PROPOSED ACTION:	Issuance of an Incidental Harassment Authorization to the United States Geological Service to Take Marine Mammals by Harassment Incidental to a Marine Geophysical Survey in the Northwest 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, National Marine Fisheries Service
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LOCATION:	Northwest Atlantic Ocean
ABSTRACT:	This Environmental Assessment analyzes the environmental impacts of the National Marine Fisheries Service, Office of Protected Resources proposals to issue an Incidental Harassment Authorization (IHA) to the United States Geological Service by Level B harassment of small numbers of marine mammals incidental to a marine geophysical survey in the northwest Atlantic Ocean. The IHA would be valid from August 8, 2018 through August 7, 2019.
DATE:	July 2018

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LIST OF ACRONYMS AND ABBREVIATIONS

μPa	microPascal
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
dB	decibel
EA	Environmental Assessment
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
FONSI	Finding of No Significant Impact
FR	Federal Register
IHA	Incidental Harassment Authorization
Km	kilometer
m	meter
MMPA	Marine Mammal Protection Act
MSFCMA	Magnuson-Stevens Fishery Conservation Management Act
NAO	NOAA Administrative Order
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NSF	National Science Foundation
NOAA	National Oceanic and Atmospheric Administration
OPR	Office of Protected Resources
OMB	Office of Management and Budget
PSO	Protected Species Observer
rms	root-mean-square
USFWS	US Fish and Wildlife Service
USGS	US Geological Survey

Chapter 1 Introduction and Purpose and Need

1.1. Background

The Marine Mammal Protection Act of 1972, as amended (MMPA; 16 U.S.C. 1631 et seq.) prohibits the incidental taking of marine mammals. The incidental take of a marine mammal falls under three categories: mortality, serious injury or harassment (*i.e.*, injury and behavioral effects). Harassment[1] 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, there are exceptions to the prohibition on take in Sections 101(a)(5)(A) and (D) of the MMPA that gives the National Marine Fisheries Service (NMFS) the authority to authorize the incidental but not intentional take of small numbers of marine mammals by harassment, provided certain determinations are made and statutory and regulatory procedures are met. Refer to Chapter 2 for details regarding this exception and NMFS incidental harassment authorization (IHA) criteria.

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.

1.2. Applicant's Incidental Take Authorization Request

The United States Geological Survey (USGS) requested an Incidental Harassment Authorization (IHA) to take marine mammals by harassment incidental to a marine geophysical survey in the northwest Atlantic Ocean. A marine geophysical survey uses reflected sound waves to produce visual representations of the Earth's subsurface. The USGS intends to conduct this survey aboard the *R/V Hugh R. Sharp*, a University National Oceanographic Laboratory (UNOLS) Federal fleet vessel owned and operated by the University of Delaware, during a cruise up to 22 days long on the northern U.S. Atlantic margin in August 2018. The program is named MATRIX, for "Mid-Atlantic Resource Imaging Experiment."

The marine geophysical survey will take place in water depths ranging from ~100 meters (m) to 3500 m, entirely within the U.S. Exclusive Economic Zone (EEZ), and acquire ~6 dip lines (roughly perpendicular to the orientation of the shelf-break) and ~3 strike lines (roughly parallel to the shelf-break) between about 35 nautical miles nmi south of Hudson Canyon on the north and Cape Hatteras on the south. In addition, multichannel seismic (MCS) data will be acquired along some linking/transit/interseismic lines between the main survey lines. Total data acquisition could be up to ~2400 kilometers (km). Some deviation in actual tracklines and timing could be necessary for reasons such as science drivers, poor data quality, inclement weather or mechanical issues with the research vessel and/or equipment. Exemplary tracklines

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

for this survey are shown in Figure 1 of the IHA Application found at https://www.fisheries.noaa.gov/national/marine-mammal-protection/incidental-take-authorizations-research-and-other-activities. For the purposes of the this EA, the location is referred to herein as "survey area"

The purpose of the proposed marine geophysical survey is to collect data to constrain the lateral and vertical distribution of gas hydrates and shallow natural gas in marine sediments relative to seafloor gas seeps, slope failures, and geological and erosional features.

1.2.1. Marine Mammals in the Proposed Action Area

There are 29 marine mammal species with confirmed or potential occurrence in the proposed action area during the time of the marine geophysical survey activities. These species would most likely be harassed incidental to USGS conducting the proposed activities:

- Humpback whale (*Megaptera novaeangliae*)
- Sei whale (*B. borealis borealis*)
- Fin whale (*B. physalus physalus*)
- Sperm whale (*Physeter macrocephalus*)
- Pygmy sperm whale (*Kogia breviceps*)
- Dwarf sperm whale (*Kogia sima*)
- Cuvier's beaked whale (*Ziphius cavirostris*)
- Gervais beaked whale (*Mesoplodon europaeus*)
- Blainville's beaked whale (*Mesoplodon densirostris*)
- Sowerby's beaked whale (*Mesoplodon bidens*)
- True's beaked whale (*Mesoplodon mirus*)
- Northern bottlenose whale (*Hyperoodon ampullatus*)
- Rough-toothed dolphin (*Steno bredanensis*)
- Common bottlenose dolphin (*Tursiops truncatus truncatus*)
- Clymene dolphin (*Stenella clymene*)
- Atlantic spotted dolphin (*Stenella frontalis*)
- Pantropical spotted dolphin (*Stenella attenuata attenuata*)
- Spinner dolphin (*Stenella longirostris longirostris*)
- Striped dolphin (*Stenella coeruleoalba*)
- Short-beaked common dolphin (*Delphinus delphis delphis*)
- Fraser's dolphin (*Lagenodelphis hosei*)
- Atlantic white-sided dolphin (*Lagenorhynchus acutus*)
- Risso's dolphin (*Grampus griseus*)
- Melon-headed whale (*Peponocephala electra*)
- Pygmy killer whale (*Feresa attenuata*)
- False killer whale (*Pseudorca crassidens*)
- Short-finned pilot whale (*Globicephala macrorhynchus*)
- Long-finned pilot whale (*Globicephala melas melas*)
- Killer whale (*Orcinus orca*)

1.3. Purpose and Need

1.3.1. Description of Proposed Action

NMFS proposes to issue an IHA to USGS pursuant to Section 101(a)(5)(D) of the MMPA and 50 CFR Part 216. The IHA would be valid from August 8, 2018 through August 7, 2019 and would authorize takes of marine mammals, by Level B harassment only, incidental to the proposed marine geophysical survey conducted by USGS. NMFS's proposed action is a direct outcome of USGS requesting an IHA to take marine mammals incidental to its proposed survey.

