&G related-activities, which, again, covers a scale of activity much larger than what NMFS is considering in the five proposed IHAs, since the PEIS covers a programmatic scale of different activity types over nine years. In this comparison, expected impacts from G&G are higher than those for Navy training and testing, though expected impacts are for all G&G activity types over nine years (e.g., not just airgun surveys) and do not include any mitigation. With this in mind, alongside "substantial yet localized" increases in ambient noise levels and the inclusion of mitigation measures, impacts are only expected to result in a minor increase to underwater noise impacts to marine mammals under BOEM's cumulative impacts scenario.

G&G activity is expected to involve relatively small numbers of vessels, which are expected to operate in a transient and intermittent fashion across a broad area, while moving at generally slow speeds and operating under applicable vessel strike avoidance measures. Based on the impact analysis described above, BOEM noted that vessel activity from G&G activity is expected to result in only a minor incremental increase to the risk of vessel collisions.

Apart from what is already described above, G&G vessel operations are not expected to add any significant trash and debris into offshore waters. Only minor incremental increases in trash and debris impacts to marine mammals are expected within the AOI. Similarly, risk of fuel spill in BOEM's cumulative impact scenario is anticipated to be "negligible."

Overall, BOEM's cumulative impact assessment found that impacts to marine mammals under a cumulative impact scenario would result in a "negligible" increase of impacts to the moderate impact rating described previously for marine mammals. See Table 7 for the impact evaluation from cumulative effects.

Table 7. Evaluation for Relevant Impact-Producing Factors and Cumulative Impact Scenario in BOEM's PEIS

Impact Producing Factor[1]	Impact Rating	Incremental Increase under Cumulative Impact Scenario to Marine Mammals[3]
Overall impacts from seismic surveys	Moderate	Negligible
Vessel and Equipment Noise	Negligible to Minor	Minor
Vessel Strike	Negligible	Minor
Debris and Entanglement	Negligible	Minor
Accidental Fuel Spills	Negligible to Moderate[2]	Negligible to Minor

[1] BOEM also considered aircraft traffic and noise, rated as negligible to minor and with a negligible increase in the cumulative impact scenario, in its impact assessment framework for marine mammals, but NMFS is not including that discussion here since aircraft will not be used in the activity associated with NMFS's proposed action.
[2] BOEM noted that if no marine mammals are contacted by spilled fuel, impacts will be negligible; if contact with an oil resulted in mortality or serious injury to an individual or group of marine mammals, the impact would be moderate.
[3] BOEM considered whether IPFs would result in incremental increases to impacts under a cumulative impact scenario. A factor with a "negligible" rating in the cumulative impact scenario is one that is considered unchanged when viewed cumulatively.

4.2 National Marine Fisheries Service Overall Approach for the Analysis of Impacts for Issuance of the Incidental Harassment Authorizations

In the notice of proposed IHAs (82 FR 26244), NMFS presented several analyses in determining that takes are within small numbers and would represent no greater than a negligible impact on the affected marine mammal species or stocks according to MMPA requirements (see "Analyses and Preliminary Determinations" sections of the notice of proposed IHAs). In addition, the

notice of proposed IHAs provides detailed descriptions of the five proposed surveys (see "Summary of Requests" and "Description of the Specified Activities"), a review of the impacts of noise on marine mammals ("Description of Marine Mammals in the Area of the Specified Activity," "Potential Effects of the Specified Activity on Marine Mammals," and "Acoustic Effects"), and a description of specific potential impacts to marine mammals and their habitat ("Anticipated Effects on Marine Mammal Habitat" and "Description of Exposure Estimates). Therefore, NMFS relies on and incorporates the information and analyses in the notice of the proposed IHAs throughout this Section in support of the approach to and assessment of impacts to marine mammals and their habitat associated with the issuance of the five IHAs.

4.2.1 Impact Characterization

As described in Section 4.1 of this EA, BOEM evaluated impacts to resources by assigning a four-level scale of environmental impacts to IPFs, or components of survey-related activities that could impact aspects of the human environment. IPFs considered as having the ability to affect marine mammals include: (1) active acoustic sound sources (e.g., airguns), (2) vessel and equipment noise (from survey and support vessels), (3) vessel traffic (e.g., physical disturbance to and risk of collisions with marine mammals), (4) aircraft traffic and noise (identified in the PEIS but not relevant to NMFS's action), (5) trash and debris, and (6) accidental fuel spills. NMFS adopts BOEM's conclusions for four of the five relevant IPFs (as described in 4.1.2), because there is no relevant new specific information to inform NMFS's analysis and because the impacts to marine mammals would be considered the same, albeit to a lesser degree given the different scale of activity considered. However, NMFS further considers potential effects due to use of active acoustic sound sources (a primary focus of NMFS's MMPA analyses).

NMFS adapts BOEM's approach to characterize and define the various impacts evaluated in their Final PEIS for use in evaluating potential environmental significance of NMFS's proposed action considered in this EA, making slight changes as appropriate to apply the framework to an understanding of potential impacts to populations of marine mammals. The adapted four-level scale of environmental impacts used by NMFS is as follows:

- **Negligible:** No injury and minimal disruption of behavioral patterns expected for individuals (note that this is not related to the definition of "negligible impact" under the MMPA);

- **Minor:** Impacts to individuals are short-term, extensive or localized, but less than severe. This could include minimal injury and a greater amount of disruption of behavioral patterns, including temporary disruption of communication and/or echolocation, behavioral disturbance of individual or localized groups of marine mammals, and limited, localized, and short-term displacement of individuals of any species from the area of impact;

- **Moderate:** Impacts to individuals are short-term, extensive, and severe; or impacts are short-term or long-lasting, localized, and severe; or impacts are long-lasting, extensive or localized, but less than severe. This could include injury and extensive or severe disruption of behavioral patterns, including temporary displacement of individuals from preferred habitats. Although individual animals may be meaningfully impacted, no effects are expected to annual rates of recruitment or survival and meaningful effects would not be expected to populations or stocks;

- **Major:** Impacts are long-lasting, extensive, and severe. This could include injury and/or long-term behavioral disruptions sufficient to impact populations or stocks through adverse effects on annual rates of recruitment or survival, as well as permanent or long-term displacement of a sufficient number of individuals from preferred habitat.

Our assignment of expected environmental impact to the appropriate level is informed as described in Section 4.2.2 below.

4.2.2 Methodology for Assessing Impact

NMFS relied on and incorporated some aspects of BOEM's analysis, such as use of BOEM's sound field modeling to inform some applicants' marine mammal take estimates. However, the analyses in BOEM's Final PEIS and NMFS's notice of proposed IHAs differ in some ways, with three main reasons being: (1) NMFS's action is specific to the taking of marine mammals in an activity much narrower in scope and scale than what is considered by BOEM; (2) BOEM's Final PEIS and NMFS's notice of proposed IHAs fulfill obligations under different statutes; and (3) the notice of proposed IHAs contains updated information, as described earlier in this EA.

In general, NMFS employs several quantitative and qualitative methodologies for assessing impact to marine mammal stocks and their habitat associated with our proposed action and alternatives. NMFS evaluates impact through its negligible impact determinations, small numbers analyses, consideration of the number of takes of marine mammals by Level A and Level B harassment, geospatial analyses to inform mitigation and impact (i.e., assessment of core abundance areas), and qualitative reviews of mitigation measures and impact.

In the notice of proposed IHAs and this EA, NMFS's assessment of potential impact includes a quantitative acoustic exposure analysis. As described earlier in this EA, NMFS historically has estimated takes based on two acoustic thresholds: sound exceeding 180 dB rms (constituting take by Level A harassment), and that exceeding 160 dB rms (take by Level B harassment). However, publication of NMFS's 2016 technical guidance (revised in 2018) provided new criteria for use in evaluating Level A harassment (Level B harassment criteria were not addressed). Furthermore, Roberts et al. (2016) published marine mammal density estimates in 2016, replacing the NODEs data. Therefore, NMFS evaluated acoustic exposure to marine mammals based on company-specific survey details provided in their applications, revised Level A threshold criteria, and new information and data regarding marine mammal density estimates. The following paragraphs summarize NMFS's acoustic exposure estimation methodology and take estimates and readers are directed to refer to the notice of proposed IHAs for detailed descriptions of NMFS's MMPA determinations and analyses.

Level A Harassment Take Estimation Methodology—BOEM calculated auditory injury exposure estimates (Level A) in their PEIS based on the NODEs marine mammal density data, two different acoustic injury exposure thresholds (i.e., Southall et al. (2007) and the historical 180 dB rms criterion), and an estimated sound source rather than actual sound sources as provided in applications. However, because (1) specific trackline estimates may differ somewhat from those considered in BOEM's PEIS; (2) PEIS exposure estimates are based on outputs from the NODEs models; and (3) PEIS exposure estimates are not based on the best available science regarding auditory injury thresholds (NMFS, 2018), we re-evaluated the potential for auditory injury for each hearing group (i.e., low-frequency, mid-frequency, high-frequency). NMFS's approach to evaluating the potential for auditory injury was revised following publication of the notice of proposed IHAs, based on review of public comments, the best available scientific information,

and consultation under Section 7 of the ESA. NMFS also accounted for new information regarding the acoustic sensitivity of mid-frequency cetaceans and regarding the likelihood of aversive behavior in the presence of airgun noise. NMFS recognizes that these Level A harassment exposure estimates are approximate. NMFS's intent in the analysis, however, is to reasonably approximate potential impact with the best available information.

For low-frequency cetaceans, consideration of the potential for auditory injury is not straightforward, because the predominant source of potential injury is the accumulation of energy, rather than instantaneous exposure to peak pressure received levels (as is the case for mid- and high-frequency cetaceans). For example, observation of a whale at the distance calculated as being the "injury zone" does not necessarily mean that the animal has in fact incurred auditory injury. Rather, the animal would have to be at the calculated distance (or closer) as the mobile source approaches, passes, and recedes from the exposed animal, being exposed to and accumulating energy from airgun pulses the entire time. Therefore, while we do believe that some limited Level A harassment of low-frequency cetaceans is unavoidable, despite the required mitigation measures (including shutdown upon detection within a 500-m exclusion zone for most mysticetes and shutdown upon detection of North Atlantic right whales within an expanded 1.5-km exclusion zone), a quantitative process (as was described in our notice of proposed IHAs) is not necessarily the most appropriate method. Therefore, we apply a simplified approach intended to acknowledge that there would likely be some minimal, yet difficult to accurately quantify, potential for Level A harassment of the most commonly occurring mysticete species (i.e., humpback, minke, and fin whales). Our estimation of potential Level A exposures for these species of low-frequency cetacean is based on consideration of average group size and survey-specific details including total planned survey effort and estimated acoustic injury zones.

NMFS has determined that Level A harassment is extremely unlikely to occur for mid-frequency cetaceans. NMFS estimated distances to new acoustic thresholds, and assessed the likelihood that individual mid-frequency cetaceans would come within or close to these distances. As described in the notice of proposed IHAs, NMFS calculated the distance from each array at which each injury threshold was met using each applicant's specific array. NMFS subsequently also calculated the maximum distance to the near-field (i.e., area near the array where pressure peaks do not arrive simultaneously from each element; source levels in the near field will be lower in reality than calculated as if the array is a point source), but does not expect animals to come within such close range since they would likely hear and/or see the arrays, and PSOs would detect closely approaching animals and shutdown the airgun source. To further evaluate the possibility of such an unlikely scenario, we calculated the distance to the acoustic thresholds based on a small 90-in^3 array (two 45-in^3 airguns) and a small and large single airgun using the source level information provided in Appendix D of BOEM's PEIS—for these sources, with only one or two elements, the source may be more accurately thought of as a point source. Since the threshold distances for these sources are also extremely small and in some cases indicate that PTS is not possible, we believe that PTS of mid-frequency cetaceans is extremely unlikely to occur.

For high-frequency cetaceans (i.e., Kogia spp. and harbor porpoise), injury zones are based on instantaneous exposure to peak pressure and are larger than the expected near-field in all cases. Therefore, we assume that Level A harassment is likely to occur for some individuals of these species. For these species, we conducted a simplified analysis through use of the existing estimates of Level B harassment for each applicant. Under the assumption that some of these estimated exposures would in fact result in Level A harassment versus Level B harassment, we

used applicant-specific calculated Level A and Level B harassment zones to generate estimates of the portion of estimated Level B harassment incidents that would be expected to be Level A harassment instead.

Level B Harassment Take Estimation Methodology—NMFS also recalculated Level B exposures to account for new information and specific survey details. All five companies originally relied on the NODEs data (which was the best available information at the receipt of applications), and three of the five companies (TGS, CGG, and Western) relied on BOEM's sound field modeling to inform their exposure modeling. Spectrum and ION conducted their own modeling.

When Roberts et al. (2016) published new density data, this then represented the best available scientific information. TGS and Western revised their applications using this new data; CGG used the new information in developing their application; and NMFS worked with Spectrum and ION to incorporate this information. Methodologies for re-calculating company-specific Level B exposure estimates using the new data and survey-specific information from the applicants, which differs from estimated exposures in the PEIS, are described below. We consider our take estimates to be the most up-to-date and based on the best available scientific information. Please see the "Description of Exposure Estimates" from the notice of proposed IHAs for a full overview of NMFS's methodology in calculating exposure estimates, which we have incorporated by reference here.

After publication of the proposed IHAs, NMFS became aware of efforts by Roberts et al. to update their NARW density model. The revised model expanded the original dataset used to provide model inputs by including survey data from the Atlantic Marine Assessment Program for Protected Species (AMAPPS), as well as aerial surveys conducted by several organizations in the southeast. The number of right whale sightings used in this model in the AOI increased by roughly 2,500 (Roberts et al., 2017). The models also now incorporate several improvements to minimize biases, an improved seasonal definition that more closely aligns with right whale biology, and showed a strong relationship between right whale abundance in the action area and distance to shore to approximately 80 km (Roberts et al., 2017), which was approximately 50 km in the previous model (Roberts et al., 2016).

Thus, using this new information, Level B harassment exposures for NARW were updated using the following methodology. Using the acoustic propagation modeling results in BOEM's PEIS (Appendix D), as was done previously by TGS, CGG, and WesternGeco, site and season specific radii to the 160 dB re: 1 µPa (rms) threshold (95 percent range, see Appendix D in the PEIS), and the total amount of trackline proposed by each company within the acoustic modeling regions specified in BOEM's 2014 PEIS, NMFS calculated monthly, region-specific ensonified areas for each company as if their entire survey tracklines were completed in each month. Then, using the updated 2017 density model outputs, we calculated average monthly regional right whale densities, which were then multiplied by the monthly ensonified areas. Finally, these data were averaged (annually across all months for TGS, CGG, and WesternGeco, and according to the proposed operating window for Spectrum and ION) to estimate the average total takes by Level B harassment. It is important to note that these calculations account for the time-area restrictions described in Chapter 2 of this EA. The final resulting Level B harassment take estimates then are based on the best available information on NARW occurrence within the action area from Roberts et al. (2017), account for time-area restrictions, and are specific to each company's tracklines and proposed operating window.

In addition to providing updated model outputs for NARW, Roberts et al. (2017) informed NMFS of updated models for fin, sei, sperm whales, and several non-ESA listed cetaceans. While these models included additional data (e.g., AMAPPS data) compared with Roberts et al. (2016) models, they produced generally similar results that did not appear to be meaningfully different, so NMFS has not incorporated those updated models in the IHAs. However, NMFS did revise take estimates to account for time-area restrictions. NMFS did so by calculating Level B harassment take that would be avoided from the proposed closures, and then subtracted this from the proposed Level B harassment takes for a final take estimate.

4.2.3 Summary of Potential Impacts of Issuing Incidental Harassment Authorizations

In considering whether it is appropriate to issue IHAs, NMFS evaluates impact based on an estimate of acoustic exposures, a qualitative review of the best available information on the impacts of survey noise on marine mammals, an assessment of the degree to which mitigation may reduce exposures and/or the impact of exposures, and conducts relevant analyses pursuant to the MMPA.

Overview of Take Impacts—Unlike BOEM's analysis that estimated Level A harassment take for 28 species based on the outdated 180-dB rms and Southall et al. 2007 criteria, NMFS's analysis, in conjunction with further assessment of the likelihood of auditory injury to result for mid-frequency cetaceans, shows that Level A harassment take is unlikely for most species. That is, no Level A harassment is expected for mid-frequency cetaceans (the majority of species), while limited Level A harassment is expected for some species of low-frequency cetacean and for high-frequency cetaceans (see 4.2.1 and Table 8). NMFS also found that Level B harassment exposures expected for the five surveys would be significantly lower than would be expected for the full program of activities considered in BOEM's PEIS (see Appendix E of BOEM's PEIS). See Section 4.4 of this EA for more information.

For takes by Level B harassment, species with moderate to high exposure levels include several species of dolphin (e.g., bottlenose dolphins, Atlantic spotted dolphins), pilot whales, sperm whales, and beaked whales. However, it is important to note that impacts cannot be inferred based on an assessment of take estimates alone, and we discuss contextual factors related to assessing impacts in the notice of proposed IHAs and in Section 4.4.