1.3.2. Purpose

The purpose of NMFS's action is to authorize take of marine mammals incidental to a marine geophysical survey proposed by USGS, consistent with applicable legal requirements. Acoustic stimuli from the use of seismic airguns during a marine geophysical survey has the potential to cause harassment of marine mammals, and thus the proposed activities warrants an IHA from NMFS. The IHA will allow USGS to take small numbers of marine mammals within a specific geographic region incidental to and as part of the 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 mammals or stocks and determines whether mitigation will achieve the least practicable impact on marine mammal 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 the IHA if it would result in more than a negligible impact on marine mammals or stocks or would result in an unmitigable impact on subsistence uses. We must prescribe the permissible methods of taking and other means of effecting the least practicable 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. The IHA must also include requirements or conditions pertaining to monitoring and reporting.

1.3.3. 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). Due to USGS submitting an adequate and complete application 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 application. Therefore, NMFS's responsibilities under Section 101(a)(5)(D) of the MMPA and its implementing regulations establish and frame the need for NMFS's proposed action.

1.4 The Environmental Review Process

NEPA requires federal agencies to examine the environmental impacts of their proposed actions within the United States and its territories. A NEPA analysis is a concise public document that provides an assessment of the potential effects a major federal action may have on the human environment. Major federal actions include activities that federal agencies fully or partially fund, regulate, conduct or approve. Because our issuance of an IHA would allow for the taking of marine mammals, consistent with provisions under the MMPA and incidental to the applicant's lawful activities, NMFS considers this as a major federal action subject to NEPA; therefore, NMFS analyzes the environmental effects associated with authorizing incidental takes of protected species and prepares the appropriate NEPA documentation. In addition, NMFS, 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. This includes coordination within the National Oceanic Atmospheric and Administration (NOAA), (e.g., the Office of the National Marine Sanctuaries) and with other regulatory agencies (e.g., the U.S. Fish and Wildlife Service), as appropriate, during NEPA reviews prior to implementation of a proposed action to ensure that requirements are met.

1.3.4. Scoping and Public Involvement

The NEPA process is intended to enable NMFS to make decisions based on an understanding of the environmental consequences and take actions to protect, restore, and enhance the environment. Although NOAA policy and procedures do not require public involvement prior to finalizing an EA, NMFS relies substantially on the public process pursuant to the MMPA to develop and evaluate environmental information relevant to an analysis under NEPA. The public comment period for the proposed IHA provides the public with information on relevant environmental issues and offers a meaningful opportunity to provide comments for our consideration in both the MMPA and NEPA decision-making processes.

The public was given the opportunity to submit comments during a 30-day comment period that began the date that the notice of the proposed IHA was filed for public inspection in the *Federal Register* (83 FR 25268; May 31, 2018). The notice included a detailed description of the proposed action resulting from the MMPA incidental take authorization process; consideration of environmental issues and impacts of relevance related to the proposed issuance of the IHA; and potential mitigation and monitoring measures to avoid and minimize potential adverse impacts to marine mammals and their habitat. The *Federal Register* notice of the proposed IHA, the draft EA and the corresponding public comment period are instrumental in providing the public with information on relevant environmental issues and offering the public a meaningful opportunity to provide comments for our consideration in both the MMPA and NEPA decision-making processes.

During the 30-day public comment period following the filing of the proposed IHA in the *Federal Register* (83 FR 25268; May 31, 2018), NMFS received one letter from the Marine Mammal Commission (Commission). The Commission contends that the USGS's take estimates are flawed, because the estimates do not contain a time component. The Commission also recommended that NMFS impose conditions on USGS's use of an echosounder during the survey and advise USGS that it needs to obtain specific authorization to take marine mammals with the echosounder. The Commission also provided program-level comments. NMFS addressed these comments sufficiently and is working with the Commission to alleviate their ongoing concerns. NMFS has posted this comment letter online at:
https://www.fisheries.noaa.gov/national/marine-mammal-protection/incidental-take-

authorizations-research-and-other-activities. A more detailed summary of the comments, and NMFS' responses to those comments, will be included in the *Federal Register* notice for the issued IHA, if NMFS determines the IHA should be issued.

1.4. 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 are based on the nature and location of the applicants proposed activities and NMFS's proposed action. Therefore, this section summarizes environmental laws and consultations applicable to NMFS's issuance of an IHA to USGS.

1.4.1. The Endangered Species Act

The ESA established protection over and conservation of threatened and endangered species (T&E) and the ecosystems upon which they depend. An endangered species is a species in danger of extinction throughout all or a significant portion of its range. A threatened species is one that is likely to become endangered within the near future throughout all or in a significant portion of its range. The USFWS and NMFS jointly administer the ESA and are responsible for the listing of species (designating a species as either threatened or endangered) and designating geographic areas as critical habitat for T&E species. 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) requires each federal agency to ensure that any action it authorizes, funds or carries out is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of designated critical habitat of such species. When a federal agency's action may affect a listed species, that agency is required to consult with NMFS and/or the USFWS under procedures set out in 50 CFR Part 402. NMFS and USFWS can also be action agencies under section 7. Informal consultation is sufficient for species the action agency determines are not likely to be adversely affected if NMFS or USFWS concurs with the action agency's findings, including any additional measures mutually agreed upon as necessary and sufficient to avoid adverse impacts to listed species and/or designated critical habitat.

NMFS's issuance of an IHA is a federal action that is also subject to the requirements of section 7 of the ESA. As a result, we are required to ensure that the issuance of an IHA to USGS is not likely to jeopardize the continued existence of any T&E species or result in the destruction or adverse modification of designated critical habitat for these species. There are three marine mammal species under NMFS's jurisdiction listed as endangered under the ESA with confirmed or possible occurrence in the proposed project area including the fin whale, sei whale, and sperm whale. NMFS's OPR Permits and Conservation Division initiated consultation with NMFS's ESA Interagency Cooperation Division on the proposed issuance of the IHA to USGS, pursuant to section 7 of the ESA, on May 3, 2018. The ESA Interagency Cooperation Division found that NMFS's issuance of this IHA to USGS will not jeopardize the continued existence of endangered or threatened species and would not affect critical habitat, and issued a Biological

Opinion on August 6, 2018 providing conclusions specific to NMFS's actions associated with USGS's proposed marine geophysical survey.

1.4.2. Magnuson-Stevens Fishery Conservation and Management Act

Under the Magnuson-Stevens Fishery Conservation and Management Act (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, funded, or undertaken, by such agency which may adversely affect essential fish habitat (EFH) identified under the MSFCMA.

The exemplary seismic transects and tie-lines for USGSs proposed marine geophysical survey intersect with Mid-Atlantic, South Atlantic, and Highly Mobile Species EFH. Table 1 lists the results for the 41 species and the life stage that overlaps with the general area of the USGS proposed marine geophysical survey. However, authorizing the take of marine mammals through the issuance of the IHA to USGS 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. Therefore, pursuant to 2017 NMFS Office of Habitat Conservation guidance on EFH and ITAs, NMFS OPR determined that the issuance of this IHA to USGS 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.

Table 1 Marine species with Essential Fish Habitat (EFH) overlapping the proposed survey area. The table is produced by combining exemplary seismic lines with the EFH polygons provided by NMFS. For life stage, E = embryo; L = larval/neonate; J=juvenile; A=adult; and SA = spawning adult.

	Life Stage for Overlapping EFH				
Species	E	L/N	J	A	SA
Atlantic herring *Clupea harengus*			o	o	
Bluefish *Pomatomus saltatrix*	o	o	o	o	o
Butterfish *Peprilus triacanthus*	o	o	o	o	o
Black sea bass *Centropristis striata*		o	o	o	
Atlantic mackerel *Scomber scombrus*	o	o	o	o	o
Snapper-Grouper	o	o	o	o	o
Scup *Stenotomus chrysops*	o	o	o	o	o
Golden tilefish *Lopholatilus chamaeleonticeps*	o	o	o	o	o
Summer flounder *Paralichthys dentatus*	o	o	o	o	o
Albacore tuna *Thunnus alalunga*	o	o	o	o	o
Bluefin tuna *Thunnus thynnus*	o	o	o	o	o
Bigeye tuna *Thunnus obesus*	o	o	o	o	o
Yellowfin tuna *Thunnus albacres*	o	o	o	o	o
Skipjack tuna *Katsuwonus pelamis*	o	o	o	o	o
Swordfish *Xiphias gladius*	o	o	o	o	o
Blue marlin *Makaira nigricans*	o	o	o	o	o
White marlin *Tetrapturus albidus*	o	o	o	o	o
Sailfish *Istiophorus platypterus*	o	o	o	o	o
Longbill spearfish *Tetrapturus pfluegeri*	o	o	o	o	o
Roundscale spearfish *Tetrapturus georgii*	o	o	o	o	o
Angel shark *Squatina dumeril*	o	o	o	o	o

Basking shark *Cetorhinus maximus*	o	o	o	o	o
Bigeye thresher shark *Alopias superciliosus*	o	o	o	o	o
Common thresher shark *Alopias vulpinus*	o	o	o	o	o
Blue shark *Prionace glauca*	o	o	o	o	o
Longfin mako shark *Isurus paucus*	o	o	o	o	o
Shortfin mako shark *Isurus oxyrinchus*	o	o	o	o	o
Smooth (spiny) dogfish *Squalus acanthias*	o	o	o	o	o
Tiger shark *Galeocerdo cuvier*	o	o	o	o	o
Sand tiger shark *Carcharias taurus*	o	o	o	o	o
Dusky shark *Carcharhinus obscurus*	o	o	o	o	o
Night shark *Carcharhinus isodon*	o	o	o	o	o
Scalloped hammerhead shark *Sphyrna lewini*	o	o	o	o	o
Oceanic whitetip shark *Carcharhinus longimanus*	o	o	o	o	o
Sandbar shark *Carcharhinus plumbeus*		o	o		
Silky shark *Carcharhinus falciformis*	o	o	o	o	o
Atlantic surfclam *Spisula solidissima*	o	o	o	o	o
Ocean quahog *Arctica islandica*	o	o	o	o	o
Spiny lobster *Panulirus argus*	o	o	o	o	o
Northern shortfin squid *Illex illecebrosus*	o	o	o	o	o
Longfin inshore squid *Loligo pealeii*	o	o	o	o	o
Coral, coral reefs and live/hard bottom[17]	o	o	o	o	o

1.5. Document Scope

NMFS prepared this final EA in accordance with NEPA (42 USC 4321, et seq.), CEQ Regulations (40 CFR 1500-1508), and NOAA policy and procedures set forth in the Companion Manual for 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 USGS's proposed marine geophysical survey. The scope of this analysis is limited to the decision for which we are responsible (*i.e.*, whether to issue the IHA). 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. Accordingly, this EA does not provide a detailed evaluation of the effects to the elements of the human environment listed in Table 2 below.

Table 2. Components of the human environment not affected by our issuance of an IHA.

Biological	Physical	Socioeconomic / Cultural
Amphibians	Air Quality	Commercial Fishing
Humans	Geography	Military Activities
Non-Indigenous Species	Land Use	Oil and Gas Activities
Seabirds	Oceanography	Recreational Fishing
	State Marine Protected Areas	Shipping and Boating
	Federal Marine Protected Areas	National Historic Preservation Sites
	National Estuarine Research Reserves	National Trails and Nationwide Inventory of Rivers
	National Marine Sanctuaries	Low Income Populations
	Park Land	Minority Populations
	Prime Farmlands	Indigenous Cultural Resources
	Wetlands	Public Health and Safety
	Wild and Scenic Rivers	Historic and Cultural Resources
	Ecologically Critical Areas	

Chapter 2 Alternatives

2.1. Introduction

As described in Chapter 1, NMFS's Proposed Action is to issue an Incidental Harassment Authorization (IHA) to authorize the take of small numbers of marine mammals incidental to the USGS's proposed marine geophysical survey. NMFS's Proposed Action is triggered by USGS's request for an IHA per the Marine Mammal Protection Act of 1972, as amended (MMPA; 16 U.S.C. 1361 *et seq.*). In accordance with 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 Chapter 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."

2.2. 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's implementing regulations do not include a regulatory definition for "least practicable adverse impact" but 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.

2.3. Description of Applicant's Specified Activity

As stated, the USGS plans to conduct a marine geophysical survey (*e.g.* seismic survey) in the northwest Atlantic Ocean. The procedures that will be used for the marine geophysical survey would be similar to those used during previous research seismic surveys funded by the National Science Foundation (NSF) or conducted by the USGS and would utilize a conventional seismic methodology. The survey will involve only one source vessel, the *R/V Hugh R. Sharp*. The source vessel will deploy two to four low-energy Generator-Injector (GI) airguns (each with a discharge volume of 105 cubic inches (in^3)) as an energy source. The GI guns could sometimes be fired in a mode that gives them a discharge volume of 210 in^3 each, but only at water depths greater than 1000 m (See description of Optimal Survey below for more details). A hydrophone streamer 750- to 1300-m-long and consisting of up to 160 channels will be continuously towed to receive the seismic signals. In addition, up to 90 disposable sonobuoy receivers will be deployed at water depths greater than 1000 m to provide velocity control and possibly wide-angle reflections along the highest priority transects. Below we provide a description of each of the airgun modes during the survey.