Overview of Impact Analysis—As part of its MMPA analyses, NMFS considered impact ratings (de minimis, low, medium, and high) for several factors relevant to the extent of impacts on marine mammals: amount of take, spatial extent, duration and frequency, and a magnitude rating.

Here, spatial extent refers to the overlap of the expected range of the affected stock with the expected footprint of the stressor. A low impact is a localized effect on a stock's range, a moderate impact is a regional effect (i.e., partial overlap with stock range), and a high impact is one where the degree of overlap is near total. The temporal aspect of the stressor is measured through consideration of duration and frequency. Duration describes how long the effects of the stressor last. Temporal frequency may range from continuous to isolated (may occur one or two times), or may be intermittent. Duration is defined as either a temporary (i.e., short term) effect lasting up to one month (i.e., prior to an animal or its habitat reverting to its prior condition); moderate-term as one to three months, or long-term (lasts beyond one season).

The amount, extent, and duration of an activity provide an understanding of the expected magnitude of the effect on a species or stock and their habitat, which NMFS then considers in the context of "likely consequences" of effects on individuals. Consequences are qualitatively evaluated, and include factors such as acoustic sensitivity, communication ranges, and an assumed ability to engage in important behaviors in potentially displaced areas. Adapting from Wood et al. (2012) in the proposed IHAs, NMFS then provides impact ratings on a scale of de minimis, low, moderate, and high for species, except for those considered "rare" in the IHAs, for which we assume a de minimus level of impact.

Briefly, NMFS finds that the likely consequences from the five surveys will be as follows (see "Negligible Impact Analyses" in the notice of proposed IHAs for a full description and explanations):

NMFS considers likely consequences as low for most delphinids and Kogia spp.; as medium for sperm whales, pilot whales, and all mysticete species (for those with a greater than a de minimis amount of exposure; they are considered as such due to the potential for masking as low-frequency hearing specialists), and as high for beaked whales (due to the combination of known acoustic sensitivity and residency patterns and a low compensatory ability). NMFS then created magnitude and impact ratings for each of the five applicants (Tables 14-18 in the notice of proposed IHAs).

In reviewing all of these factors collectively, as well as an extensive review of literature on geophysical surveys and marine mammals, and a suite of appropriate mitigation and monitoring requirements, NMFS determined in the notice of proposed IHAs that the authorization of marine mammal take incidental to these surveys is not expected to affect rates of recruitment or survival in any of the 34 marine species (and 39 managed stocks), nor have substantial population-level impacts. Thus, NMFS's findings vary slightly from BOEM's in the presentation of findings (i.e., they differ from BOEM's overall finding of G&G activity having a "moderate" impact on marine mammals), but provide similar conclusions when considering impacts to marine mammal recruitment and survival. However, we note that BOEM's programmatic analysis provided this conclusion in relation to a much larger scope of activity.

As compared to the BOEM PEIS, NMFS did not assess cumulative impacts from the five surveys or other activity in its notice of proposed IHAs; instead, this is discussed below in a review of the two alternatives considered here, in concert with a review of the effects on marine mammals and their habitat. See Sections 4.4.6, 4.5, and 4.6 of this EA.

4.3 Effects of Alternative 1 (No Action Alternative)

Where a choice of "no action" by the agency would result in predictable actions by others, this consequence of the "no action" alternative should be included in the analysis. (CEQ, Forty Questions, 3.A). NMFS's view is that it is likely that the applicants would choose to undertake their actions in compliance with the law rather than proceed without the take authorization. Under the No Action Alternative, NMFS would not issue the IHAs authorizing take of marine mammals. As a result, the exceptions to the prohibition on take of marine mammals per the MMPA would not apply and the applicants would not conduct the geophysical surveys as described in the application. There would be no direct or indirect impacts to marine mammals or their habitat resulting from no action. The marine mammal species and their habitat conditions

would remain substantially similar to the condition described in the Affected Environment section of this EA.

4.4 Effects of Alternative 2 (Preferred Alternative)

Under Alternative 2, NMFS would issue individual IHAs to the five companies authorizing take, by harassment only, of 34 species of marine mammals (with 39 managed stocks) incidental to the proposed geophysical survey activities subject to the prescribed mitigation, monitoring, and reporting requirements set forth in the IHAs. Impacts to marine mammals, their habitat, and the wider marine environment are described below.

4.4.1 Impacts to Marine Mammals

As discussed previously, the primary impacts to marine mammals from issuance of these IHAs would occur via acoustic exposure to the sound source. Impacts to marine mammals from airguns, however, are highly variable. The magnitude of effect is intrinsically related to many factors, including: acoustic signal characteristics, received level, distance from the source, duration of the sound exposure, marine mammal behavioral state (e.g., migrating), biological condition, and environmental and physical conditions and effects on acoustic propagation.

Both BOEM's PEIS and the IHAs describe, generally, potential impacts from geophysical survey noise. However, BOEM's PEIS analyzes a large program of activity (i.e., nine years of multiple types of G&G surveys), whereas this EA considers effects of issuing IHAs associated with 5 specific surveys in depth. We incorporate the PEIS and notice of proposed IHAs by reference, and broadly summarize main impacts here and highlight new literature relevant to our analysis. We start with a discussion of the potential impacts of airgun noise on marine mammals, and then move into more specific analyses.

4.4.2 Overview of Potential Impacts

Impacts to marine mammals from anthropogenic noise, including airguns, can be grouped into three main categories: behavioral disruption, masking, and physical or physiological impacts (Nowacek et al., 2007). Broadly, this ranges from hearing loss (temporary or permanent), increased stress response, habitat displacement, changes to behavioral patterns (e.g., increased swimming speed, shorter dive duration), masking, injury, to even death in certain circumstances not present here (Richardson et al., 1995; Weilgart 2007).

1. *Threshold Shift*—Marine mammals exposed to high-intensity sound, or to lower-intensity sound for prolonged periods, can experience hearing threshold shift (TS), or the loss of hearing sensitivities at certain frequencies (Nowacek et al., 2007; Finneran, 2015). TS can be permanent (PTS), where the loss of hearing sensitivity is not fully recoverable, or temporary (TTS), in which case an individual's hearing threshold can recover with time (Southall et al., 2007). Repeated exposure leading to TTS can also lead to PTS (Weilgart 2007). If PTS occurs, there is physical damage to sound receptors.

Currently, TTS data only exist for four species of cetaceans: bottlenose dolphin, beluga whale (Delphinapterus leucas), harbor porpoise, and Yangtze finless porpoise (Neophocoena asiaeorientalis), which were exposed to a limited number of sound sources (i.e., mostly tones and octave-band noise) in laboratory settings (Finneran, 2015). In general, harbor porpoises have a lower TTS onset than other studied cetacean species (Finneran, 2015), but little remains known on the exact frequencies and conditions for onset of TTS and PTS (Finneran, 2015). Additionally, the existing marine mammal TTS data come from a limited number of individuals within these species. There are no data available on noise-induced hearing loss for mysticetes.

Critical questions remain regarding the rate of TTS growth and recovery after exposure to intermittent noise and the effects of single and multiple pulses. Data at present are also insufficient to construct generalized models for recovery and determine the time necessary to treat subsequent exposures as independent events. More information is needed on the relationship between auditory evoked potential and behavioral measures of TTS for various stimuli. For summaries of data on TTS in marine mammals or for further discussion of TTS onset thresholds, please see Southall et al. (2007), Finneran and Jenkins (2012), Finneran (2015), and NMFS (2018).

2. *Behavioral Effects*—Behavioral disturbance can occur via many forms, including subtle changes in behavior (e.g., brief avoidance of an area or changes in vocalizations), longer-time changes in behavior, or more potentially long-term and severe responses. Behavioral responses to sound are highly variable and context-specific, and any reactions depend on numerous intrinsic and extrinsic factors (e.g., species, state of maturity, experience, current activity, reproductive state, auditory sensitivity, time of day), as well as the interplay between factors (e.g., Richardson et al., 1995; Wartzok et al., 2003; Southall et al., 2007; Weilgart, 2007; Archer et al., 2010).

Habituation can occur when an animal's response to a stimulus wanes with repeated exposure, usually in the absence of unpleasant associated events (Wartzok et al., 2003). Animals are most likely to habituate to sounds that are predictable and unvarying. Behavioral disturbance can include: habitat displacement or avoidance (McCauley et al., 2000a; Forney et al., 2017), habituation to a sound source (Gordon et al., 2003), or decreases in vocalization. For example, several studies have observed cessation or changes in fin whale calls (e.g.. Castellote et al., 2012; Cerchio et al., 2014) and in bowhead whale calls during their fall migration in the Alaskan Beaufort Sea, at distances of 41 to 45 km exposed to median received levels (SPL) of at least 116 dB re 1 μPa (Blackwell et al., 2013). In contrast, other studies documented increases in blue whale call production amidst received levels of 131 dB re 1 μPa2-s, potentially indicating blue whales attempting to "compensate" for increases in background noise levels (Di Iorio and Clark, 2010). Other studies show airgun avoidance for bowhead whales at distances of 20 km or more at received sound levels of 120-130 dB rms during use of airgun arrays (Richardson et al., 1999). Thus, available studies show wide variation in response to underwater sound, and the degree of impact depends on many factors, including behavioral state, reproductive state, distance to the sound source, and more.

3. *Stress Responses*—Other impacts include both stress response (Wright et al., 2007; Rolland et al., 2012) and chronic stress from repeated exposure to a sound source (NRC, 2003; Wright et al., 2011), both of which can carry consequences for fitness and health. Additionally, an animal experiencing TTS is likely to experience a stress response (NRC, 2003). An animal's perception of a threat may be sufficient to trigger stress responses consisting of some combination of behavioral responses, autonomic nervous system responses, neuroendocrine responses, or immune responses (e.g., Seyle, 1950; Moberg, 2000).

Relationships between these physiological mechanisms, animal behavior, and the costs of stress responses are well-studied through controlled experiments and for both laboratory and free-ranging animals (e.g., Holberton et al., 1996; Hood et al., 1998; Jessop et al., 2003; Krausman et al., 2004; Lankford et al., 2005). Stress responses due to exposure to anthropogenic sounds or other stressors and their effects on marine mammals have also been reviewed (e.g., Fair and

Becker, 2000; Romano et al., 2002b) and, more rarely, studied in wild populations (e.g., Romano et al., 2002a). For example, Rolland et al., (2012) found that noise reduction from reduced ship traffic in the Bay of Fundy was associated with decreased stress in North Atlantic right whales. These and other studies lead to a reasonable expectation that some marine mammals will experience physiological stress responses upon exposure to acoustic stressors and that it is possible that some of these would be classified as "distress." In addition, any animal experiencing TTS would likely also experience stress responses (NRC, 2003).

4. *Auditory Masking*—Geophysical surveys also have the ability to cause auditory masking, whereby the receipt of sound can be interfered with by another coincident sound at similar frequencies and at similar or higher intensity, and may impact an animal's ability to detect or discriminate between vital acoustic signals (Richardson et al., 1995; Gordon et al., 2003; Compton et al., 2008; Nieukirk et al., 2012). The ability of a noise source to mask biologically important sounds depends on the characteristics of both the noise source and the signal of interest (e.g., signal-to-noise ratio, temporal variability, direction), in relation to each other and to an animal's hearing abilities (e.g., sensitivity, frequency range, critical ratios, frequency discrimination, directional discrimination, age or TTS hearing loss), and existing ambient noise and propagation conditions.

It is important to note that masking, which broadly involves marine mammals being unable to receive or distinguish between acoustic signals in the presence of noise of similar frequencies, differs from PTS and TTS, which involve hearing loss or damage to the animal. As with PTS and TTS, characteristics of the noise source, distance from the source, an individual's behavioral and physiological state, and more influence the magnitude of potential masking. Masking can result in consequences to the animal, such as changes in vocalization, increased energetic costs, reduction in communication space, and more (e.g., Clark et al., 2009; Di Iorio and Clark, 2009).

5. *Non-Acoustic Impact*—Non-acoustic impacts to marine mammals are discussed here, but considered to be unlikely. One potential impact to marine mammals from the proposed activity is vessel strike. Vessel collisions with marine mammals, or ship strikes, can result in death or serious injury of the animal. Wounds resulting from ship strike may include massive trauma, hemorrhaging, broken bones, or propeller lacerations (Knowlton and Kraus, 2001). The severity of injuries typically depends on the size and speed of the vessel, with the probability of death or serious injury increasing as vessel speed increases (Knowlton and Kraus, 2001; Laist et al., 2001; Vanderlaan and Taggart, 2007; Conn and Silber, 2013).

Vessel strike is of particular concern for mysticetes, as historical records show that most vessel strikes occur to fin, humpback, NARW, gray, minke, and other large whales (Laist et al., 2001; Jensen and Silber 2003; Vanderlaan et al., 2007). A UME is ongoing for humpback whales along the Atlantic Coast. As of October 2018, partial or full necropsy examinations have been conducted on approximately half of the 84 known cases. Of the cases examined, approximately half had evidence of human interaction (ship strike or entanglement). Some of these investigated mortalities showed blunt force trauma or pre-mortem propeller wounds indicative of vessel strike, indicating a strike rate above the annual long-term average; however, these findings of pre-mortem vessel strike are not consistent across all of the whales examined and more research is needed (NOAA Fisheries, 2018a). Similarly, NOAA declared a UME for right whales in June 2017, following 20 right whale deaths as of October 2018 (NOAA Fisheries, 2018b). While it is too early to determine the cause of these deaths, ship strike has historically been a significant source of mortality for these species. While NMFS recognizes vessel strike is a significant

concern for marine mammals, the prescribed Vessel Strike Avoidance measures—including reducing vessel speeds, maintaining standoff distances, and other mitigation—will significantly reduce the potential of ship strikes for right whales and other species.

Other non-acoustic impacts also include entanglement and fuel spills from vessels associated with survey activity. NMFS is not aware of any associations of marine mammals becoming entangled with geophysical survey gear. Furthermore, accidental fuel spill from vessel diesel is a possibility, but NMFS agrees with BOEM's finding that the likelihood of this is remote.

New Literature—Here, we summarize important new literature on marine mammals and ocean noise relevant to the IHAs; i.e., newer information that was not evaluated in the 2017 notice of proposed IHAs. Briefly, they include new research showing that humpback whale mother-calf pairs communicate in low amplitude calls to avoid predatory detection (Videsen et al., 2017). This could have potential implications for the low-frequency sounds of airguns masking these calls, but NMFS does not have information to specifically delineate exact impacts from our action to these calls. However, NMFS finds required mitigation (e.g., shutdowns for large whales with a calf, as well as subsidiary benefits from some of the time-area restrictions) helps reduce any adverse impacts to this species. Additionally, Stanistreet et al. (2017) recently identified beaked whale presence consistently off Cape Hatteras and Onslow Bay NC throughout the year. NMFS designed several year-round closure areas of important canyon and steep-depth gradient habitats specific to beaked whales—Areas #1-3 based on beaked whale core abundance areas (see Chapter 2 in this EA and the "Beaked Whale" subsection in the notice of proposed IHAs)—as well as a seasonal closure of beaked whale habitat off of Cape Hatteras, and finds these will provide reasonable protection to these species and their habitat from the proposed activity. Additionally, Stanistreet et al. (2018) described sperm whale acoustic recordings in the western Atlantic, where they acoustically detected sperm whales year-round, and with a winter (defined in the study as January to March) peak in occurrence off Cape Hatteras and less seasonality in occurrence south of Cape Hatteras. This paper is reflected in the temporal aspect of Area #4. See Sections 4.4.5 and 4.4.6 for a discussion of several new scientific papers specific to NARW.

4.4.3 Estimated Marine Mammal Take by Harassment

The total number of authorized marine mammal takes are displayed in Table 8. Anticipated effects will primarily be by Level B harassment, as airgun use has the potential to result in the temporary disruption of behavioral patterns for marine mammals, temporary displacement, or other minor effects, rather than auditory injury. There is potential for auditory injury (Level A harassment) for only a few species—either high-frequency or low-frequency hearing specialists, on the basis of peak pressure and cumulative SEL, respectively. Auditory injury is unlikely for mid-frequency hearing specialists (e.g., dolphins and sperm whales). Lethal takes are not expected to be possible, even without prescribed mitigation and monitoring, and no such takes are authorized.