The Optimal Survey (GG mode) (See Table 3) for the Proposed Action would acquire the portion of the solid lines in Figure 1 at water depths greater than 1000 m using the GI-guns in "GG" mode. In this mode, the four GI guns would produce a total of 840 in^3 of air and sonobuoys would be deployed to passively record data at long distances. When shooting to sonobuoys while in GG mode, the GI guns will be operated with both chambers releasing air simultaneously (*i.e.*, “generator-generator” or “GG” mode). The rest of the survey, including the portion shallower than 1000 m water depth on the uppermost slope and the interseismic linking lines (dashed lines in Figure 1), would be acquired with four GI guns operated in normal mode (also called GI mode), producing a total of 420 in^3 of air.

The Base Survey (GI mode) (See Table 3) assumes that all of the solid lines in Figure 1 of the IHA Application, as well as all of the interseismic connecting lines, would be acquired using four GI guns operating in normal mode (GI mode), producing a total air volume of 420 in^3. Only a maximum of half of the interseismic linking lines (dashed lines in Figure 1 of the IHA Application) would be acquired. These lines are longer and geometrically more complex at the deepwater side than near the shelf-break.

Table 3. General characteristics of exemplary survey scenarios for the Proposed Action.

	GI mode (4x105 in^3)		**GG mode (4x210 in^3)**	
	Depth and line type	Track line distance	Depth and line type	Track line distance
Optimal Survey	100-1000 m water depth on exemplary lines AND 50% of interseismic, linking lines	~750 km	Greater than 1000 m on exemplary lines	~1600 km
Base Survey	Exemplary lines plus 50% of interseismic, linking lines	2350 km		

During the cruise, the USGS would continuously use an echosounder (EK60/EK80) with 38 kHz transducer at water depths less than ~1800 m to locate water column anomalies associated with seafloor seeps emitting gas bubbles. The 38 kHz transducer would be mounted in the *R/V Hugh R. Sharp’s* retractable keel and would typically ping 0.5 to 2 Hz with pings of 0.256 to 1.024 millisecond (m/s) duration. The returned signals would be detected on an EK60 or EK80 (broadband) transceiver. Based on past USGS experience with this instrument, it is unlikely to acquire useful data at water depths greater than 1800 m, although it could be used in passive mode at these depths to record broadband ambient signals in the water column.

Airgun Array Description

The *R/V Hugh R. Sharp* will tow two or four 105-in^3 Sercel GI airguns at a time as the primary energy source following exemplary survey lines and transit/linking/interseismic lines between the primary exemplary lines. Seismic pulses for the GI guns will be emitted at intervals of ~12 s. At speeds of ~7.4 km/h (4 knots (kn)), the shot intervals correspond to a spacing of ~25 m.

In standard GI mode, the generator chamber of each GI airgun is the primary source, the one responsible for introducing the sound pulse into the ocean, is 105 in^3. The 105 in^3 injector chamber injects air into the previously-generated bubble to reduce bubble reverberations and does not introduce more sound into the water. In GG mode, each gun simultaneously releases an air volume of 105 in^3 + 105 in^3= 210 in^3. On the proposed survey, four GI guns will be operated either in base mode (4x105 in^3) or GG mode (4x210 in^3) as long as compressors are functioning correctly. If compressors are not functioning properly, a backup mode consisting of two GI guns will be used. The text below describes the three preferred modes of operation.

The Base Configuration, Configuration 1, will use 4 GI guns and generate 420 in^3 total volume, as shown in Figure 2 of the IHA Application. Airguns will be towed at 3 m water depth, two on each side of the stern, with 8.6 m lateral (athwartships) separation between the pairs of guns and 2 m front-to-back separation between the guns on each stern tow line.

The GG Configuration, Configuration 2, will use four GI guns and generate 840 in^3 total volume, as shown in Figure 3 of the IHA application. In this configuration, the airguns will be fired in GG mode, as described above. Airguns will be towed at 3 m water depth, two on each side of the stern, with 8.6 m lateral (athwartships) separation between the pairs of airguns and 2 m front-to-back separation between the airguns on each stern tow line. The GG configuration would be used only at greater than 1000 m water depth and on specific exemplary lines on which sonobuoy data are being collected.

The Backup Configuration (Configuration 3) is two GI airguns producing 210 in^3 total volume. If a compressor were offline, this lowest-energy configuration would be used to sustain data acquisition. Airguns will be towed at 3 m water depth of the port towpoint on the stern, with 2 m front-to-back separation between the guns.

As the GI airguns are towed along the survey line, the towed hydrophone array receives the reflected signals and transfers the data to the on-board processing system. Given the short streamer length behind the vessel (1300 m), the turning rate of the vessel while the gear is deployed is much higher than the limit of five degrees per minute for a seismic vessel towing a streamer of more typical length (*e.g.*, 6 km or more). Thus, the maneuverability of the vessel is not strongly limited during operations.

Table 4. GI Airgun Specifications.

Energy Source	Two (backup configuration) to four (base and GG configuration) GI airguns of 105 in^3 each
Tow depth of energy source	3 m
Air discharge volume	Total volume ~210 in^3 (backup configuration, Appendix A) to 840 in^3 (limited use GG configuration at greater than 1000 m)
Back-to-front separation of pairs of guns	2 m
Side-to-side separation of pairs of guns	8.6 m
Dominant frequency components	0–188 Hertz

Proposed mitigation, monitoring, and reporting measures are described in detail later in this document (please see “Proposed Mitigation and Monitoring Measures” below).

2.3.1. Specified Time and Specified Area

The marine geophysical survey’s airgun operations are scheduled to occur for up to 19 days during a cruise that may be as long as 22 days, departing port on August 8, 2018. Some minor deviation from these dates is possible, depending on logistics and weather. The survey is bound within the region ~34.75° N–40° N, ~71–75° W in the northwest Atlantic Ocean (See Figure 1 of IHA application), with the closest approach to the U.S. coastline at 70 km (North Carolina) to 130 km (New Jersey). The survey area starts 35 nmi south of Hudson Canyon on the north and is bound by Cape Hatteras on the south, the nominal shelf break (~100 m water depth) on the west, and the ~3500 m bathymetric contour on the east.