Table 8. Number of Incidental Takes Authorized by Harassment

Common name	Spectrum		TGS		ION		Western		CGG	
	Level A	Level B	Level A	Level B	Level A	Level B	Level A	Level B	Level A	Level B
North Atlantic right whale	0	2	0	9	0	2	0	4	0	2
Humpback whale	2	19	4	56	2	5	0	49	2	5
Minke whale	2	252	4	208	2	10	0	100	4	124
Bryde's whale	0	2	0	2	0	2	0	2	0	2
Sei whale	0	2	0	2	0	2	0	2	0	2
Fin whale	2	163	4	1,140	2	3	0	537	4	45

Blue whale	0	1	0	1	0	1	0	1	0	1
Sperm whale	0	684	0	3,579	0	16	0	1,941	0	1,304
Kogia spp.	3	125	11	1,210	2[1]	28	10	562	2[1]	238
Beaked whales	0	2,291	0	12,072	0	490	0	4,960	0	3,511
Northern bottlenose whale	0	4	0	4	0	4	0	4	0	4
Rough-toothed dolphin	0	117	0	261	0	14[1]	0	123	0	177
Common bottlenose dolphin	0	14,938	0	40,595	0	2,599	0	23,600	0	9,063
Clymene dolphin	0	4,045	0	821	0	252	0	391	0	6,382
Atlantic spotted dolphin	0	8,466	0	41,222	0	568	0	18,724	0	6,596
Pantropical spotted dolphin	0	1,017	0	1,470	0	78	0	690	0	1,566
Spinner dolphin	0	91	0	91	0	91	0	91	0	91
Striped dolphin	0	5,144	0	23,418	0	162	0	8,845	0	6,328
Common dolphin	0	6,008	0	52,728	0	372	0	20,683	0	6,026
Fraser's dolphin	0	204	0	204	0	204	0	204	0	204
Atlantic white-sided dolphin	0	48	0	48	0	48	0	48	0	48
Risso's dolphin	0	414	0	3,241	0	90	0	1,608	0	809
Melon-headed whale	0	50	0	50	0	50	0	50	0	50
Pygmy killer whale	0	6	0	6	0	6	0	6	0	6
False killer whale	0	28	0	28	0	28	0	28	0	28
Killer whale	0	7	0	7	0	7	0	7	0	7
Pilot whales	0	1,591	0	8,902	0	199	0	4,682	0	1,964
Harbor porpoise	8	355	3	322	3[1]	18	3	152	3[1]	27

[1] Exposure estimate increased to account for average group size observed during AMAPPS survey effort. For ION, estimated Level A harassment of *Kogia* spp. and harbor porpoise was zero and, for CGG, estimated Level A harassment of harbor porpoise was zero. We assume as a precaution that one group (as estimated from AMAPPS data) may incur Level A harassment. The take numbers also reflect the modified tracklines submitted by Spectrum and described in subsection 2.2. In general, the predicted number of takes from Spectrum's proposed activities were reduced due to adjusted track lines.

It is important to note that an estimate of takes alone is not enough information on which to determine impacts to marine mammals. One function of take numbers is to provide a quantitative basis for assessing impacts, but they must be viewed contextually in relation to mitigation and monitoring requirements as well as other relevant information. Below, we discuss several factors that NMFS considered in assessing the aggregate impacts to marine mammals from these five IHAs.

4.4.4 Mitigation and Monitoring Requirements

As described in Chapter 2 of this EA, NMFS is requiring a suite of mitigation measures that are expected to be effective in reducing impacts to marine mammals based on the best available information, and which NMFS has designed as necessary to achieve the least practicable adverse impact on affected marine mammal individuals and stocks and their habitat, as required by the MMPA. In developing these mitigation measures, NMFS considered mitigation measures evaluated in BOEM's PEIS, with special attention to those included in BOEM's preferred alternative and identified in their ROD, as well as those proposed by the applicants. NMFS has prescribed additional mitigation measures as necessary to satisfy MMPA requirements, and thus NMFS's required mitigation and monitoring adds additional protection, compared with the mitigation requirements proposed in these other documents. A description of the benefits to particular species through NMFS's required mitigation is described below.

In authorizing take incidental to airgun survey activities (and other activities), NMFS has always included measures focused on avoidance of marine mammal exposures to received sound levels exceeding historical injury criteria (e.g., 180 dB rms), but has also included time/area restrictions in areas of particular importance for marine mammal critical behaviors or subsistence uses, as well as other measures focused on reducing behavioral impacts, where appropriate. Accordingly, while retaining a focus on avoiding the potential for auditory injury to the extent practicable, NMFS's focus here also includes avoiding exposures for the most sensitive species and/or circumstances—whether due to expected sensitivity to the noise source, overall status of the species, or because of the importance of particular habitat for the species—including expanded shutdown requirements, time-area restrictions, and recognition that avoidance of exposure also benefits individual marine mammals by minimizing potential for more severe behavioral reactions. NMFS aims to reduce acoustic exposures as much as possible via use of visual and acoustic monitoring, but in this case has required a suite of additional measures given the spatiotemporal scope of these specified activities.

First, NMFS is requiring visual monitoring of a 1-km zone before, during, and after use of the acoustic source, and shutting down for any species seen within a 500-m exclusion zone. This 500-m standard exclusion zone encompasses the area for most species within which auditory injury could occur on the basis of instantaneous exposure. This distance also provides additional protection from the potential for more severe behavioral reactions for marine mammals at close range to the acoustic source, as well as falling within a distance where detection probabilities are reasonably high for most species. Shutdowns upon observations of marine mammals seen entering or within the exclusion zone applies to all species except small delphinids, as they are the most commonly observed marine mammal in the AOI and are likely the only species to voluntarily approach a source vessel. The best available science indicates that mid-frequency cetaceans should not be considered particularly sensitive to potential auditory injury due to the low-frequency content of the airgun signal and, in fact, a large body of literature indicates that small delphinids commonly approach vessels and/or towed arrays during active sound production for purposes of bow riding (e.g., Barkaszi et al. 2012). NMFS is also requiring use of a towed PAM system to support visual observation efforts before and during use of the acoustic source, which is expected to be particularly important for detection of cryptic or deep-diving species as well as at night or in poor visibility conditions.

The 500-m exclusion zone contains the entirety of any potential injury zone for mid-frequency cetaceans, while the zones within which injury could occur may be larger for high-frequency cetaceans (on the basis of peak pressure and depending on the specific array) and for low-frequency cetaceans (on the basis of cumulative sound exposure). Only three species of high-frequency cetacean could occur in the AOI: the harbor porpoise and two Kogia spp. Harbor porpoises are expected to occur rarely and only in the northern portion of the survey area if at all. A shutdown measure for Kogia spp., as well as a time-area restriction, is required to address these potential injury concerns (see descriptions below in this section). For low-frequency cetaceans, several of these are considered rare species (sei, Bryde's, and blue whales), and other mitigation measures (e.g., shutdowns for individuals with calf and some time-area restrictions) are expected to provide additional benefits to these species to augment visual and acoustic shutdowns within the exclusion zone.

Additionally, NMFS is requiring ramp-up of the acoustic source in all surveys. There is some debate as to the effectiveness of ramp-up (e.g., Compton et al., 2008; Parsons et al., 2009). However, ramp-up is an accepted component of basic airgun mitigation protocols and is likely to

be most beneficial for species more sensitive to the acoustic disturbance (e.g., beaked whales; Tyack et al., 2011; DeRuiter et al., 2013; Miller et al., 2015). For those reasons, NMFS believes it appropriate to require it here.

Given the scope of the applicants' planned surveys and overlap with a wide number of species and habitat, NMFS has required additional mitigation measures that are specific to these actions. These mitigation measures are discussed below and summarized in Tables 3, 4, and 9.

(1) Buffer zone: During ramp-up of the acoustic source, NMFS is requiring visual monitoring of a 1-km zone for a minimum of 30 minutes prior to commencing ramp-up (i.e., pre-clearance watch). This provides PSOs the ability to ensure any visually-detectable species are outside of a 1-km zone surrounding the sound source. Ramp-up cannot begin until species have cleared the zone (i.e., 15 minutes for small odontocetes and 30 minutes for all other species).

(2) Shut-downs at extended distance: NMFS is requiring shutdowns of the acoustic source at an extended distance of 1.5 km upon observation of NARW, large whales with a calf, observation of a beaked whale or Kogia spp., and upon any observation of an aggregation of large whales. Explanations for these shutdowns are as follows:

North Atlantic right whales—NMFS is requiring more stringent shutdowns for right whales, as the population's precarious status and likely decline (Kraus et al., 2005, Waring et al., 2016, Pettis and Hamilton, 2016, Pace III et al., 2017) indicate that disturbance should be minimized. In addition, the extended 90 km closure from November to April includes any habitat within which the majority of any right whales would occur during migration or the calving season (or we require that comparable protection is achieved through implementation of a NMFS-approved mitigation and monitoring plan at distances between 47-80 km offshore); in the off chance additional individuals are encountered beyond this boundary or between May to October, this shut-down helps minimize disturbance resulting from acoustic exposure. Though the primary causes of mortality and decline of right whales appears to be ship strike and fishing-related entanglement (Baumgarter et al., 2017), this helps reduce vulnerability to additional stressors, such as from acoustic disturbance.

Large whales with calf—Given that (1) most large whales are endangered, (2) the functional hearing ranges of mysticetes overlap with the frequencies associated with airgun survey activity, and (3) the difficulties in correctly identifying rorquals at greater distances, NMFS believes these shutdowns are a necessary measure to help ensure undisturbed calving, or mother/calf communication, for the persistence of these populations or stocks. Furthermore, a recent study found that humpback mother and calf pairs exhibit weak tonal and grunt sounds, likely communicated at such levels to reduce predatory and male humpback exposure during vital nursing and resting periods, and this small active acoustic space could increase sensitivity to increases in ambient noise (Videsen et al., 2017). This study presents an additional compelling piece of evidence supporting this shutdown requirement to reduce chances of exposure for not only humpbacks, but other large whales.

Observations of beaked whales or Kogia spp.—Beaked whales and Kogia spp. are two of the most acoustically sensitive guilds to underwater noise. They are deep-diving species, and disturbance could lead to severe behavioral responses. Furthermore, they exhibit high site fidelity to canyon areas and steep-depth gradients around waters off Cape Hatteras, meaning that displacement to other habitat areas may have negative effects on foraging or fitness. There are

generally low detection probabilities for these species (e.g., Barlow 1999; Barlow and Forney, 2007). Finally, Kogia spp.'s auditory injury zones extend from 350-1,550 m (NMFS, 2018)—a distance that exceeds the exclusion zone and for which a PSO could realistically sight these animals. Recognizing these factors, shutdowns provide an additional protective measure in addition to the time-area restrictions (described below).

Aggregations of large whales—It is likely that aggregations of these animals are engaging in important behavior (e.g., foraging, socializing), and exposure to the acoustic source could disrupt such behavior and potentially lead to energetic costs. Again, NMFS requires this measure in this context to reduce the likelihood and magnitude of exposure, given the spatiotemporal extent of this activity.

(3) Time-area closures and other restrictions: NMFS has required multiple geographic restrictions and time-area closures specific to this action that protect some of the most vulnerable marine species and their important habitat (Table 4, Table 9). First, no survey effort may occur within 30 km of the coast year-round, which provides additional protection for coastal stocks of bottlenose dolphin. All bottlenose dolphin stocks are designated as depleted under the MMPA, and they experienced an Unusual Mortality Event (UME) from 2013 to 2015. Genetic analysis shows that 99 percent of dolphins affected by this UME were of the coastal ecotype. Dolphins of the coastal ecotypes are generally expected to occur within 20 km of the coast, and a 10 km buffer is provided to encompass the area within which sound exceeding behavioral harassment thresholds (e.g., sound levels exceeding 160 dB rms) would reasonably be expected to occur (BOEM, 2014a).

For NARW, NMFS is requiring an exclusion of all survey effort from November 1 through April 30 in the area from the coastline to 90 km offshore (or we require that comparable protection is achieved through implementation of a NMFS-approved mitigation and monitoring plan at distances between 47-80 km offshore). NARW are considered to be critically endangered, with a declared UME in effect since August 2017. Twenty confirmed deaths have occurred as of October 2018. While most of these deaths have been in Canadian waters and have occurred in areas outside the AOI, recent literature suggests decreases in calves and adults present in the southeastern calving grounds (Waring et al., 2016) and declines in abundance. Therefore, additional measures are warranted to minimize any disturbance of right whales or their critical habitat, especially during the calving season. This restriction encompasses an 80 km distance starting from the shoreline that contains the majority of right whale sightings in the southeast to-date (Roberts et al., 2017), as well as a 10 km buffer zone (i.e., the area within which sound exceeding behavioral harassment thresholds (e.g., sound levels exceeding 160 dB rms) would reasonably be expected to occur). As noted previously, this distance has been expanded from the closure evaluated in BOEM's preferred alternative in the PEIS and the notice of proposed IHAs (i.e., a 47 km closure) based on updated NARW density models (Roberts et al., 2017). It is important to note that the exposure estimates for right whales were revised on the basis of the newer model, with the avoided exposures resulting from the closure accounted for. The number of right whale takes has consequently decreased from the proposed to final IHAs. It is unlikely that a survey vessel will encounter NARW outside of the closure area (Roberts et al., 2017).

NMFS is requiring four additional time-area restrictions in the AOI. As described in Chapter 2 of this EA, Areas #1-3 close specific deepwater canyon areas to use of the acoustic source year-round, and Area #4 closes the shelf break off Cape Hatteras and waters around "The Point" from

January through March, based on passive acoustic monitoring data for sperm whales indicating increased presence of sperm whales in these months (Stanistreet et al., 2018).

These closures are primarily targeted at sperm whales, beaked whales, and pilot whales. For all of these species, authorized exposures are moderate to high, and vulnerability to exposure is compounded by other factors. Beaked and sperm whales are particularly sensitive to the acoustic source, and given the sperm whale's long dive times and foraging patterns at depth, exposure to the acoustic source could disturb foraging behavior. Finally, pilot whale populations are considered vulnerable as a result of high levels of mortality from commercial fishing, and therefore have suppressed resiliency to other potential stressors.

In addition to these three target species, it is assumed closures will have subsidiary benefits to other species that are present. Area closure #4 in particular is expected to be beneficial to a variety of species (McAlarney et al., 2015), particularly bottlenose dolphins, Risso's dolphins, and common dolphins. These species have moderate to high exposure estimates, so it is expected this closure will be beneficial in reducing exposures.

Subsidiary benefits for Area #1-3 are expected to occur for Kogia spp., pantropical spotted dolphins, Clymene dolphins, and rough-toothed dolphins. Some of these species (e.g., Kogia spp., pantropical spotted dolphins) also have moderate to high exposure estimates, and thus these closures help reduce potential exposure to the sound source in canyon-area habitat expected to be important foraging habitat for several species.

These time-area restrictions are accounted for in the take estimates. Additionally, it is expected that implementation of these closure areas will significantly reduce the impact of takes that do occur by diverting survey effort from areas expected to be of greatest importance for marine mammals. Table 9 summarizes the spatiotemporal components and intended benefit species of the suite of mitigation measures to this action.

Table 9. Summary of Additional Mitigation Specific to this Action Designed to Protect Specific Species and Habitats

Mitigation Measure	Spatial Extent	Temporal Extent	Intended Species for Protection
Shutdown for North Atlantic right whales at extended distance	Entirety of AOI	Effective during all survey activity	North Atlantic right whales
Shutdowns for large whales with a calf	Entirety of AOI	Effective during all survey activity	Sperm whale or any mysticete
Shutdowns for observations of beaked whales or Kogia spp.	Entirety of AOI	Effective during all survey activity	Beaked whales (i.e., Cuvier's beaked whale or Mesoplodon spp. but not the northern bottlenose whale) and Kogia spp. (i.e., pygmy sperm whale and dwarf sperm whale)

Mitigation Measure	Spatial Extent	Temporal Extent	Intended Species for Protection
Shutdowns for aggregations (6+ individuals) of large whales	Entirety of AOI	Effective during all survey activity	Sperm whale or any mysticete
Coastal restriction	30 km from the coastline in entirety of the AOI	Year-Round	Bottlenose dolphins (coastal stocks)
North Atlantic Right whale closure	90 km from the coastline[1]	November 1 through April 30	North Atlantic right whales
Area #1	Encompasses the Hatteras Transverse Canyon	Year-Round	Beaked whales
Area #2	Centered on Hatteras Canyon	Year-Round	Beaked whales and sperm whales
Area #3	Centered on deepwater valley system between Hendrickson and Baltimore Canyons	Year-Round	Beaked whales and sperm whales
Area #4	Cape Hatteras and the shelf break environment northward to the boundary of the AOI and further southward	January 1 through March 31	Pilot whales, beaked whales, sperm whales

[1] In lieu of this requirement, applicants may develop and submit a monitoring and mitigation plan for NMFS's approval that would be sufficient to achieve comparable protection for North Atlantic right whales. If approved, applicants would be required to maintain a minimum coastal standoff distance of 47 km from November through April while operating in adherence with the approved plan from 47 through 80 km offshore.

4.4.5 Impacts to Marine Mammal Habitat

Both BOEM's PEIS and the notice of proposed IHAs describe potential effects of airgun surveys on marine mammals in detail, and are incorporated by reference. Here, we provide brief summaries of potential impacts on marine mammal habitat given new scientific information (i.e., Roberts et al., 2016; Roberts et al., 2017) and the revised critical habitat designation for North Atlantic right whales.

Physical Disturbance—The planned geophysical surveys do not include seafloor placement of anchors, nodes, cables, sensors, or other equipment, and therefore the surveys are not expected to result in any physical damage to habitat.

Effects on Prey—Marine mammal prey selection varies by species, sex, reproductive status, distribution of both marine mammals and prey, and other factors. Primary prey types include fish, cephalopods, and planktonic species, though marine mammal prey type is unknown for

some species. Like marine mammals, it is well documented that fish utilize sound production for a variety of key biological life functions, including mating, spawning, habitat selection, and more (e.g., Mann et al., 2010; Wall, Lembke, and Mann, 2012; Fine and Parmentier, 2015). Invertebrates appear to be able to detect sounds (Pumphrey, 1950; Frings and Frings, 1967) and are most sensitive to low-frequency sounds (Packard et al., 1990; Budelmann and Williamson, 1994; Lovell et al., 2005; Mooney et al., 2010). Available data suggest that cephalopods are capable of sensing particle motion, and detect low frequencies up to 1-1.5 kHz, depending on the species, and so are likely to detect airgun noise (Kaifu et al., 2008; Hu et al., 2009; Mooney et al., 2010; Samson et al., 2014). There is a growing body of literature that increased anthropogenic noise, including from geophysical surveys, is known to cause cessation in vocalization, habitat displacement, and injury and sometimes death in fish (McCauley et al., 2003; Slotte et al., 2004; Fewtrell and McCauley 2012), cephalopods (André et al., 2011), and invertebrates (Day et al., 2017). Some studies also found negative impacts to catch rates during or after airgun surveys (Løkkeborg and Vold Soldal 1993; Engås et al., 1996). Other studies, however, have not found impacts to fish (Peña et al., 2013)—which could be due to a number of factors such as habituation to airgun noise and/or fidelity to feeding and/or current patterns.

Based on current literature, the most likely impact to prey from airgun surveys is temporary avoidance of habitat. Surveys using towed airgun arrays move through an area relatively quickly, limiting exposure to multiple impulsive sounds. In all cases, sound levels would return to ambient once a survey ends and the noise source is shut down. When exposure to sound ends, behavioral and/or physiological responses are expected to end relatively quickly (McCauley et al., 2000b). As described in the notice of proposed IHAs, due to the transient nature of the surveys and the prescribed mitigation, any other impacts to prey are not expected to be permanent or adverse.

In addition to the review and discussion of impacts to prey considered in both BOEM's PEIS and the notice of proposed IHAs, we reviewed new scientific literature since publication of these two documents to review the potential effects from airgun surveys on marine mammal prey. Major studies include the following: Streever et al. (2016) documented a general decline in fish catches during airgun surveys (although catches closest to the sound source showed declines, those further away showed increases, suggesting general displacement); Paxton et al. (2017) documented noise from an airgun survey along the inner continental shelf of North Carolina, where noise exceeded 170 dB re 1 μPa peak on two temperate reefs 0.7 and 6.5 km from the survey ship path; the authors documented declines in fish abundance during surveys. McCauley et al. (2017) documented that zooplankton densities decreased in net tows by 64% within an hour of airgun exposure, and caused a two-to-threefold increase in dead adult and larval zooplankton.

While we recognize that these studies show impacts to potential prey species for marine mammals, or in the case of McCauley et al. (2017), support food chains, it is difficult to draw direct conclusions from these studies regarding how the five surveys will directly and indirectly affect prey. These studies were conducted over varied geographic areas, time periods, environmental conditions, and survey dynamics, and indicate the need for further study regarding these issues.

Acoustic Habitat—As described in Section 3.1.2, the acoustic soundscape comprises an important component of marine mammal habitat. Animals produce sound for, or listen for sounds produced by conspecifics (communication during feeding, mating, and other social activities), other animals (finding prey or avoiding predators), and the physical environment

(finding suitable habitats, navigating). Baseline information on the acoustic soundscape and general ambient sound levels within the AOI are not well defined and vary across spatiotemporal scales, but it can be reasonably expected that surveys will increase acoustic energy into the localized environment. The low-frequency sounds produced by airguns can propagate across large distances in the water column, with distance and speed depending on a range of conditions such as salinity, bottom type, temperature, etc. (Hildebrand, 2009). Airgun signals have been detectable at great distances from their source. In one study, Nieukirk et al. (2012) observed that airgun sounds were detected at the Mid-Atlantic Ridge almost 4,000 km away from their source. They note, however, that hydrophones were located in the deep sound channel, where conditions are more favorable for attenuation (Nieukirk et al., 2012). Studies in other areas documented that airgun surveys increased background noise by 30-45 dB within a kilometer of activity, by 10-25 dB within 15 km of activity, and by a few dB at 128 km (Guerra et al., 2011).

As noted in Sections 1.5.2 and 4.2.2, sound field modeling was conducted by BOEM. While this modeling provides insight into assessing marine mammal exposure to received sound levels at certain distances (see Section 4.1.3), it does not estimate increases in ambient sound levels in the AOI. Given that environmental and physical conditions (e.g., weather, currents, bottom-type) impact propagation and that specific timing of the surveys in specific locations is unknown, it is not possible to preemptively model the soundscape in the AOI from the proposed surveys. However, given the aforementioned studies and other literature, it is expected that the geophysical surveys by the five companies will increase the loudness of the ambient acoustic environment in the AOI, in the areas and times immediately surrounding the five surveys.

As described previously, the prescribed time-area restrictions are also intended to protect important habitat from increases in noise (see Table 4 and Table 9). This includes the seasonal NARW closure extending for 90 km from the coast from November to April (or comparable protection is achieved through implementation of a NMFS-approved mitigation and monitoring plan at distances between 47-80 km offshore), which protects right whale critical habitat and encompasses SMAs, as described in Chapter 3 of this EA. This closure protects right whales during migration and calving and minimizes impacts to the acoustic environment in these areas. In addition to this closure, Areas #1-4 also minimize impacts to acoustic habitat within important habitat areas—particularly deepwater canyons that are vital habitat for sperm whales and beaked whales.

North Atlantic right whale critical habitat—As described in Section 3.2.2, NMFS designated critical habitat for NARW in southeastern U.S. Atlantic waters. However, NMFS is not allowing companies to survey within 90 km of the coast (which encompasses right whale critical habitat and SMAs) from November to April (or we require that comparable protection is achieved through implementation of a NMFS-approved mitigation and monitoring plan at distances between 47-80 km offshore), when right whales use this habitat for calving and migration. Furthermore, vessel operators must also observe a 10 km buffer around all DMAs established for right whales, which is sufficient to buffer for received sound levels exceeding the 160 dB rms Level B harassment threshold under a variety of modeled conditions (e.g., different seasons, depths, bottom types) (BOEM, 2014a). Therefore, no acoustic or other impacts are expected to NARW critical habitat.

As mentioned above, effects from increases in acoustic noise on habitat are not expected to affect physical habitat itself (e.g., bottom habitat or certain geographic features). Furthermore, it is not anticipated that these surveys will increase contaminants into the surrounding marine

environment that would have an effect on habitat. Instead, this proposed activity involves vessels running tracklines with towed airguns, causing increases in sound levels in the marine environment. Thus, the primary means for marine mammal habitat to be affected is through impacts to their "acoustic habitat." Effects to acoustic habitat and the marine soundscape, however, are expected to be relatively temporary and localized from each survey. This is due to the limited duration of surveys (<365 days each), multiple time-area restrictions throughout the AOI (e.g., temporal closures to Areas #1-4, expanded buffer zones off the coast, etc.; see Table 4), and the transient nature of survey vessels, which will be traversing throughout a broad area of the Atlantic (from Delaware to Cape Canaveral, FL out to 350 nmi). Vessels will be transiting along survey tracklines, and not remaining in specific areas for set lengths of time. Furthermore, though neither NMFS nor BOEM are requiring that the five companies maintain specific geographic distances between surveys, companies typically maintain some separation distance between surveys. Therefore, though there are potentially five ongoing surveys, it is expected that they will be occurring at different times and geographic areas throughout the AOI and not have long-lasting impacts on acoustic habitat. Consideration of this synthesis of information on habitat impacts are incorporated later in this chapter.

4.4.6 Aggregate Impacts of Airgun Surveys

Table 10 below shows aggregate Level A and Level B harassment takes across all five surveys for which NMFS is issuing IHAs, with comparison to all exposures modeled by BOEM for airgun surveys throughout the AOI over a nine-year period. Note that the PEIS additionally considered acoustic exposures expected to occur as a result of other types of G&G surveys; these are not included in BOEM's aggregate totals below. In the PEIS, BOEM estimated injurious exposure using both the Southall et al. (2007) criteria and the historical 180 dB rms threshold (Tables E-4 and E-5, respectively, in Appendix E of BOEM's PEIS). Below, we report the results of the analysis using the Southall et al. (2007) criteria for low-frequency cetaceans (i.e., all mysticetes) and the results of the analysis using the historical threshold for mid- and high-frequency cetaceans (i.e., all other species). Our analysis of the potential for auditory injury, on the basis of the revised criteria and weighting functions described in NMFS (2018) indicate that low-frequency cetaceans are most susceptible to auditory injury due to exposure to airgun noise as a result of cumulative sound exposure (similar to the Southall criteria), whereas the other hearing groups are most susceptible to injury on the basis of instantaneous exposure to peak pressure levels (analogous to the historical 180-dB rms criterion). Acoustic exposure expected to result in disruption of behavioral patterns is assessed against the 160 dB rms criterion, as shown in Table E-6 in Appendix E of BOEM's PEIS. When comparing NMFS's aggregate takes to the aggregate modeled exposures for airgun surveys from BOEM's PEIS, we see that BOEM's modeled exposure estimates—which informed BOEM's conclusion of "minor to moderate" (see 4.1.1 in this EA) impacts resulting to marine mammals from active acoustic sound sources—are substantially higher for most species (one exception being the minke whale).

NMFS recognizes that take numbers in the IHAs cannot be directly compared to acoustic exposures evaluated in BOEM's PEIS, in part because BOEM's analysis was developed using different density data and a representative airgun array (versus actual proposed arrays as described in the applications). However, it is still helpful to compare these numbers in demonstrating that NMFS's authorizations result in much lower levels of aggregate impact than were evaluated by BOEM. Even with a much wider scope of activities considered, as well as a much longer temporal scale over which impacts could occur, BOEM's PEIS evaluated impacts to marine mammals at a maximum level of "moderate," despite requiring substantially less stringent mitigation than is required by NMFS.

Table 10. NMFS Authorized Take Versus BOEM PEIS Estimated Exposures

Common name	Level A Takes: NMFS Authorized[1]	Level A: BOEM Estimated Exposures[2]	Level B Takes: NMFS Authorized	Level B Takes: BOEM Estimated Exposures[3]
North Atlantic right whale	0	0	19	954
Humpback whale	10	17	134	3,817
Minke whale	12	0	694	206
Bryde's whale	0	4	10	1,304
Sei whale	0	1	10	1,317
Fin whale	12	0	1,888	3,015
Blue whale	0	5	5	1,429
Sperm whale	0	977	7,524	95,708
Kogia spp.[5]	15	107	2,176	10,464
Beaked whales[6]	0	761	23,324	74,554
Northern bottlenose whale	0	1	20	90
Rough-toothed dolphin	0	89	819	8,763
Bottlenose dolphin	0	42,535	90,795	4,168,872
Clymene dolphin	0	1,406	11,891	137,795
Atlantic spotted dolphin	0	20,587	75,576	173,663
Pantropical spotted dolphin	0	3,044	4,821	298,327
Spinner dolphin	0	13	455	1,296
Striped dolphin	0	13,622	43,897	1,335,139
Common dolphin	0	22,747	85,817	2,229,473
Fraser's dolphin	0	1	1,020	126

Common name	Level A Takes: NMFS Authorized[1]	Level A: BOEM Estimated Exposures[2]	Level B Takes: NMFS Authorized	Level B Takes: BOEM Estimated Exposures[3]
Atlantic white-sided dolphin	0	31	240	3,075
Risso's dolphin	0	11,329	6,162	1,110,342
Melon-headed whale	0	17	250	1,664
Pygmy killer whale	0	15	30	1,458
False killer whale	0	19	140	1,874
Killer whale	0	13	35	1,252
Pilot whales[7]	0	18,989	17,338	1,861,079
Harbor porpoise	20	47	874	4,559

[1] NMFS evaluated potential takes by Level A harassment using BOEM's PEIS analysis, adjusted to account for the specific effort levels and array sizes of the five applicants, as well as by accounting for new technical guidance (NMFS, 2018). However, on the basis of the best available scientific information, NMFS does not believe that auditory injury is a reasonably likely outcome for mid-frequency cetaceans and.
[2] Values in this column represent the aggregate Level A harassment exposures for all airgun surveys, as shown in Tables E-4 and E-5 in BOEM's PEIS, representing the appropriate exposure results for the three hearing groups.
[3] Values in this column represent the aggregate Level B harassment exposures for all airgun surveys, as shown in Table E-6 in BOEM's PEIS.
[4] BOEM separately lists exposures for pygmy sperm whales and dwarf sperm whales. Values reflected here show combined estimates for both species.
[5] BOEM separately lists exposures for Sowerby's beaked whales, Blainville's beaked whales, Gervais' beaked whales, True's beaked whales, and Cuvier's beaked whales. Values reflected here show combined estimates for these species.
[6] BOEM separately lists exposures for short-finned and long-finned pilot whales. Values reflected here show combined estimates for both species.

We emphasize that take numbers alone are not enough information to adequately assess potential impacts to marine mammals. For example, for some of the species, there are contextual factors (such as mitigation or species distribution) that reduce concern over the level of actual exposure.

We also emphasize what these modeled take numbers do, and do not, suggest. As described in greater detail elsewhere, each enumerated take in the table above indicates that an instance of exposure above the associated threshold (i.e., a take) occurred to some individual for some amount of time within one day (could be seconds, minutes, or hours—but relative movement of vessels and animals suggests longer periods of time are less likely). On one hand, each of these exposures could occur to different individuals, which would mean that no individual was taken

by these activities more than one time within a year. Alternately, some individuals could be taken on multiple days—we believe this scenario is somewhat more likely, although the distances across which the individual surveys travel and the low probability that multiple surveys will be near each other in time and space suggest it is unlikely that single individuals would be taken over more than a handful of days, much less on many successive days. Also, assuming repeat exposures of the same individuals lessens the overall number of individual marine mammals taken.

Of the species with authorized take, seven are classified as low-frequency cetaceans (i.e., all mysticete species), 24 are classified as mid-frequency cetaceans (sperm whales, dolphins, toothed whales, beaked whales), and three are classified as high-frequency cetaceans (i.e., harbor porpoise and Kogia spp.) (see Figure 1). As shown here, it is primarily mid-frequency cetaceans that have the highest authorized takes (sperm whales, certain dolphins, beaked whales). It is important to note, however, that auditory injury is highly unlikely for this hearing group, as their generalized hearing range (150 Hz to 160 kHz) does not overlap with the predominantly low-frequency content of acoustic signals from airgun surveys, and they have a high threshold for the onset of auditory injury (Figure 1). Below, we provide a discussion for some of the species with the highest take numbers or for those that may be particularly sensitive to use of the acoustic source for each of the three functional hearing groups.

High-Frequency Cetaceans—High-frequency cetaceans are expected to be more sensitive to noise exposure, as evidenced by their lower thresholds for the onset of auditory injury (NMFS, 2018), as well as a large body of literature indicating greater behavioral sensitivity to noise exposure. Harbor porpoises and Kogia spp. are the only high-frequency cetaceans that could occur in the AOI. For harbor porpoises, NMFS expects their occurrence within the AOI to generally be unlikely, and if so, would only occur within the northern portion of the survey area (Waring et al., 2016; Roberts et al., 2016). For Kogia spp., there are several contextual factors expected to limit the indicated takes from having meaningful impacts on rates of recruitment or survival. First, recent survey and stranding data suggest increasing Kogia spp. abundance (NMFS, 2011; 2013a; Waring et al., 2007; 2013). Furthermore, the time-area closures are expected to provide benefits for these species, and shutdowns for Kogia spp. at extended distance provide an additional protective measure. Finally, NMFS expects these species to have an ability to perform important behavior in alternate areas in the AOI, as they are expected to occur broadly over the continental slope (e.g., Bloodworth and Odell, 2008).

Mid-Frequency Cetaceans—These species—delphinids, beaked whales, and sperm whales—are those with the highest magnitude of take in the AOI. Below is a discussion on contextual factors based on their life history, mitigation and monitoring, and related factors.

Bottlenose dolphins—While a high number takes for bottlenose dolphins are authorized, these takes do not factor in the 30 km coastal restriction or other mitigation, which should minimize to the extent possible any impacts on coastal stocks of bottlenose dolphin. The offshore stock of bottlenose dolphins are expected to benefit from the Area #4 closure (Roberts et al., 2016). Offshore bottlenose dolphins also have a wide distribution over continental slope and pelagic waters in the AOI (e.g., Waring et al., 2016; Roberts et al., 2016), which increases the possibility that bottlenose dolphins will be able to find other viable habitat if temporarily displaced.

Furthermore, literature shows that bottlenose dolphins are able to reasonably compensate from exposure to airguns. In one study that measured hearing thresholds in three captive bottlenose

dolphins before and after exposure to ten pulses produced by an airgun (highest exposures at peak SPLs from 196 to 210 dB and cumulative (unweighted) SELs from 193-195 dB), no substantial TTS was observed in the dolphins (Finneran et al. 2015). In addition, behavioral reactions were observed that indicated that animals can learn behaviors that effectively mitigate noise exposures (although exposure patterns must be learned, which is less likely in wild animals than for the captive animals considered in the study). The authors note that the failure to induce more significant auditory effects was likely due to the intermittent nature of exposure, the relatively low peak pressure produced by the acoustic source, and the low-frequency energy in airgun pulses as compared with the frequency range of best sensitivity for dolphins and other mid-frequency cetaceans. Between the coastal restriction, subsidiary benefits in Area #4 closure, the bottlenose dolphin's broad distribution over pelagic waters in the AOI, and lack of significant auditory effects in Finneran et al. (2015), NMFS does not think bottlenose dolphins will experience effects from this activity that impact their recruitment or survival.