2.4. Alternative 1 – Issuance of an Authorization with Mitigation Measures

The Proposed Action constitutes Alternative 1 and is the Preferred Alternative. Under this alternative, NMFS would issue an IHA to USGS allowing the incidental take, by Level B harassment only, of 29 species of marine mammals, subject to the mandatory mitigation and monitoring measures and reporting requirements set forth in the proposed IHA, if issued. This Alternative includes mandatory requirements for USGS to achieve the MMPA standard of effecting the least practicable impact on each species or stock of marine mammal and their habitat, paying particular attention to mating grounds and other areas of similar significance.

2.4.1. Proposed Mitigation and Monitoring Measures

NMFS must prescribe the means of effecting the least practicable impact on the species or stocks of marine mammals and their habitat. In order to do so, we must consider USGS's proposed mitigation measures, as well as other potential measures, and assess how such measures could benefit the affected species or stocks and their habitat. Our evaluation of potential measures is discussed in depth in Section 2.2.

To reduce the potential for disturbance associated with the activities, USGS has proposed to implement several mitigation and monitoring measures. Orca Dreams, LLC would employ the following mitigation measures:

1. Vessel-based monitoring- Protected Species Observer (PSO) observations would take place during all daytime airgun operations and nighttime start ups (if applicable) of the airguns. If airguns are operating throughout the night, observations would begin 30 minutes prior to sunrise. If airguns are operating after sunset, observations would continue until 30 minutes following sunset. Following a shutdown for any reason, observations would occur for at least 30 minutes prior to the planned start of airgun operations. Observations would also occur for 30 minutes after airgun operations cease for any reason. Observations would also be made during daytime periods when the *R/V Hugh R. Sharp* is underway without seismic operations, such as during transits, to allow for comparison of sighting rates and behavior with and without airgun operations and between acquisition periods. Airgun operations would be suspended when marine mammals are observed within, or about to enter, the designated Exclusion Zone (EZ) (as described below).

   During seismic operations, three visual PSOs would be based aboard the *R/V Hugh R.Sharp*. PSOs would be appointed by USGS with NMFS approval. During the majority of seismic operations (excluding ramp-up), one PSO will monitor for marine mammals around the seismic vessel. PSO(s) would be on duty in shifts of duration no longer than four hours. Other crew would also be instructed to assist in detecting marine mammals and in implementing mitigation requirements (if practical). Before the start of the seismic survey, the crew would be given additional instruction in detecting marine mammals and implementing mitigation requirements.

The *R/V Hugh R. Sharp* is a suitable platform from which PSOs would watch for marine mammals. Standard equipment for marine mammal observers would be 7 x 50 reticule binoculars, optical range finders, and Big Eye binoculars. At night, night-vision equipment would be available. The observers would be in communication with ship's officers on the bridge and scientists in the vessel's operations laboratory, so they can advise promptly of the need for avoidance maneuvers or seismic source shutdown.

The PSOs must have no tasks other than to conduct observational effort, record observational data, and communicate with and instruct relevant vessel crew with regard to the presence of marine mammals and mitigation requirements. PSO resumes would be provided to NMFS for approval. At least one PSO must have a minimum of 90 days at sea experience working as a PSO during a seismic survey. One "experienced" visual PSO will be designated as the lead for the entire protected species observation team. The lead will serve as primary point of contact for the USGS scientist-in-charge or his/her designee. The PSOs must have successfully completed relevant training, including completion of all required coursework and passing a written and/or oral examination developed for the training program, and must have successfully attained a bachelor's degree from an accredited college or university with a major in one of the natural sciences and a minimum of 30 semester hours or equivalent in the biological sciences and at least one undergraduate course in math or statistics. The educational requirements may be waived if the PSO has acquired the relevant skills through alternate training, including (1) secondary education and/or experience comparable to PSO duties; (2) previous work experience conducting academic, commercial, or government-sponsored marine mammal surveys; or (3) previous work experience as a PSO; the PSO should demonstrate good standing and consistently good performance of PSO duties.

2. Exclusion Zone and Buffer Zone - An EZ is a defined area within which occurrence of a marine mammal triggers mitigation action intended to reduce the potential for certain outcomes, *e.g.*, auditory injury, disruption of critical behaviors. The PSOs would establish a minimum EZ with a 100 m radius from the airgun array. The 100 m EZ would be based on radial distance from any element of the airgun array (rather than being based on the center of the array or around the vessel itself). With certain exceptions (described below), if a marine mammal appears within, enters, or appears on a course to enter this zone, the acoustic source would be shut down (see Shutdown Procedures below).

   The 100 m radial distance of the standard EZ is precautionary in the sense that it would be expected to contain sound exceeding injury criteria (Level A thresholds) for all marine mammal hearing groups (See Table 9) while also providing a consistent, reasonably observable zone within which PSOs would typically be able to conduct effective observational effort. As a result no Level A harassment is expected nor proposed for this action.

Our intent in prescribing a standard EZ distance is to (1) encompass zones within which auditory injury could occur on the basis of instantaneous exposure; (2) provide additional protection from the potential for more severe behavioral reactions (*e.g.*, panic, antipredator response) for marine mammals at relatively close range to the acoustic source; (3) provide consistency for PSOs, who need to monitor and implement the EZ; and (4) define a distance within which detection probabilities are reasonably high for most species under typical conditions.

PSOs would also establish and monitor a buffer zone equivalent to the Level B harassment zones presented in Table 5. During use of the acoustic source, occurrence of marine mammals within the buffer zone (but outside the EZ) would be communicated to the USGS scientist-in-charge or his/her designee to prepare for potential shutdown of the acoustic source. The buffer zone is discussed further under *Ramp-Up Procedures* below.

3. Shutdown Procedures - If a marine mammal is detected outside the EZ but is likely to enter the EZ, the airguns would be shut down before the animal is within the EZ. Likewise, if a marine mammal is already within the EZ when first detected, the airguns would be shut down immediately.

   Following a shutdown, airgun activity would not resume until the marine mammal has cleared the 100 m EZ. The animal would be considered to have cleared the 100 m EZ if the following conditions have been met:

   - it is visually observed to have departed the 100 m EZ;
   - it has not been seen within the 100 m EZ for 15 min in the case of small odontocetes; or
   - it has not been seen within the 100 m EZ for 30 min in the case of mysticetes and large odontocetes, including sperm, pygmy sperm, beaked whales, and large delphinids.