Other delphinid species—Many of the delphinid species have medium to high magnitude of take (e.g., striped dolphins, Risso's dolphins, rough-toothed dolphins, Atlantic spotted dolphins). However, these species do not have significant issues related to population status or context. Throughout the AOI, many oceanic delphinid species are generally more associated with dynamic oceanographic characteristics rather than static physical features, and those species with substantial distribution to the north of the survey area (e.g., common dolphin) would likely be little affected at the population level by the proposed activity. Further, NMFS also finds that for species with high distributions associated with shelf break waters north of Cape Hatteras (e.g., common dolphins and Risso's dolphins), the time-area closures will also have subsidiary benefits to these species. Thus, given their broad distribution, population status, and lack of affinity to specific habitat areas, NMFS believes they have generally high compensatory ability for any behavioral disruption that may occur throughout the AOI.

Additionally, Atlantic spotted dolphins also regularly occur in waters throughout the AOI, including in continental shelf waters south of Cape Hatteras and in continental shelf edge and continental slope waters north of this region (Payne et al., 1984; Mullin and Fulling, 2003), largely occupying the continental shelf region from southern Virginia to Florida. The Atlantic spotted dolphin has a bifurcated distribution, with substantial numbers expected on shelf waters to the south as well as in more oceanic waters to the north. The portion of the population found in shelf waters will be relatively unaffected by the planned surveys, as most survey effort is planned for deeper waters. NMFS finds their broad distribution and stable population status would contribute to an ability to reasonably recover or temporarily find other suitable habitat during exposure.

Beaked whales—Beaked whales are considered here as a guild, and include Cuvier's, Blainville's, Gervais, Sowerby's, and True's beaked whales. Beaked whales are considered to be particularly behaviorally sensitive to acoustic exposure (e.g., Tyack et al., 2011; DeRuiter et al., 2013; Stimpert et al., 2014; Miller et al., 2015). They are deep divers and exhibit an affinity for steep bathymetric features where mesopelagic squid and other prey persist (e.g., Madsen et al., 2014; MacLeod and D'Amico, 2006; Moors-Murphy, 2014). They are known to show site fidelity to Cape Hatteras year-round. This residency raises concern that displacement could affect foraging rates, reproduction, or health, or that the species could elect to remain in the area and face greater exposure to a sound source (Forney et al., 2017). Considering these factors collectively, NMFS has given particular focus to beaked whales in required mitigation. The year-round closure duration of Areas # 1-3 are intentionally designed to address the residency patterns

for beaked whales, with the time-area closure for Area #4 expected to provide benefits from January through March. NMFS is also requiring shutdowns at extended distance given their acoustic sensitivities.

Pilot whales—Pilot whales are treated here as a genus, including short-finned and long-finned pilot whales. Like many species discussed here, pilot whales are distributed primarily along the continental shelf edge, occupying areas of high relief or submerged banks, and are also associated with the Gulf Stream wall and thermal fronts along the shelf edge (Waring et al., 2016). High pilot whale density was predicted throughout the year at an area of the shelf break and continental slope north of where the Gulf Stream separates from the shelf at Cape Hatteras. Sightings were reported in this vicinity in nearly every month of the year (Roberts et al., 2015c). As a result of the medium to high magnitude of take, residency along the shelf break near Cape Hatteras, and other contextual factors, Area #4 is expected to be particularly beneficial to pilot whales.

Sperm whales—Sperm whales are commonly associated with submarine canyons (Moors-Murphy, 2014). Specifically in this region, they have been found to be associated with canyons (Whitehead et al., 1992), the north wall of the Gulf Stream (Waring et al., 1993), and temperature fronts and warm-core eddies (Waring et al., 2001; Griffin, 1999). Sperm whales are considered acoustically sensitive to airgun noise. One study in the Gulf of Mexico found that upon exposure to airgun noise at a received level in the range of 140-160 dB at distance of 7-13 km, sperm whales did not show horizontal avoidance behavior at the water's surface, but displayed decreased buzz rates, indicating that their foraging may have been impacted (Miller et al., 2009). However, more data is needed to understand the potential impacts of these findings (Miller et al., 2009).

Given evidence for changes in foraging efficiency (Miller et al., 2009), the species status, and the relatively high magnitude of predicted takes, we have given special consideration to mitigation focused on sperm whales and have defined time-area restrictions specifically designed to reduce such impacts on sperm whales in areas expected to be of greatest importance (i.e., slope habitat and deepwater canyons). NMFS has designed Area #4, particularly the temporal component of it (Stanistreet et al., 2018), to address occurrence and distribution of highest density in the AOI. Given the canyons that Areas #2 and 3 protect, these year-round closures are also expected to be particularly beneficial for sperm whales. Finally, sperm whales resting in social aggregations at the surface, or at the surface with calves, would be protected by NMFS's mitigation requirements.

Low-Frequency Cetaceans—Three mysticete species—humpback, minke, and fin whales—have low to high magnitude of take, depending on the species. As discussed in the notice of proposed IHAs, spatial extent for humpback whales in the AOI is expected to be low for most of the year, but likely moderate during winter when humpbacks are migrating from the calving grounds, while spatial extent for minke whales is likely low in summer, moderate in spring and fall, and high in winter. While we consider spatial extent to be low year-round for fin whales, their range overlap with the AOI does vary across the seasons and is closer to moderate in winter and spring. Several mitigation measures, such as shutdowns for adults with a calf and other closure areas, viewed in concert with a broad distribution over the activity area, help protect vital cow-calf communication and other biological functioning. The closures also offer subsidiary benefits to waters near the shelf break and canyon areas that may be beneficial to these species.

In considering the potential effects of the proposed action, particular concern was given to the NARW, given their conservation status, overlap of critical habitat with the survey area, and acoustic sensitivity. The most recent SAR estimates NARW abundance at 451 individuals, and there is currently a declared Unusual Mortality Event (UME) with 20 deaths since June 2017. Causes behind the UME deaths are unknown at the time this EA was prepared. To-date, the UME is largely occurring outside of the AOI. In recognition of what appears to be a decline in population size and the significant stressors impacting right whales (e.g., entanglement, ship strike), we reviewed new literature demonstrating increased right whale presence in waters of the Mid- and South Atlantic outside of the primary areas they are historically known to occupy at certain times of the year (Oedekoven et al., 2015; Salisbury et al., 2016; Davis et al., 2017, Roberts et al., 2017).

Based on the above factors and use of the best available density information (Roberts et al., 2017), NMFS designed mitigation expected to be effective in avoiding impacts to NARW important habitats and in minimizing to the maximum extent practicable any impacts to individual NARW. NMFS is not allowing any survey activity from November to April within 90 km of the coast to avoid impacts to important migratory and calving habitat (or we require that comparable protection is achieved through implementation of a NMFS-approved mitigation and monitoring plan at distances between 47-80 km offshore). NMFS also requires cessation of survey activity within 10 km of DMAs, should they be created. Finally, NMFS is requiring shutdowns of the acoustic source upon observation of a right whale at extended distance. Therefore, given the extent and duration of closures for right whales, combined with the limited duration and broad geographic extent of the surveys, NMFS has minimized possible impacts to right whales and believes the possibility of significant impacts resulting from the proposed activity to be unlikely.

4.4.7 Conclusion

NMFS recognizes that the spatial extent and concurrent nature of five geophysical surveys presents the potential for physiological and/or behavioral impacts to marine mammals in the AOI. NMFS also acknowledges that combined take authorizations for some species are moderate to high in terms of numbers (see proposed IHAs for further detail). However, NMFS emphasizes that assessing impacts to species cannot be done on the basis of quantified “takes” alone; rather, NMFS considers the likely efficacy of mitigation in minimizing the significance of any impacts to individuals or the populations as a whole, and considers relevant contextual factors that help explain whether the estimated takes would be likely to result in significant impacts. NMFS has designed and required a unique suite of mitigation measures—including several time-area closures, area restrictions, and shutdown procedures—that reflect the best available scientific information and restrict survey effort within the most vital habitat areas of the AOI. As a result of the broad spatial extent of the AOI and the transitory, temporary nature of potential impacts at any given location, coupled with NMFS’s required mitigation, NMFS’s action is not expected to cause direct, indirect or cumulative adverse impacts on marine mammal recruitment or survival. Thus while it anticipates short-term direct adverse minor to moderate effects to individuals as a result of Level A and Level B harassment, it predicts that impacts to affected marine mammal populations will be negligible to moderate overall (see Section 4.2 for description of these terms).

Specifically, for those species rarely occurring in the AOI, NMFS has proposed to authorize nominal take by Level B harassment only. For these species—sei, Bryde’s, and blue whales; the northern bottlenose whale; killer whale, false killer whale, pygmy killer whale, and melon-

headed whale; and spinner, Fraser's, and Atlantic white-sided dolphins—impacts to populations are expected to be negligible (as defined in 4.2). For most species, predicted numbers of takes by Level B harassment are moderate to high (with minimal additional takes by Level A harassment anticipated in some cases), but would not be expected to be severe. Therefore, for most species impacts to populations are expected to be minor. This group also includes the North Atlantic right whale, for which only a small number of takes by Level B harassment are anticipated, with no take by Level A harassment. In addition, we have adopted expanded mitigation requirements (both habitat-based and real-time) that are expected to minimize effects to right whales and their habitat to the extent possible. For most species, this combination of factors would result in an assignment of negligible; however, in recognition of the status of right whales, and the potential for impacts to baleen whales in general over larger spatial scales, we consider potential impacts to right whales as minor. For sperm whales and beaked whales, impacts to populations are expected to be moderate. This is a result of the combination of high numbers of take by Level B harassment in conjunction with some potential for severe impacts on localized scales for some individuals that are either temporarily displaced from preferred habitats or, alternatively, remain on those habitats and experience more severe disruption of behavioral patterns, but also in consideration of the moderating effect of the habitat-based mitigation designed to reduce impacts to these species.

4.5 Cumulative Effects

NEPA defines cumulative effects as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other actions" (40 CFR §1508.7). Cumulative impacts can result from individually minor but collectively significant actions that take place over a period of time. Past, present, and reasonably foreseeable impacts to marine mammal populations in the Mid-and South Atlantic include the following: geophysical surveys, climate change, military activity, marine pollution, disease, increased vessel traffic, and entanglement. These activities account for cumulative impacts to regional and global populations of marine mammals, many of which are a small fraction of their former abundance.

BOEM summarized the potential cumulative effects to marine mammals and their habitat within the AOI, and evaluated cumulative impacts as being "negligible to minor" (see Chapter 4.3.2.3 of BOEM's PEIS). NMFS has reviewed the best available scientific information and has prescribed mitigation accordingly in order to minimize potential impacts to marine mammal individuals and populations to the maximum extent practicable, as required by the MMPA. Furthermore, the five surveys are limited in time (i.e., approximately one year) and will be distributed over a wide geographic region. NMFS does not expect substantial physical overlap between the surveys given the spatial extent of the AOI (854,779 km^2). NMFS, having reviewed the potential cumulative impacts of the issuance of IHAs in association with five surveys—a much smaller scope and scale of activity compared with that considered in BOEM's PEIS—finds that the effects of issuing the five IHAs independently and collectively will not result in significant cumulative effects to marine mammals and their habitat.

Therefore, NMFS does not anticipate these activities resulting in significant impacts on the environment, either individually, or incrementally when considered in addition to other activities. BOEM's PEIS provides a comprehensive summary and review of cumulative impacts on many resources, including marine mammals; NMFS incorporates that by reference and summarizes those findings regarding activities affecting the marine mammals in the AOI here.

4.5.1 Past, Present, or Future Deep Penetration Airgun Survey Activities

Geophysical surveys for hydrocarbon exploration were conducted in the U.S. Mid- and South Atlantic Ocean between 1976 and 1983. Fifty-one wells were drilled in the Atlantic OCS between 1975 and 1984, including one well in the Mid-Atlantic OCS Planning Area and seven in the South Atlantic OCS Planning Area (BOEM, n.d.). One drillable prospect was identified in the early 1980s roughly 72 km northeast of Cape Hatteras, North Carolina in waters roughly 820 m deep (USDOI, MMS, 1998). Since the 1970s and 1980s, the only other geophysical surveys that have occurred in this area were conducted by the National Science Foundation for academic and research purposes (79 FR 38496, 79 FR 57512).

BOEM manages oil and gas development activity under the National OCS Oil and Gas Leasing Program, which establishes a schedule of oil and gas lease sales on the U.S. OCS. BOEM is working under the current five-year lease plan for 2017-2022, in which the U.S. Atlantic Ocean was excluded from oil and gas development. However, as directed by Executive Order 13795 (April 28, 2017) and Secretary's Order 3350 (May 1, 2017), BOEM has initiated the process to develop a new National OCS Program for 2019-2024, which would replace the 2017-2022 Program. BOEM published a Draft Proposed Program in January 2018. The AOI is included in the 2019-2024 Program, and NMFS anticipates that additional companies could apply for IHAs to conduct geophysical surveys if the finalized program allows for lease sales within the AOI. Other than this, there are no other known deep penetration airgun surveys scheduled to occur in the AOI at the time of these surveys and NMFS is not aware of future deep penetration airgun surveys outside of the five considered herein.

4.5.2 Climate Change

Global climate change could significantly affect marine resources in the Atlantic. Broadly, possible impacts include temperature and rainfall changes, rising sea levels, and changes to ocean conditions, such as ocean circulation patterns and storm frequency. These changes may affect marine ecosystems in the AOI by increasing the vertical stratification of the water column, shifting prey distribution, impacting competition, and generally impacting species' ranges (Richardson and Schoeman, 2004; Learmonth, et al., 2006). Such modifications could cause ecosystem regime shifts as the productivity of the regional ecosystem undergoes various changes related to nutrient inputs and coastal ocean processes (Doney et al., 2011; USFWS, 2011).

The potential impact of climate change on marine mammals is receiving increasing attention in scientific literature, but many knowledge gaps remain (Silber et al., 2017). To-date, efforts have mostly focused on statistical habitat models, which are useful for managing species on short timescales but more challenging to apply across broad habitat and decadal scales (Silber et al., 2017). Significant uncertainties exist on how climate change will impact marine mammals, but it is expected that range shifts (e.g., in response to shifting prey distribution or expansion of breeding grounds), timing of important biological activities (e.g., breeding), regional abundance, or other impacts could occur (e.g. Learmonth et al., 2006, Laidre et al., 2015; Runge et al., 2015). Impacts of climate change on marine mammals in the Arctic are becoming apparent (e.g., Kovacs et al., 2011; Laidre et al., 2008), but potential future impacts to marine mammals in the Atlantic are more poorly understood. While some effects are anticipated, the precise impacts of global climate change on the AOI, whether positive or negative, cannot currently be predicted.

4.5.3 Marine Pollution

Marine mammals are exposed to contaminants via prey consumption, surrounding water quality, and air quality. Point and non-point source pollutants from coastal runoff, offshore mineral and gravel mining, at-sea disposal of dredged materials and sewage effluent, marine debris, and organic compounds from aquaculture are all threats to marine mammals in the project area. The long-term impacts of these pollutants, however, are difficult to measure. Persistent organic pollutants tend to bioaccumulate through the food chain; therefore, the chronic exposure of persistent organic pollutants in the environment is perhaps of the most concern to high trophic level predators.

The applicants' activities associated with geophysical surveys are not expected to cause increased exposure of persistent organic pollutants to marine mammals in the AOI vicinity, due to the nature of the activity (e.g., firing of airguns). Additional input of vessel traffic is considered minimal, and NMFS does not consider contaminants or pollutants from survey vessels to have any additive effect different from current vessels transiting through the AOI. As mentioned in Chapter 4.3.2, accidentally spilled diesel fuel from a vessel could pose a potential threat to marine mammals, but NMFS finds the likelihood of that occurring extremely small.

In recent years, some attention has been paid to consideration of ocean noise as a form of marine pollution under the United Nations Convention on the Law of the Sea given the definition of "pollution of the marine environment" on Article 1(4) (Firestone and Jarvis, 2007). Additionally, the Convention on Biological Diversity and Convention on Migratory Species currently classify ocean noise as a pollutant (Nowacek et al., 2015).

4.5.4 Disease

Disease is common in many marine mammal populations and has been responsible for major die-offs worldwide, but such events are usually relatively short-lived. As described in BOEM's PEIS, bottlenose dolphins in the AOI experienced elevated strandings from 2013 to 2015, resulting in a UME event attributable to cetacean morbillivirus (NMFS, 2015). Morbillivirus can lead to death or secondary infections, like skin lesions, pneumonia, brain infections, and other impacts. This UME has ended, but morbillivirus could reappear as a potential risk and it can spread to cetaceans through the eye, mouth, stomach, skin wounds, or sexual contact (NMFS, 2014). There are no other known diseases threatening marine mammals in the AOI at this time. Issuance of IHAs will not result in any additive effects or spreading of disease.

4.5.5 Increased Vessel Traffic

The applicants' proposed activities would not result in a cumulative increase in vessel traffic beyond any direct impacts associated with the surveys by the five companies. Each applicant intends to use a minimum of one source and one chase vessel. Please see applications for more information: *www.fisheries.noaa.gov/action/incidental-take-authorization-oil-and-gas-industry-geophysical-survey-activity-atlantic*.

As discussed in the notice of proposed IHAs, vessel noise is considered a generally low-frequency, non-pulsed sound. Since the vessels will be widely dispersed in space and time, we consider vessel traffic associated with the surveys to result in a negligible increase in vessel noise. Otherwise, ship traffic and associated ocean noise is expected to remain at levels existing before issuance of these IHAs.

4.5.6 Commercial Fishing

As described in Chapter 3, numerous commercial fisheries operate within the AOI, including pelagic longlines, trawls (surface, mid-water, or bottom), gillnets, purse seines, hook-and-lines,

pound nets, and more. Several ports within the AOI have some of the highest commercial fishing revenue in the U.S., and dozens of fishing communities exist along the coast (BOEM, 2014a). As of 2016, commercial landings within the AOI totaled over roughly 250,096 metric tons (NMFS, 2018).

In recent decades, NMFS has created multiple Take Reduction Plans for some fisheries that result in substantial bycatch of marine mammals. These include the Harbor Porpoise Take Reduction Plan to reduce interaction between harbor porpoises and commercial gillnet gear (here relevant in the Mid-Atlantic); the Atlantic Trawl Gear Take Reduction Team, which addresses bycatch of common dolphins and white-sided dolphins in Atlantic trawl fisheries, and the Pelagic Longline Take Reduction Plan, which addresses incidental mortality and serious injury for pilot whales and Risso's dolphins from pelagic longline fisheries. NMFS also implemented an Atlantic Large Whale Take Reduction Plan (ALWTRP) in 1997 to reduce injuries and deaths of large whales due to incidental entanglement in fishing gear.

The NARW in particular is severely impacted through entanglement in fishing gear, primarily in lines associated with trap and pot gear. The ALWTRP was developed to address these issues, with a group consisting of fishermen, scientists, and state and federal officials providing advise towards requirements for commercial fishermen to use certain gear types that are less harmful to NARW, and in establishing areas where fishing cannot take place during certain times when NARW are present. NMFS and the ALWTRP are currently developing management measures to reduce the number of buoy lines in the water column in an effort to further reduce the risk of entanglement in fishing gear. For the period 2012 through 2016, the minimum rate of annual human-caused mortality and serious injury to right whales from incidental fishery entanglement was 5.15 per year. However, since the beginning of the ongoing NARW UME, there has been a total of 20 confirmed dead stranded whales. Full necropsy examination results are currently available for seven of these that occurred in Canada. Results indicate that two whales died from entanglement in fishing gear. In response, the Canadian government has enacted fishery closures to help reduce future entanglements and has modified fixed gear fisheries.

4.6 Conclusion

In developing this document, as well as through development of the IHAs and formal Section 7 consultation under the ESA, including public comments received on the proposed IHAs, NMFS has reviewed the best available scientific information, in concert with information provided by the applicants and in BOEM's PEIS, to assess direct, indirect, and cumulative impacts to marine mammals and their habitat in the AOI. We acknowledge that the authorized incidental take could potentially result in direct short-term and long-term adverse impacts to individual marine mammals, including TS, masking, behavioral response, temporary displacement, or stress. We also recognize that this activity could have the same types of physical, behavioral, or masking impacts on marine mammal prey, though temporary displacement is the more likely outcome given the nature of the geophysical survey operations. Furthermore, we also recognize that Level B harassment of marine mammals is moderate to high in terms of numbers for some species (as described in our notice of proposed IHAs). As stated above, take estimates are not the sole basis for NMFS's assessment of the overall intensity of the impact. NMFS's assessment is focused on whether the predicted level of take, when considered in context, will have a meaningful biological consequence at a species or population level. NMFS, therefore, has assessed and integrated other contextual factors, as described throughout—including the required mitigation measures—in determining the overall impact of issuance of the five IHAs on the human environment. For marine mammals, these include: species' life history and biology, distribution,

abundance, and status of the stock; mitigation and monitoring; characteristics of the surveys and sound sources; and components of the AOI. When the level of take is considered in context, it is NMFS's scientific judgment that most affected marine mammal species, including those listed under the ESA, will experience no population-level effects (as described in Section 4.2 of this EA as a "minor" level of effects). The level of effects for beaked whales and sperm whales is deemed "moderate;" however, as described in Section 4.2, although individual animals may be meaningfully impacted, no effects are expected to annual rates of recruitment or survival and meaningful effects would not be expected at the population level. The basis for our conclusion is discussed above and explained further here.

Geophysical surveys release intermittent, temporary sounds into the marine environment as they transit along a survey track, meaning the surveys do not remain in place and fire airguns within a continuous area. In all cases, it is expected that sound levels would return to previous ambient levels once the acoustic source moves a certain distance from the area, or the surveys cease. When exposure to sound ends, behavioral and/or physiological responses are expected to end relatively quickly (e.g., within hours to days) (McCauley et al., 2000b). They will also be transiting across an extremely broad area in the Mid and South Atlantic—854,779 km²—without expected overlap. Furthermore, it is unlikely that they will all occur at the same time, as some will occur for less than six months. In other words, we would not expect the duration of a sound source to be greater than moderate and intermittent in any given area.

Due to the required mitigation by NMFS, surveys have also been excluded from portions of the total AOI deemed to result in the greatest benefit to marine mammals. Surveys cannot operate within 30 km of the coast year-round, within 90 km of the coast from November to April (or we require that comparable protection is achieved through implementation of a NMFS-approved mitigation and monitoring plan at distances between 47-80 km offshore), within three different closures around deepwater canyon areas, and from January to March along the shelf break near Cape Hatteras. These restrictions will not only reduce the overall numbers of take but, more importantly, will eliminate or minimize impacts to marine mammals in the areas most important to them for feeding, breeding and other important functions. Therefore, these measures are expected to meaningfully reduce the severity of the takes that do occur by limiting impacts that could reduce reproductive success or survivorship. For example, reducing interference with feeding reduces the likelihood of energetic impacts that could impact individual fitness, and minimizing interference with social communication reduces likelihood of impacts to breeding success. While many affected species in the AOI feed and breed in accordance with dynamic oceanographic features, certain species are more dependent on static bathymetric features and may be resident in certain areas. Our mitigation is specifically designed to afford protection to those species we believe to be most reliant on specific areas (as well as those species deemed most vulnerable, such as the NARW). In summary, the most important habitat areas for marine mammals in the AOI are substantially protected, and acoustic exposure for certain animals within closest range to the sound source will be minimized due to required shutdowns. In some instances, detection of species at extended range will trigger shutdowns of the acoustic source, further minimizing effects of acoustic exposure.

NMFS recognizes concern over the fact that there will be five 2D seismic surveys being conducted in the same geographic area, which has not previously been heavily surveyed. However, NMFS finds that when the required mitigation and monitoring is considered in combination with the large spatial extent over which the activities are spread across comparatively short durations (less than one year), the potential impacts are both temporary and

relatively minor. Therefore, NMFS does not expect aggregate impacts from the five surveys to marine mammals to affect rates of recruitment or survival, either alone or in combination with other past, present, or ongoing activities in the AOI (e.g., fisheries, marine pollution).

Based on the description and analysis of NMFS's activity provided in this EA, in the notice of proposed IHAs, and in BOEM's PEIS, NMFS finds that issuing individual IHAs to the five companies authorizing take of marine mammals will not result in significant direct, indirect, or cumulative impacts to the human environment as we anticipate no more than minor adverse effects at the population level. We do not expect the applicants' activities to affect annual rates of recruitment or survival of marine mammal species or stocks in the AOI. We expect impacts to marine mammals to be temporary and localized around the active source vessels, remain within the bounds of the established take authorizations (Table 7), and that the required mitigation and monitoring provide substantial protection to marine mammals and their habitat.

CHAPTER 5 LIST OF PREPARERS

Prepared By:

Office of Protected Resources
National Marine Fisheries Service

CHAPTER 6 LITERATURE CITED

André, M., Solé, M., Lenoir, M., Durfort, M., Quero, C., Mas, et al. 2011. Low-frequency sounds induce acoustic trauma in cephalopods. Frontiers in Ecology and the Environment 9(9):489-493.

Andrew, R.K., Howe, B.M., Mercer, J.A. and M.A. Dzieciuch. 2002. Ocean ambient sound: comparing the 1960s with the 1990s for a receiver off the California coast. Acoustics Research Letters Online 3(2): 65-70.

Archer, F.I., S.L. Mesnick, and A.C. Allen. 2010. Variation and predictors of vessel response behavior in a tropical dolphin community. NOAA Technical Memorandum NMFS-SWFSC-457, National Marine Fisheries Service: 60.

Baird, R.W., D.L. Webster, Z. Swaim, H.J. Foley, D.B. Anderson, and A.J. Read. 2015. Spatial use by Cuvier's beaked whales, short-finned pilot whales, common bottlenose dolphins, and short-beaked common dolphins satellite tagged off Cape Hatteras, North Carolina, in 2014. Prepared by HDR, Inc. for Department of the Navy: 42.

Barkaszi, M.J., M. Butler, R. Compton, A. Unietis, and B. Bennet. 2012. Seismic survey mitigation measures and marine mammal observer reports. OCS Study BOEM 2012-015, Bureau of Ocean Energy Management: 51.

Barlow, J. 1999. Trackline detection probability for long-diving whales. Pages 209-221 in G.W. Garner, S.C. Amstrup, J.L. Laake, B.F.J. Manly, L.L. McDonald, and D.G. Robertson, eds. Marine Mammal Survey and Assessment Methods. A. A. Balkema, Rotterdam.

Barlow, J. and K.A. Forney. 2007. Abundance and population density of cetaceans in the California Current ecosystem. Fishery Bulletin 105 (4):509-526.

Baumgartner, M.F., Wenzel, F.W., Lysiak, N.S. and M.R. Patrician. 2017. North Atlantic right whale foraging ecology and its role in human-caused mortality. Marine Ecology Progress Series, 581:165-181.

Blackwell, S.B., Nations, C.S., McDonald, T.L., Greene, C.R., Thode, A.M., Guerra, M. and A.M. Macrander. 2013. Effects of airgun sounds on bowhead whale calling rates in the Alaskan Beaufort Sea. Marine Mammal Science 29(4): E342–E365.

Blackwell, S.B., Nations, C.S., McDonald, T.L. Thode, A.M., Mathias, D. and K.H. Kim, et al. 2015. Effects of airgun sounds on bowhead whale calling rates: Evidence for two behavioral thresholds. PLoS ONE 10 (6): e0125720.

Blake, J.A. and J.F. Grassle. 1994. Benthic community structure on the U.S. South Atlantic slope off the Carolinas: Spatial heterogeneity in a current-dominated system. Deep-Sea Research II 41(4-6):835-874.

Bloodworth, B.E. and D.K. Odell. 2008. Kogia breviceps (Cetacea kogiidae). Mammal Species 819:1-12.

BOEM (Bureau of Ocean Energy Management). 2014a. Atlantic OCS proposed geological and geophysical activities: Mid-Atlantic and South Atlantic Planning Areas. Final Programmatic Environmental Impact Statement. OCS EIS/EA BOEM 2014-001, Bureau of Ocean Energy Management: 2,158.

BOEM. 2014b. Record of Decision: Atlantic OCS proposed geological and geophysical activities Mid-Atlantic and South Atlantic Planning Areas, Final Programmatic Environmental Impact Statement (PEIS). Bureau of Ocean Energy Management: 12.

BOEM. 2017. Gulf of Mexico OCS proposed geological and geophysical activities: Western, Central, and Eastern Planning Areas. Final Programmatic Environmental Impact Statement. Volume I. OCS EIS/EA BOEM 2017-051, Bureau of Ocean Energy Management: 792.

BOEM. n.d. Atlantic Oil and Gas Information. Accessed October 2017. https://www.boem.gov/Atlantic-Oil-and-Gas-Information/

Boesch, D.F. 1979. Benthic ecological studies. Chapter 6. In: Middle Atlantic Outer Continental Shelf environmental studies, Volume IIB. Chemical and biological benchmark studies. Contract No. AA550-CT6-62. Prepared by the Virginia Institute of Marine Science for the Bureau of Land Management, Washington, D.C.: 165.

Budelmann, B.U., and R. Williamson. 1994. Directional sensitivity of hair cell afferents in the Octopus statocyst. Journal of Experimental Biology 187 (1):245-259.

Carr, S.A., I. Gaboury, M. Laurinolli, A.O. MacGillivray, S.P. Turner, M. Zykov, et al. 2011. Acoustic Modeling Report. Appendix B *in* Marine seismic research funded by the National Science Foundation or conducted by the U.S. Geological Survey: Final Programmatic Environmental Impact Statement/Overseas Environmental Impact Statement. Prepared by JASCO Research, Marine Acoustics, Inc., and LGL for TEC Inc. under contract to National Science Foundation and U.S. Geological Survey: 111.

Castellote, M., C. Clark and M.O. Lammers. 2012. Acoustic and behavioral changes by fin whales (*Balaenoptera physalus*) in response to shipping and airgun noise. Biological Conservation 147: 115-122.

Cerchio, S., S. Strindberg, T. Collins, C. Bennett and H. Rosenbaum. 2014. Seismic surveys negatively affect humpback whale singing activity off northern Angola. PLoS ONE 9 (3): e86464.

Clark, C.W., W.T. Ellison, B.L. Southall, L. Hatch, S.M. Van Parijs, A. Frankel, and D. Ponirakis. 2009. Acoustic masking in marine ecosystems: Intuitions, analysis, and implication. Marine Ecology Progress Series 395:201-222.

Clarke, M.R. 1980. Cephalopoda in the diet of sperm whales of the Southern Hemisphere and their bearing on sperm whale biology. Discovery Reports 37:1–324.

Coleman, F.C., Figueira, W.F., Ueland, J.S. and L.B. Crowder. 2004. The impact of United States recreational fisheries on marine fish populations. Science 305(5692): 1958-1960.

Compton, R., L. Goodwin, R. Handy, and V. Abbott. 2008. A critical examination of worldwide guidelines for minimising the disturbance to marine mammals during seismic surveys. Marine Policy 32 (3):255-262.

Conn, P.B. and G.K. Silber. 2013. Vessel speed restrictions reduce risk of collision-related mortality for North Atlantic right whales. Ecosphere 4 (4):Article 43.

Davis, G.E., Baumgartner, M.F., Bonnell, J.M., Bell, J., Berchok, C., Thornton, J.B., Brault, S., et al. 2017. Long-term passive acoustic recordings track the changing distribution of North Atlantic right whales (Eubalaena glacialis) from 2004 to 2014. Scientific Reports 7(1): 13460.

Day, R.D., McCauley, R.D., Fitzgibbon, Q.P., Hartmann, K. and J.M. Semmens. 2017. Exposure to seismic air gun signals causes physiological harm and alters behavior in the scallop Pecten fumatus. Proceedings of the National Academy of Sciences 114(40):E8537-E8546.

DeRuiter, S.L., B.L. Southall, J. Calambokidis, W.M. Zimmer, D. Sadykova, E.A. Falcone, et al. 2013. First direct measurements of behavioural responses by Cuvier's beaked whales to mid-frequency active sonar. Biology letters 9 (4):20130223.

Diaz, R.J., J.A. Blake, and D.C. Rhoads. 1993. Benthic study of the continental slope off Cape Hatteras, North Carolina. Volume II, Final report. U.S. Dept. of the Interior, Minerals Management Service, Atlantic OCS Region. OCS Study MMS 93-0015.

Di Iorio, L. and Clark, C.W., 2010. Exposure to seismic survey alters blue whale acoustic communication. Biology letters 6(1):51-54.

Doney, S.C., Ruckelshaus, M., Duffy, J.E., Barry, J.P., Chan, F. and C.A. English et al. 2012. Climate change impacts on marine ecosystems. Annual Review of Marine Science 4:11-37.

Dunlop, R.A., M.J. Noad, R.D. McCauley, E. Kniest, R. Slade, D. Paton, and D.H. Cato. 2016. Response of humpback whales (*Megaptera novaeangliae*) to ramp-up of a small experimental air gun array. Marine Pollution Bulletin 103: 72-83.

Dunlop, R.A., M.J. Noad, R.D. McCauley, E. Kniest, R. Slade, D. Paton, and D.H. Cato. 2016. The behavioural response of migrating humpback whales to a full seismic array. Proceedings of the Royal Society B 284: 20171901.

Edwards, E.F., C. Hall, T.J. Moore, C. Sheredy, and J.V. Redfern. 2015. Global distribution of fin whales Balaenoptera physalus in the post-whaling era (1980-2012). Mammal Review 45 (4):197-214.

Engås, A., Løkkeborg, S., Ona, E. and Soldal, A.V., 1996. Effects of seismic shooting on local abundance and catch rates of cod ((Gadus morhua) and haddock)(Melanogrammus aeglefinus). Canadian Journal of Fisheries and Aquatic Sciences 53(10): 2238-2249.