   This shutdown requirement would be in place for all marine mammals, with the exception of small delphinoids under certain circumstances. This exception to the shutdown requirement would apply solely to specific genera of small dolphins — *Tursiops, Steno, Stenella, Lagenorhynchus* and *Delphinus* — Instead of shutdown, the acoustic source must be powered down to the smallest single element of the array if a dolphin of the indicated genera appears within or enters the 100-m exclusion zone. If there is uncertainty regarding identification (i.e., whether the observed animal(s) belongs to the group described above), shutdown must be implemented. Power-down conditions shall be maintained until the animal(s) are no longer observed within the exclusion zone, following which full-power operations may be resumed without ramp-up. PSOs may elect to waive the power-down requirement if the animal(s) appear to be voluntarily approaching the vessel for the purpose of interacting with the vessel or towed gear, and may use best professional judgment in making this decision.

   We include this small delphinoid exception because shutdown requirements for small delphinoids under all circumstances represent practicability concerns without likely commensurate benefits for the animals in question. Small delphinoids are generally the most commonly observed marine mammals in the specific geographic region and would typically be the only marine mammals likely to intentionally approach the vessel. As described below, auditory injury is extremely unlikely to occur for mid-frequency cetaceans (*e.g.*, delphinids), as this group is relatively insensitive to sound produced at the predominant frequencies in an airgun pulse while also having a relatively high threshold for the onset of auditory injury (*i.e.*, permanent threshold shift).

A large body of anecdotal evidence indicates that small delphinoids commonly approach vessels and/or towed arrays during active sound production for purposes of bow riding, with no apparent effect observed in those delphinoids (*e.g.*, Barkaszi *et al*., 2012). The potential for increased shutdowns resulting from such a measure would require the *R/V Hugh R. Sharp* to revisit the missed track line to reacquire data, resulting in an overall increase in the total sound energy input to the marine environment and an increase in the total duration over which the survey is active in a given area. Although other mid-frequency hearing specialists (*e.g.*, large delphinoids) are no more likely to incur auditory injury than are small delphinoids, they are much less likely to approach vessels. Therefore, retaining a shutdown requirement for large delphinoids would not have similar impacts in terms of either practicability for the applicant or corollary increase in sound energy output and time on the water. We do anticipate some benefit for a shutdown requirement for large delphinoids in that it simplifies somewhat the total range of decision-making for PSOs and may preclude any potential for physiological effects other than to the auditory impacts. In addition, the required shutdown measure may prevent more severe behavioral reactions for any large delphnoids in close proximity to the source vessel.

Shutdown of the acoustic source would also be required upon observation beyond the 100 m EZ of any of the following:

- A large whale (*i.e.*, sperm whale or any baleen whale) with a calf;
- An aggregation of large whales of any species (*i.e.*, sperm whale or any baleen whale) that does not appear to be traveling (*e.g*., feeding, socializing, etc.); or
- A marine mammal species not authorized (*i.e.* a north Atlantic right whale) for take that is approaching or entering the Level B harassment zone.
- An authorized marine mammal species that has reached its total allotted Level B take that is approaching or entering the Level B harassment zone.

These would be the only four potential situations that would require shutdown of the array for marine mammals observed beyond the 100 m EZ.

4. Ramp-up Procedures- Ramp-up of an acoustic source is intended to provide a gradual increase in sound levels following a shutdown, enabling animals to move away from the source if the signal is sufficiently aversive prior to its reaching full intensity. Ramp-up would be required after the array is shut down for any reason. Ramp up to the full array would take 20 minutes, starting with operation of a single airgun and with one additional airgun added every 5 minutes.

   At least two PSOs would be required to monitor during ramp-up. During ramp up, the PSOs would monitor the 100 m EZ, and if marine mammals were observed within or approaching the 100 m EZ, a shutdown would be implemented as though the full array were operational. If airguns have been shut down due to PSO detection of a marine mammal within or approaching the 100 m EZ, ramp-up would not be initiated until all marine mammals have cleared the EZ, during the day or night. Criteria for clearing the EZ would be as described above.

Thirty minutes of pre-clearance observation are required prior to ramp-up for any shutdown of longer than 30 minutes (*i.e.*, if the array were shut down during transit from one line to another). This 30 minute pre-clearance period may occur during any vessel activity (*i.e.*, transit). If a marine mammal were observed within or approaching the 100 m EZ or 100 m buffer zone during this pre-clearance period, ramp-up would not be initiated until all marine mammals cleared the 100 m EZ or 100 m buffer zone. Criteria for clearing the EZ would be as described above. If the airgun array has been shut down for reasons other than mitigation (*e.g.*, mechanical difficulty) for a period of less than 30 minutes, it may be activated again without ramp-up if PSOs have maintained constant visual observation and no detections of any marine mammal have occurred within the EZ or 100 m buffer zone. Ramp-up would be planned to occur during periods of good visibility when possible. However, ramp-up would be allowed at night and during poor visibility if the 100 m EZ and 100 m buffer zone have been monitored by visual PSOs for 30 minutes prior to ramp-up.

The USGS scientist-in-charge or his/her designee would be required to notify a designated PSO of the planned start of ramp-up as agreed-upon with the lead PSO; the notification time should not be less than 60 minutes prior to the planned ramp-up. A designated PSO must be notified again immediately prior to initiating ramp-up procedures and the USGS scientist-in-charge or his/her designee must receive confirmation from the PSO to proceed. The USGS scientist-in-charge or his/her designee must provide information to PSOs documenting that appropriate procedures were followed. Following deactivation of the array for reasons other than mitigation, the USGS scientist-in-charge or his/her designee would be required to communicate the near-term operational plan to the lead PSO with justification for any planned nighttime ramp-up.

5. Vessel Strike Avoidance Measures - Vessel strike avoidance measures are intended to minimize the potential for collisions with marine mammals. These requirements do not apply in any case where compliance would create an imminent and serious threat to a person or vessel or to the extent that a vessel is restricted in its ability to maneuver and, because of the restriction, cannot comply.

   The proposed measures include the following: The USGS scientist-in-charge or his/her designee, the vessel operator (The University of Delaware) and crew would maintain a vigilant watch for all marine mammals and slow down or stop the vessel or alter course to avoid striking any marine mammal. A visual observer aboard the vessel would monitor a vessel strike avoidance zone around the vessel according to the parameters stated below. Visual observers monitoring the vessel strike avoidance zone would be either third-party observers or crew members, but crew members responsible for these duties would be provided sufficient training to distinguish marine mammals from other phenomena. Vessel strike avoidance measures would be followed during surveys and while in transit.