Erbe, C., C. Reichmuth, K. Cunningham, K. Lucke, and R. Dooling. 2016. Communication masking in marine mammals: A review and research strategy. Marine Pollution Bulletin 103 (1-2):15-38.

Fair, P.A. and P.R. Becker. 2000. Review of stress in marine mammals. Journal of Aquatic Ecosystem Stress and Recovery 7 (4):335-354.

Fewtrell, J.L. and McCauley, R.D., 2012. Impact of air gun noise on the behaviour of marine fish and squid. Marine pollution bulletin 64(5): 984-993.

Fine, M.L. and E. Parmentier, E., 2015. Mechanisms of fish sound production. Sound communication in fishes. Springer Vienna. 77-126.

Finneran, J.J. 2015. Noise-induced hearing loss in marine mammals: A review of temporary threshold shift studies from 1996 to 2015. Journal of the Acoustical Society of America 138 (3):1702-1726.

Finneran, J.J. and A.K. Jenkins. 2012. Criteria and thresholds for U.S. Navy acoustic and explosive effects analysis. Technical Report, Space and Naval Warfare Systems Center Pacific, U.S. Navy: 64.

Finneran, J.J., C.E. Schlundt, B.K. Branstetter, J.S. Trickey, V. Bowman, and K. Jenkins. 2015. Effects of multiple impulses from a seismic air gun on bottlenose dolphin hearing and behavior. Journal of the Acoustical Society of America 137 (4):1634-1646.

Firestone, J. and C. Jarvis. 2007. Response and Responsibility: Regulating Noise Pollution in the Marine Environment. Journal of International Wildlife Law and Policy (10): 109-152.

Forney, K.A., Southall, B.L., Slooten, E., Dawson, S., Read, A.J., Baird, R.W. and R.L. Brownell Jr. 2017. Nowhere to go: noise impact assessments for marine mammal populations with high site fidelity. Endangered Species Research (32):391-413.

Frasier, K.E., A.J. Debich, J.A. Hildebrand, A.C. Rice, A.M. Brewer, S.T. Herbert, et al. 2016. Passive acoustic monitoring for marine mammals in the Jacksonville Range Complex, August 2014-May 2015. MPL Technical Memorandum #602, prepared by Scripps Institution of Oceanography for Department of the Navy: 59.

Frings, H., and M. Frings. 1967. Underwater sound fields and behavior of marine invertebrates. In: W.N. Tavolga (ed.). Marine Bio-acoustics. Pergammon Press, Oxford, UK.

Gailey, G., O. Sychenko, T. McDonald, R. Racca, A. Rutenko, and K. Broker. 2016. Behavioural responses of western gray whales to a 4-D seismic survey off northeastern Sakhalin Island, Russia. Endangered Species Research (30): 53-71

Gannon, D.P. and D.M. Waples. 2004. Diets of Coastal Bottlenose Dolphins from the U.S. Mid-Atlantic Coast Differ by Habitat. Marine Mammal Science 20(3):527-545.

Gordon, J., Gillespie, D., Potter, J., Frantzis, A., Simmonds, M.P., Swift, R. and D. Thompson. 2003. A review of the effects of seismic surveys on marine mammals. Marine Technology Society Journal 37(4):16-34.

Griffin, R.B. 1999. Sperm whale distributions and community ecology associated with a warm-core ring off Georges Bank. Marine Mammal Science 15 (1):33-51.

Guerra, M., Thode, A.M., Blackwell, S.B. and M.A. Macrander. 2011. Quantifying seismic survey reverberation off the Alaskan North Slope. The Journal of the Acoustical Society of America 130(5):3046-3058.

Hatch, L., Clark, C., Merrick, R., Van Parijs, S., Ponirakis, D., Schwehr, K., Thompson, M. and D. Wiley. 2008. Characterizing the relative contributions of large vessels to total ocean noise fields: a case study using the Gerry E. Studds Stellwagen Bank National Marine Sanctuary. Environmental management 42(5):735-752.

Hatch, L.T., Clark, C.W., Van Parijs, S.M., Frankel, A.S. and D.W. Ponirakis. 2012. Quantifying loss of acoustic communication space for right whales in and around a US National Marine Sanctuary. Conservation Biology 26(6): 983-994.

Hayes, S.A., Josephon, E., Mase-Foley, K., and P.E. Rosel (eds.). 2016. U.S. Atlantic and Gulf of Mexico marine mammal stock assessments: 2016. NOAA Technical Memorandum NMFS- NE-214, National Marine Fisheries Service: 276.

Hildebrand, J.A. 2009. Anthropogenic and natural sources of ambient noise in the ocean. Marine Ecology Progress Series 395:5-20.

Holberton, R.L., B. Helmuth, and J.C. Wingfield. 1996. The corticosterone stress response in gentoo and king penguins during the non-fasting period. Condor 98 (4):850-854.

Hood, L.C., P.D. Boersma, and J.C. Wingfield. 1998. The adrenocortical response to stress in incubating Magellanic penguins (Spheniscus magellanicus). Auk 115 (1):76-84.

Hu, M., H.Y. Yan, W.S. Chung, J.C. Shiao, and P.P. Hwang. 2009. Acoustical evoked potentials in two cephalopods inferred using the auditory brainstem response (ABR) approach. Comparative Biochemistry and Physiology Part A: Molecular and Integrative Physiology 153:278-283.

IAGC (International Association of Geophysical Contractors). 2015. Mitigation measures for cetaceans during geophysical operations. Available at: www.iagc.org/uploads/4/5/0/7/45074397/2015-02_iagcmitigation_measures_for_cetaceans.pdf.

Jensen, A.S. and G.K. Silber. 2003. Large Whale Ship Strike Database. U.S. Department of Commerce, NOAA Technical Memorandum. NMFS-OPR: 37.

Jensen, A.S. and G.K. Silber. 2004. Large whale ship strike database. NOAA Technical Memorandum NMFS-OPR-25, National Marine Fisheries Service: 37.

Jessop, T.S., A.D. Tucker, C.J. Limpus, and J.M. Whittier. 2003. Interactions between ecology, demography, capture stress, and profiles of corticosterone and glucose in a free-living population of Australian freshwater crocodiles. General and Comparative Endocrinology 132 (1):161-170.

Kaifu, K., T. Akamatsu, and S. Segawa. 2008. Underwater sound detection by cephalopod statocyst. Fisheries Science 74:781-786.

Kenney, R.D., Scott, G.P., Thompson, T.J. and H.E. Winn. 1997. Estimates of prey consumption and trophic impacts of cetaceans in the USA northeast continental shelf ecosystem. Journal of Northwest Atlantic Fishery Science 22:155-171.

Knowlton, A.R. and S.D. Kraus. 2001. Mortality and serious injury of northern right whales (Eubalaena glacialis) in the western North Atlantic Ocean. Journal of Cetacean Research and Management Special Issue 2:193-208.

Kovacs, K.M., Lydersen, C., Overland, J.E. and Moore, S.E., 2011. Impacts of changing sea-ice conditions on Arctic marine mammals. Marine Biodiversity 41(1): 181-194.

Kraus, S.D., M.W. Brown, H. Caswell, C.W. Clark, M. Fujiwara, P.K. Hamilton, et al. 2005. North Atlantic right whales in crisis. Science 309 (5734): 561-562.

Krausman, P.R., L.K. Harris, C.L. Blasch, K.K.G. Koenen, and J. Francine. 2004. Effects of military operations on behavior and hearing of endangered Sonoran pronghorn. Wildlife Monographs 157:1-41.

LaBrecque, E., C. Curtice, J. Harrison, S.M. Van Parijs, and P.N. Halpin. 2015. Biologically important areas for cetaceans within U.S. waters: East coast region. Aquatic Mammals 41 (1):17-29.

Laidre, K.L., Stirling, I., Lowry, L.F., Wiig, Ø., Heide-Jørgensen, M.P. and Ferguson, S.H., 2008. Quantifying the sensitivity of Arctic marine mammals to climate-induced habitat change. Ecological Applications 18(2): S97-S125.

Laidre, K. L., Stern, H., Kovacs, K. M., Lowry, L., Moore, S. E., and E.V. Regehr, E. V. 2015. Arctic marine mammal population status, sea ice habitat loss, and conservation recommendations for the 21st century. Conservation Biology 29:724–737

Laist, D.W., A.R. Knowlton, J.G. Mead, A.S. Collet, and M. Podesta. 2001. Collisions between ships and whales. Marine Mammal Science 17 (1):35-75.

Lankford, S.E., T.E. Adams, R.A. Miller, and J.J. Cech. 2005. The cost of chronic stress: Impacts of a nonhabituating stress response on metabolic variables and swimming performance in sturgeon. Physiological and Biochemical Zoology 78:599-609.

Learmonth, J.A., MacLeod, C.D., Santos, M.B., Pierce, G.J., Crick, H.Q.P. and R.A. Robinson. 2006. Potential effects of climate change on marine mammals. Oceanography and Marine Biology (44):431.

Løkkeborg, S. and Soldal, A.V., 1993. The influence of seismic exploration with airguns on cod (Gadus morhua) behaviour and catch rates. In ICES Mar. Sci. Symp 196: 62-67.

Lovell, J., M. Findlay, R. Moate, and H. Yan. 2005. The hearing abilities of the prawn Palaemon serratus. Comparative Biochemistry and Physiology A 140:89-100.

MacLeod, C.D. and A. D'Amico. 2006. A review of beaked whale behaviour and ecology in relation to assessing and mitigating impacts of anthropogenic noise. Journal of Cetacean Research and Management 7 (3):211-221.

Madsen, P.T., N. Aguilar de Soto, P.L. Tyack, and M. Johnson. 2014. Beaked whales. Current Biology 24 (16):R1-R2.

Mann, D., Locascio, J., Schärer, M., Nemeth, M. and R. Appeldoorn. 2010. Sound production by red hind Epinephelus guttatus in spatially segregated spawning aggregations. Aquatic Biology 10(2): 149-154.

McAlarney, R., E. Cummings, C. Paxton, D.A. Pabst, A. Read, J. Bell, and W. McLellan. 2015. Species diversity and abundance at a cetacean "hot spot" off Cape Hatteras, North Carolina, USA. Paper presented at the 21st Biennial Conference on the Biology of Marine Mammals, San Francisco, California.

McCauley, R.D., J. Fewtrell, A.J. Duncan, C. Jenner, M-N. Jenner, J.D. Penrose, et al. 2000a. Marine seismic surveys – A study of environmental implications. APPEA Journal: 693-708.

McCauley, R.D., J. Fewtrell, A.J. Duncan, C. Jenner, M.-N. Jenner, J.D. Penrose, et al. 2000b. Marine seismic surveys: Analysis and propagation of air-gun signals; and effects of air-gun exposure on humpback whales, sea turtles, fishes and squid. Prepared for Australian Petroleum Production Exploration Association, Curtin University of Technology: 203.

McCauley, R.D., Fewtrell, J. and A.N. Popper. 2003. High intensity anthropogenic sound damages fish ears. The Journal of the Acoustical Society of America 113(1):638-642.

McCauley, E. Kniest, R. Slade, D. Paton, and D.H. Cato. 2016. Response of humpback whales (Megaptera novaeangliae) to ramp-up of a small experimental air gun array. Marine Pollution Bulletin 103: 72-83.

McCauley, R., Day, R.D., Swadling, K.M., Fitzgibbon, Q.P., Watson, R.A. and J.M. Semmens. 2017. Widely used marine seismic survey air gun operations negatively impact zooplankton. Nature Ecology & Evolution (1):1-8.

McDonald, M.A., Hildebrand, J.A. and S.C. Webb. 1995. Blue and fin whales observed on a seafloor array in the Northeast Pacific. The Journal of the Acoustical Society of America 98(2): 712-721.

McDonald, M.A., Hildebrand, J.A. and S.M. Wiggins. 2006. Increases in deep ocean ambient noise in the Northeast Pacific west of San Nicolas Island, California. The Journal of the Acoustical Society of America 120(2):711-718.

Miller, P.J.O., M.P. Johnson, P.T. Madsen, N. Biassoni, M. Quero, and P.L. Tyack. 2009. Using at-sea experiments to study the effects of airguns on the foraging behavior of sperm whales in the Gulf of Mexico. Deep Sea Research I 56 (7):1168-1181.

Miller, D.L. and L. Thomas. 2015. Mixture models for distance sampling detection functions. PLoS ONE 10 (3):e0118726.

Mintzer, V.J., Gannon, D.P., Barros, N.B. and Read, A.J., 2008. Stomach contents of mass-stranded short-finned pilot whales (Globicephala macrorhynchus) from North Carolina. Marine Mammal Science 24(2): 290-302.

Moberg, G.P. 2000. Biological response to stress: Implications for animal welfare. Pages 1-21 in G.P. Moberg and J.A. Mench, eds. The Biology of Animal Stress: Basic Principles and Implications for Animal Welfare. CABI Publishing, Oxon, United Kingdom.

Mooney, T.A., R.T. Hanlon, J. Christensen-Dalsgaard, P.T. Madsen, D. Ketten, and P.E. Nachtigall. 2010. Sound detection by the longfin squid (Loligo pealeii) studied with auditory evoked potentials: Sensitivity to low-frequency particle motion and not pressure. Journal of Experimental Biology 213:3748-3759.

Moors-Murphy, H.B. 2014. Submarine canyons as important habitat for cetaceans, with special reference to the Gully: A review. Deep Sea Research Part II: Topical Studies in Oceanography 104:6-19.

Mullin, K.D. and G.L. Fulling. 2003. Abundance of cetaceans in the southern U.S. North Atlantic Ocean during summer 1998. Fishery Bulletin 101 (3):603-613.

National Research Council (NRC). 2003. Ocean Noise and Marine Mammals. Washington, DC: National Academy Press: 192.

Nelms, S.E., Piniak, W.E., Weir, C.R. and B.J. Godley. 2016. Seismic surveys and marine turtles: An underestimated global threat? Biological Conservation 193: 49-65.

Nieukirk, S.L., Mellinger, D.K., Moore, S.E., Klinck, K., Dziak, R.P. and J. Goslin, J. 2012. Sounds from airguns and fin whales recorded in the mid-Atlantic Ocean, 1999–2009. The Journal of the Acoustical Society of America 131(2):1102-1112.

NMFS. 2011. A comprehensive assessment of marine mammal, marine turtle, and seabird abundance and spatial distribution in US waters of the western North Atlantic Ocean. 2011 Annual Report to the Inter-Agency Agreement M10PG00075/0001, National Marine Fisheries Service: 166.

NMFS. 2013a. Biological opinion on the Programmatic Geological and Geophysical Activities in the Mid- and South Atlantic Planning Areas from 2013 to 2010. National Marine Fisheries Service: 370.

NMFS. 2013b. Annual report of a comprehensive assessment of marine mammal, marine turtle, and seabird abundance and spatial distribution in US waters of the western North Atlantic Ocean. National Marine Fisheries Service: 204.

NMFS. 2016. Technical guidance for assessing the effects of anthropogenic sound on marine mammal hearing: Underwater acoustic thresholds for onset of permanent and temporary threshold shifts. NOAA Technical Memorandum NMFS-OPR-55, National Marine Fisheries Service: 178.

NMFS. 2018. 2018 revision to: Technical guidance for assessing the effects of anthropogenic sound on marine mammal hearing (Version 2.0). NOAA Technical Memorandum NMFS-OPR-59, National Marine Fisheries Service: 178.

NMFS. 2018. Commercial Fisheries Statistics: Annual Commercial Landing Statistics. Webpage. https://www.st.nmfs.noaa.gov/commercial-fisheries/commercial-landings/annual-landings/index

NRC (National Research Council). 2003. Ocean noise and marine mammals. National Academy of Sciences: 220.

NOAA Fisheries. 2014. Morbillivirus Infection in Dolphins, Porpoises, and Whales. Webpage. http://www.nmfs.noaa.gov/pr/health/mmume/midatlantic2013/morbillivirus_cetaceans.pdf

NOAA Fisheries. 2015. 2013-2015 Bottlenose Dolphin Unusual Mortality Event in the Mid-Atlantic. Webpage. http://www.nmfs.noaa.gov/pr/health/mmume/midatldolphins2013.html

NOAA Fisheries. 2018a. 2016-2018 Humpback Whale Unusual Mortality Event along the Atlantic Coast. Webpage. http://www.nmfs.noaa.gov/pr/health/mmume/2017humpbackatlanticume.html.

NOAA Fisheries. 2018b. 2017-2018 North Atlantic Right Whale Unusual Mortality Event. Webpage. https://www.fisheries.noaa.gov/national/marine-life-distress/2017-2018-north-atlantic-right-whale-unusual-mortality-event

Nowacek, D.P., Thorne, L.H., Johnston, D.W. and Tyack, P.L., 2007. Responses of cetaceans to anthropogenic noise. Mammal Review 37(2): 81-115.

Nowacek, D.P., C.W. Clark, D. Mann, P.J.O. Miller, H.C. Rosenbaum, J.S. Golden, et al. 2015. Marine seismic surveys and ocean noise: Time for coordinated and prudent planning. Frontiers in Ecology and the Environment 13 (7):378-386.

Nowacek, D.P. and B.L. Southall. 2016. Effective planning strategies for managing environmental risk associated with geophysical and other imaging surveys. International Union for Conservation of Nature and Natural Resources: 45.

Oedekoven, C., E. Fleishman, P. Hamilton, J. S. Clark, and R. S. Schick. 2015. Expert Elicitation of Seasonal Abundance of North Atlantic Right Whales Eubalaena Glacialis in the Mid-Atlantic. Endangered Species Research 29 (1): 51–58.

Pace, R.M., Corkeron, P.J. and Kraus, S.D., 2017. State–space mark–recapture estimates reveal a recent decline in abundance of North Atlantic right whales. Ecology and Evolution 7(21): 8730-8741.

Packard, A., H.E. Karlsen, and O. Sand. 1990. Low frequency hearing in cephalopods. Journal of Comparative Physiology A 166:501-505.

Parks, S.E. and P.L. Tyack. 2005. Sound production by North Atlantic right whales (Eubalaena glacialis) in surface active groups. Journal of the Acoustical Society of America 117 (5): 3297-3306

Parks, S.E., Urazghildiiev, I. and C.W. Clark. 2009. Variability in ambient noise levels and call parameters of North Atlantic right whales in three habitat areas. The Journal of the Acoustical Society of America 125(2): 1230-1239.

Parsons, E.C.M., S.J. Dolman, M. Jasny, N.A. Rose, M.P. Simmonds, and A.J. Wright. 2009. A critique of the UK's JNCC seismic survey guidelines for minimising acoustic disturbance to marine mammals: Best practise? Marine pollution bulletin 58 (5):643-651.

Paxton, A.B., Taylor, J.C., Nowacek, D.P., Dale, J., Cole, E., Voss, C.M. and C.H. Peterson. 2017. Seismic survey noise disrupted fish use of a temperate reef. Marine Policy 78:68-73.

Payne, P.M., L.A. Selzer, and A.R. Knowlton. 1984. Distribution and density of cetaceans, marine turtles, and seabirds in the shelf waters of the northeastern United States, June 1980 - December 1983, based on shipboard observations. Prepared by Manomet Bird Observatory for National Marine Fisheries Service: 298.

Peña, H., Handegard, N.O. and E. Ona. 2013. Feeding herring schools do not react to seismic air gun surveys. ICES Journal of Marine Science 70(6): 1174-1180.

Pettis, H.M. and P.K. Hamilton. 2016. North Atlantic Right Whale Consortium 2016 annual report card. Report to the North Atlantic Right Whale Consortium, November 2016: 14.

Popov, V.V., E.V. Sysueva, D.I. Nechaev, V.V. Rozhnov, and A.Y. Supin. 2016. Auditory evoked potentials in the auditory system of a beluga whale Delphinapterus leucas to prolonged sound stimuli. Journal of the Acoustical Society of America 139:1101-1109.

Pumphrey, R.J. 1950. Hearing. In: Society for Experimental Biology, ed. Physiological mechanisms in animal behavior. Symposia of the Society for Experimental Biology 4:3-18.

Ray, G.C., B.P. Hayden, M.G. McCormick-Ray, and T.M. Smith. 1997. Land-seascape diversity of the U.S.A. east coast coastal zone with particular reference to estuaries. In: Ormand, R.F.G., J.D. Gage, and M.V. Angel, eds. Marine biodiversity, patterns and processes. Cambridge University Press. Pp. 337-371.

Richardson, W. J., C. R. Greene, C. I. Malme, and D. H. Thomson. 1995. Marine Mammals and Noise. Academic Press, San Diego, California.

Richardson, W.J., Miller, G.W. and Greene Jr, C.R., 1999. Displacement of migrating bowhead whales by sounds from seismic surveys in shallow waters of the Beaufort Sea. The Journal of the Acoustical Society of America 106(4):2281-2281.

Richardson, A.J. and Schoeman, D.S., 2004. Climate impact on plankton ecosystems in the Northeast Atlantic. Science 305(5690):1609-1612.

Roberts, J.J., B.D. Best, L. Mannocci, E. Fujioka, P.N. Halpin, D.L. Palka, et al. 2015a. Density model for minke whale (Balaenoptera acutorostrata) in the U.S. Atlantic: Supplementary information, Version 8.3, 2015-09-26. Marine Geospatial Ecology Lab, Duke University, Durham, North Carolina.

Roberts, J.J., B.D. Best, L. Mannocci, E. Fujioka, P.N. Halpin, D.L. Palka, et al. 2015b. Density model for northern bottlenose whale (Hyperoodon ampullatus) in the U.S. Atlantic: Supplementary information, Version 1.2, 2015-09-26. Marine Geospatial Ecology Lab, Duke University, Durham, North Carolina.

Roberts, J.J., B.D. Best, L. Mannocci, E. Fujioka, P.N. Halpin, D.L. Palka, et al. 2015c. Density model for pilot whales (Globicephala spp.) in the U.S. Atlantic: Supplementary information, Version 4.3, 2015-09-30. Marine Geospatial Ecology Lab, Duke University, Durham, North Carolina.

Roberts, J.J., B.D. Best, L. Mannocci, E. Fujioka, P.N. Halpin, D.L. Palka, et al. 2016. Habitat based cetacean density models for the U.S. Atlantic and Gulf of Mexico. Scientific Reports 6:22615.

Roberts, J., L. Mannocci, and P. Halpin. 2017. Final Project Report: Marine Species Density Data Gap Assessments and Update for the AFTT Study Area, 2016-2017 (Opt. Year 1). Document version 1.4. Report prepared for Naval Facilities Engineering Command, Atlantic by the Duke University Marine Geospatial Ecology Lab, Durham, NC.

Rolland, R.M., S.E. Parks, K.E. Hunt, M. Castellote, P.J. Corkeron, D.P. Nowacek, et al. 2012. Evidence that ship noise increases stress in right whales. Proceedings of the Royal Society of London Series B Biological Sciences 279 (1737):2363-2368.

Romano, T., M. Keogh, and K. Danil. 2002a. Investigation of the effects of repeated chase and encirclement on the immune system of spotted dolphins (Stenella attenuata) in the eastern tropical Pacific. Administrative Report LJ-02-35C, National Marine Fisheries Service: 37.

Romano, T.A., D.L. Felten, S.Y. Stevens, J.A. Olschowka, V. Quaranta, and S.H. Ridgway. 2002b. Immune response, stress, and environment: Implications for cetaceans. Pages 253-279 in C.J. Pfeiffer, ed. Molecular and Cell Biology of Marine Mammals. Krieger Publishing Co., Malabar, Florida.

Runge, J. A., Ji, R. B., Thompson, C. R. S., Record, N. R., Chen, C., Vandemark, D. C., et al. 2015. Persistence of Calanus finmarchicus in the western Gulf of Maine during recent extreme warming. Journal of Plankton Research 37:221–232.

Salisbury, D.P., Clark, C.W. and Rice, A.N., 2016. Right whale occurrence in the coastal waters of Virginia, USA: Endangered species presence in a rapidly developing energy market. Marine Mammal Science 32(2):508-519.

Samson, J.E., T.A. Mooney, S.W. Gussekloo, and R.T. Hanlon. 2014. Graded behavioral responses and habituation to sound in the common cuttlefish Sepia officinalis. Journal of Experimental Biology 217 (Pt 24):4347-4355.

Seyle, H. 1950. Stress and the general adaptation syndrome. British Medical Journal June 17:1383-1392.

Shertzer, K.W., E.H. Williams, and J.C. Taylor. 2009. Spatial structure and temporal patterns in a large marine ecosystem: Exploited reef fishes of the southeast United States. Fisheries Research 100 (2):126-133.

Silber, G.K., Lettrich, M., Thomas, P.O., Baker, J., Baumgartner, M., Becker, et al. 2017. Projecting Marine Mammal Distribution in a Changing Climate. Frontiers in Marine Science 4:413

Slotte, A., Hansen, K., Dalen, J. and Ona, E., 2004. Acoustic mapping of pelagic fish distribution and abundance in relation to a seismic shooting area off the Norwegian west coast. Fisheries Research 67(2): 143-150.

Smith-Vaniz, W.F., B.B. Collette, and B.E. Luckhurst. 1999. Fishes of Bermuda: History, zoogeography, annotated checklist, and identification keys. American Society of Ichthyologists and Herpetologists Special Publication Number 4, Lawrence, KS: 424.

Southall, B.L., A.E. Bowles, W.T. Ellison, J.J. Finneran, R.L. Gentry, C.R. Greene, et al. 2007. Marine mammal noise exposure criteria: Initial scientific recommendations. Aquatic Mammals 33 (4):411-521.

Stanistreet, J.E., Nowacek, D.P., Baumann-Pickering, S., Bell, J.T., Cholewiak, D.M., Hildebrand, J.A., and L.E. Hodge et al. 2017. Using passive acoustic monitoring to document the distribution of beaked whale species in the western North Atlantic Ocean. Canadian Journal of Fisheries and Aquatic Sciences 999:1-12.

Stanistreet, J. E., and coauthors. 2018. Spatial and seasonal patterns in acoustic detections of sperm whales Physeter macrocephalus along the continental slope in the western North Atlantic Ocean. Endangered Species Research 35:1-13.

Stimpert, A.K., S.L. DeRuiter, B.L. Southall, D.J. Moretti, E.A. Falcone, J.A. Goldbogen, et al. 2014. Acoustic and foraging behavior of a Baird's beaked whale, Berardius bairdii, exposed to simulated sonar. Scientific Reports 4 (7031): 1-8.

Streever, B., Raborn, S.W., Kim, K.H., Hawkins, A.D. and A.N. 2016. Changes in Fish Catch Rates in the Presence of Air Gun Sounds in Prudhoe Bay, Alaska. ARCTIC 69(4):346-358.

Tucholke, B.E. 1987. Submarine geology. In: Milliman, J.D. and W.R. Wright, eds. The marine environment of the U.S. Atlantic continental slope and rise. Boston/Woods Hole, MA: Jones and Bartlett Publishers, Inc.: 56-113.

Tyack, P.L., W.M.X. Zimmer, D. Moretti, B.L. Southall, D.E. Claridge, J.W. Durban, et al. 2011. Beaked whales respond to simulated and actual Navy sonar. PLoS ONE 6 (3):e17009.

U.S. Dept. of Commerce, National Marine Fisheries Service. 2013b. Recreational fisheries. NOAA Fisheries, Office of Science and Technology. Internet website: http:// www.st.nmfs.noaa.gov/recreational-fisheries/access-data/run-a-data-query/queiries/index. Accessed September 4, 2013.

U.S. Dept. of the Interior, Minerals Management Service (MMS). 1998. North Carolina/Minerals Management Service Technical Workshop on Manteo Unit Exploration. February 4-5, 1998. Minerals Management Service, Gulf of Mexico Region, New Orleans, LA. OCS Report MMS 98-0024. Available at: http://www.gomr.boemre.gov/PI/PDFImages/ESPIS/3/3225.pdf

U.S. Dept. of the Interior, Fish and Wildlife Service and U.S. Dept. of Commerce, U.S. Census Bureau. 2013. 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation. FHW/11-NAT (RV):172.

U.S. Fleet Forces. 2009. Virginia Capes Range Complex, final environmental impact statement/overseas environmental impact assessment. Volume 1. Internet website: http://64.78.11.86/ uxofiles/enclosures/VACAPES_FEIS_Vol_1_Chapter3.pdf. Retrieved from BOEM, 2014a.

U.S. Dept. of the Navy. 2008. Final – Atlantic fleet active sonar training environmental impact statement/overseas environmental impact statement. Retrieved from: http://www.nmfs.noaa.gov/pr/pdfs/permits/afast_eis.pdf. 1-876.

U.S. Dept. of the Navy. 2013. Draft environmental impact statement/overseas environmental impact statement for Atlantic fleet training and testing. Internet website: http://aftteis.com/DocumentsandReferences/AFTTDocuments/DraftEISOEIS(May2012).aspx.

U.S. Dept. of the Navy. 2017. Draft environmental impact statement/overseas environmental impact statement for Atlantic fleet training and testing. Internet website: http://www.aftteis.com

USFWS. 2011. Climate Change in the Pacific Northwest. Website. www.fws.gov/pacific/Climatechange/changepnw.html

Vanderlaan, A.S. and Taggart, C.T., 2007. Vessel collisions with whales: the probability of lethal injury based on vessel speed. Marine mammal science 23(1):144-156.

Videsen, S.K., Bejder, L., Johnson, M. and Madsen, P.T., 2017. High suckling rates and acoustic crypsis of humpback whale neonates maximise potential for mother–calf energy transfer. Functional Ecology 31 (8): 1561-1573.

Wall, C.C., Lembke, C. and Mann, D.A., 2012. Shelf-scale mapping of sound production by fishes in the eastern Gulf of Mexico, using autonomous glider technology. Marine Ecology Progress Series 449:55-64.

Waring, G.T., C.P. Fairfield, C.M. Ruhsam, and M. Sano. 1993. Sperm whales associated with Gulf Stream features off the north-eastern USA shelf. Fisheries Oceanography 2 (2):101-105.

Waring, G.T., Hamazaki, T., Sheehan, D., Wood, G. and Baker, S., 2001. Characterization of beaked whale (Ziphiidae) and sperm whale (Physeter macrocephalus) summer habitat in shelf-edge and deeper waters off the northeast US. Marine Mammal Science 17(4): 703-717.

Waring, G.T., E. Josephson, C.P. Fairfield, and K. Maze-Foley (eds.). 2007. U.S. Atlantic and Gulf of Mexico marine mammal stock assessments: 2007. NOAA Technical Memorandum NMFS-NE-205, National Marine Fisheries Service: 426.

Waring, G.T., E. Josephson, K. Maze-Foley, and P.E. Rosel (eds.). 2013. U.S. Atlantic and Gulf of Mexico marine mammal stock assessments: 2012. Volume I. National Marine Fisheries Service: 425.

Waring, G.T., E. Josephson, K. Maze-Foley, and P.E. Rosel (eds.). 2016. U.S. Atlantic and Gulf of Mexico marine mammal stock assessments: 2015. NOAA Technical Memorandum NMFS-NE-238, National Marine Fisheries Service: 512.

Wartzok, D., A.N. Popper, J. Gordon, and J. Merrill. 2003. Factors affecting the responses of marine mammals to acoustic disturbance. Marine Technology Society Journal 37 (4):6-15.

Weilgart, L.S., 2007. A brief review of known effects of noise on marine mammals. International Journal of Comparative Psychology 20(2): 159-168.

Weir, C.R. and S.J. Dolman. 2007. Comparative review of the regional marine mammal mitigation guidelines implemented during industrial seismic surveys, and guidance towards a worldwide standard. Journal of International Wildlife Law and Policy 10 (1):1-27.

Weir, C.B. 2008. Overt Responses of Humpback Whales (Megaptera novaeangliae), Sperm Whales (Physeter macrocephalus), and Atlantic Spotted Dolphins (Stenella frontalis) to Seismic Exploration off Angola. Aquatic Mammals 34(1):71-83.

Wigley, R.L. and R.B. Theroux. 1981. Atlantic continental shelf and slope of the United States – Macrobenthic invertebrate fauna of the Middle Atlantic Bight region – faunal composition and quantitative distribution. U.S. Geological Survey Professional Paper 529-N1-N22.

Whitehead, H., S. Brennan, and D. Grover. 1992. Distribution and behaviour of male sperm whales on the Scotian Shelf, Canada. Canadian Journal of Zoology 70 (5):912-918.

Whitehead, H., MacLeod, C.D. and P. Rodhouse. (2003) Differences in niche breadth among some teuthivorous mesopelagic marine predators. Marine Mammal Science 19:400–406.

Wiebe, P.H., E.H. Backus, R.H. Backus, D.A. Caron, P.M. Glibert, and J.F. Grassle, et al. 1987. Biological oceanography. In: Milliman, J.D. and W.R. Wright, eds. The marine environment of the U.S. Atlantic continental slope and rise. Boston/Woods Hole, MA: Jones and Bartlett Publishers, Inc.:186-193.

Wright, A.J., Soto, N.A., Baldwin, A.L., Bateson, M., Beale, C.M., Clark, C., and T. Deak, et al. 2007. Do marine mammals experience stress related to anthropogenic noise? International Journal of Comparative Psychology 20(2):274-316.

Wright, A.J., Deak, T., and E.C.M. Parsons, E.C.M., 2011. Size matters: management of stress responses and chronic stress in beaked whales and other marine mammals may require larger exclusion zones. Marine Pollution Bulletin 63(1):5-9.

Yoder, J.A. 1991. Warm-temperate food chains of the southeast shelf ecosystem. Pages 49-66 in K. Sherman, L.M. Alexander, and B.D. Gold, eds. Food Chains, Yields, Models and Management of Large Marine Ecosystems. American Association for the Advancement of Science Symposium, Westview Press, Boulder, CO.

Zykov, M. and S. Carr. 2014. Acoustic Modeling Report: Atlantic G&G Programmatic EIS. Appendix D *in* Atlantic OCS proposed geological and geophysical activities, Mid-Atlantic and South Atlantic Planning Areas: Final Programmatic Environmental impact Statement. Prepared by JASCO Applied Sciences for CSA Ocean Sciences Inc. under contract to Bureau of Ocean Energy Management: 100.