The vessel will maintain a minimum separation distance of 100 m from large whales (*i.e.*, baleen whales and sperm whales) except for north Atlantic right whales which the vessel will maintain a minimum separation distance of 500 m. If a large whale is within 100 m or a north Atlantic right whale is 500 m from the vessel, the vessel will reduce speed and shift the engine to neutral, and will not engage the engines until the whale has moved outside of the vessel's path and the minimum separation distance has been established. If the vessel is stationary, the vessel would not engage engines until the whale(s) has moved out of the vessel's path and beyond 100 m. The vessel would maintain a minimum separation distance of 50 m from all other marine mammals (with the exception of delphinids of the genera *Tursiops*, *Steno*, *Stenella*, *Lagenorhynchus* and *Delphinus* that approach the vessel, as described above). If an animal is encountered during transit, the vessel would attempt to remain parallel to the animal's course, avoiding excessive speed or abrupt changes in course. Vessel speeds would be reduced to 10 kn or less when mother/calf pairs, pods, or large assemblages of cetaceans (what constitues "large" will vary depending on species) are observed within 500 m of the vessel. Mariners may use professional judgment as to when such circumstances warranting additional caution are present.

6. Actions to Minimize Additional Harm to Live-Stranded (or Milling) Marine Mammals- In the event of a live stranding (or near-shore atypical milling) event within 50 km of the survey operations, where the NMFS stranding network is engaged in herding or other interventions to return animals to the water, the Director of OPR, NMFS (or designee) will advise the IHA-holder of the need to implement shutdown procedures for all active acoustic sources operating within 50 km of the stranding. Shutdown procedures for live stranding or milling marine mammals include the following:

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

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

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

    Shutdown procedures are not related to the investigation of the cause of the stranding and their implementation is not intended to imply that the specified activity is the cause of the stranding. Rather, shutdown procedures are intended to protect marine mammals exhibiting indicators of distress by minimizing their exposure to possible additional stressors, regardless of the factors that contributed to the stranding.

Based on our evaluation of the applicant's proposed measures, NMFS has determined that the proposed mitigation measures provide the means effecting the least practicable impact on the affected species or stocks and their habitat, paying particular attention to rookeries, mating grounds, and areas of similar significance.

2.5. Alternative 2 – No Action

In accordance with NOAAs implementing procedures, the Companion Manual (CM) 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 IHA to USGS, in which case we assume this applicant would not proceed with their proposed marine geophysical survey as described in their application. 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 CM, serves as a baseline against which the impacts of the Preferred Alternative will be compared and contrasted.

2.6. Alternatives Considered but Eliminated from Further Consideration

NMFS considered whether other alternatives could meet the purpose, need, and support of USGS's proposed project. An alternative that would allow for the issuance of an IHA with no required mitigation or monitoring measures was considered but eliminated from consideration, as it would not be in compliance with the MMPA and, therefore, would not meet the purpose and need. For that reason, this alternative is not analyzed further in this document.

Chapter 3 Affected Environment

NMFS reviewed all possible environmental, cultural, historical, social, and economic resources based on the geographic location associated with NMFS's proposed action, alternatives, and USGS's request for an IHA. Based on this review, this section describes the affected environment and existing (baseline) conditions for select resource categories. As explained in Chapter 1, certain resource categories not affected by NMFS's proposed action and alternatives were not carried forward for further consideration or evaluation in this EA (See Table 2). Chapter 4 provides an analysis and description of environmental impacts associated with the affected environment.

3.1. Physical Environment

USGS's proposed survey area lies offshore the Mid-Atlantic Bight (MAB), a 621 mi (1,000 km) coastal region stretching from Massachusetts to North Carolina. The Proposed Action is within the southern half of the MAB, with the northern edge located 35 nm south of Hudson Canyon and Cape Hatteras representing the southern extent. The western edge of the Study Area lies at the shelf-break and includes the heads of large shelf-breaking canyons, including Baltimore Canyon, Washington Canyon, and Norfolk Canyon. The eastern edge is wholly within the US EEZ.

The survey area is greatly influenced by the Gulf Stream, although the core of the Gulf Stream heads northeast and lies farther offshore with increasing distance north of Cape Hatteras. The Gulf Stream is a powerful, warm, and swiftly flowing Western Boundary Current that carries warm equatorial waters into the North Atlantic (Pickard and Emery, 1990; Verity et al., 1993). Eddies often spin off the Gulf Stream and carry warm-cored water masses toward and sometimes onto the shelf. Between the Gulf Stream's main flow and the location of the shelf break, counterclockwise gyres often develop, entraining warm water from the Gulf Stream and colder waters from near the shelf-break. Landward of these systems, currents can be complicated. The shelf-break current (primarily the Scotian current) flows southward in much of the study area, but near-surface waters sometimes locally reverse direction. Upwelling along the Atlantic coast is both wind-driven and a result of dynamic uplift (Shen et al., 2000; Lentz et al., 2003).

In addition to these currents, currents originating from the outflow of both the Chesapeake and Delaware Bays influence the surface circulation in the MAB. The Chesapeake Bay plume flows seaward from the mouth of the Bay and then turns south to form a coastal jet that can extend as far as Cape Hatteras. Similarly, the Delaware Coastal Current begins in Delaware Bay and flows southward along the Delmarva Peninsula before being entrained into the Chesapeake Bay plume. The climate for the Study Area is that of a typical marine environment. It is influenced to varying degrees year–round by passing systems, prevailing winds, and warm Gulf Stream waters. Three atmospheric pressure systems control the wind patterns and climate for this region: The Bermuda-Azores High, the Icelandic Low, and the Ohio Valley High (Blanton et al., 1985). The Bermuda-Azores High dominates the climate in the region from approximately May through August, and produces south-easterly winds of <6 m/s (<20 ft/s) (BOEM, 2012b). Persistent high levels of humidity and moisture during this time can increase precipitation levels and increase fog.

The proposed Study Area is susceptible to tropical and sub-tropical cyclones, which can greatly influence the weather and sea state. During the summer and fall, tropical cyclones are severe, but infrequent (BOEM 2012b). In contrast, during the winter and spring, extra-tropical cyclones occur frequently. Most storms, including hurricanes, occur during the North Atlantic hurricane season from June through November. Between 1815 and 2015, Atlantic tropical storms and hurricanes were most frequent in September, followed by August then October according to data from the National Hurricane Center cited by NOAA's Atlantic Oceanographic and Meteorological Laboratory (http://www.aoml.noaa.gov/hrd/tcfaq/E17.html).

3.1.1. Ambient Sound

The need to understand the marine acoustic environment is critical when assessing the effects of anthropogenic noise on marine wildlife. Sounds generated by seismic airguns within the marine environment can affect its inhabitants' behavior (*e.g.*, deflection from loud sounds) or ability to effectively live in the marine environment (*e.g.*, masking of sounds that could otherwise be heard).

Ambient sound levels are the result of numerous natural and anthropogenic sounds that can propagate over large distances and vary greatly on a seasonal and spatial scale. These ambient sounds occupy all frequencies and contributions in ocean soundscape from a few hundred Hz to 200 kHz (NRC, 2003). The main sources of underwater ambient sound are typically associated with:

- Wind and wave action
- Precipitation
- Vessel activities
- Biological sounds (*e.g.*, fish, snapping shrimp)

Ambient noise levels at any one location in the survey area 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 would be impacted by the proposed issuance of an IHA would be marine mammals, which would be directly impacted by the authorization of incidental take. The marine mammals authorized for take are discussed below.

3.2.1. Marine Mammals

Of the 29 cetacean species that may incur take during the time of the proposed survey, three are listed under the ESA as endangered: sperm whales, fin whales, and sei whales. The rest of this section deals with species distribution in the proposed survey area in the northwest Atlantic Ocean. Information on the status for each of the cetacean species is presented in Table 5 below.

Although the occurrence of North Atlantic right whale, harbor porpoise, minke whale, Bryde's whale, blue whale, and white-beaked dolphin is plausible in the survey area, NMFS has not authorized USGS to take these species. Due to the temporal and/or spatial occurrence of these species/stocks, it is such that take is not expected to occur. Density estimates presented in Roberts *et al.* (2016) present very low-density estimates within the proposed survey area for the six marine mammal species listed above during the month of August (See Table 6 of IHA Application). This, in combination with the short length of the cruise and low-level airguns provide reasonable evidence that take authorization is not necessary, nor should they be authorized for these species.

Table 5 Marine Mammals that Could Occur in the Project Area.

Common name	Scientific name	Stock	ESA/MMPA status; Strategic (Y/N)[1]	NMFS stock abundance (CV, N_{min}, most recent abundance survey)[2]	Predicted abundance (CV)[5]	PBR	Annual M/SI[3]
Order Cetartiodactyla – Cetacea – Superfamily Mysticeti (baleen whales)							
Family Balaenidae							
North Atlantic right whale	*Eubalaena glacialis*	Western North Atlantic (WNA)	E/D; Y	458 (n/a; 455; n/a)	334(0.25)	1.4	36
Family Balaenopteridae (rorquals)							
Humpback whale	*Megaptera novaeangliae novaeangliae*	Gulf of Maine	-; N	335 (.42; 239; 2012)	1,637(0.07)	3.7	8.5
Minke whale	*Balaenoptera acutorostrata acutorostrata*	Canadian East Coast	-; N	2,591 (0.81; 1,425; 2011)	2,112(0.05)	14	9
Bryde's whale	*B. edeni brydei*	None defined[4]	-; n/a	n/a	7(0.58)	n/a	n/a
Sei whale	*B. borealis borealis*	Nova Scotia	E/D; Y	357 (0.52; 236; 2011)	98(0.25)	0.5	0.8
Fin whale	*B. physalus physalus*	WNA	E/D; Y	1,618 (0.33; 1,234; 2011)	4,633(0.08)	2.5	2.65
Blue whale	*B. musculus musculus*	WNA	E/D; Y	Unknown (n/a; 440; n/a)	11(0.41)	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)	3.6	0.8
Family Kogiidae							
Pygmy sperm whale	*Kogia breviceps*	WNA	-; N	3,785 (0.47; 2,598; 2011)	678(0.23)	21	3.5
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)	50	0.4
Gervais beaked whale	*Mesoplodon europaeus*	WNA	-; N	7,092 (0.54; 4,632; 2011)		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)	Undet.	0
Family Delphinidae							
Rough-toothed dolphin	*Steno bredanensis*	WNA	-; N	271 (1.0; 134; 2011)	532(0.36)	1.3	0
Common bottlenose dolphin	*Tursiops truncatus truncatus*	WNA Offshore	-; N	77,532 (0.40; 56,053; 2011)	97,476(0.06)	561	39.4
Clymene dolphin	*Stenella clymene*	WNA	-; N	Unknown	12,515(0.56)	Undet.	0
Atlantic spotted dolphin	*S. frontalis*	WNA	-; N	44,715 (0.43; 31,610; 2011)	55,436(0.32)	316	0
Pantropical spotted dolphin	*S. attenuata attenuata*	WNA	-; N	3,333 (0.91; 1,733; 2011)	4,436(0.33)	17	0
Spinner dolphin	*S. longirostris longirostris*	WNA	-; N	Unknown	262(0.93)	Undet.	0
Striped dolphin	*S. coeruleoalba*	WNA	-; N	54,807 (0.3; 42,804; 2011)	75,657(0.21)	428	0
Short-beaked common dolphin	*Delphinus delphis delphis*	WNA	-; N	70,184 (0.28; 55,690; 2011)	86,098(0.12)	557	437
Fraser's dolphin	*Lagenodelphis hosei*	WNA	-; N	Unknown	492(0.76)	Undet.	0
Atlantic white-sided dolphin	*Lagenorhynchus acutus*	WNA	-; N	48,819 (0.61; 30,403; 2011)	37,180(0.07)	304	57
Risso's dolphin	*Grampus griseus*	WNA	-; N	18,250 (0.46; 12,619; 2011)	7,732(0.09)	126	43.2
Melon-headed whale	*Peponocephala electra*	WNA	-; N	Unknown	1,175(0.50)	Undet.	0
Pygmy killer whale	*Feresa attenuata*	WNA	-; N	Unknown	N/A	Undet.	0
False killer whale	*Pseudorca crassidens*	WNA	-; Y	442 (1.06; 212; 2011)	95(0.84)	2.1	Unk
Killer whale	*Orcinus orca*	WNA	-; N	Unknown	11	Undet.	0

Short-finned pilot whale	*Globicephala macrorhynchus*	WNA	-; Y	21,515 (0.37; 15,913; 2011)	18,977(0.11)	159	192
Long-finned pilot whale	*G. melas melas*	WNA	-; Y	5,636 (0.63; 3,464; 2011)		35	38
White-beaked dolphin	*Lagenorhynchus albirostris*	WNA	-; N	2,003 (0.94; 1,023; 2007)	39(0.42)	10	0
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)	706	307

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.nmfs.noaa.gov/pr/sars/. CV is coefficient of variation; Nmin is the minimum estimate of stock abundance. In some cases, CV is not applicable.
3 - 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.
[4]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 believed to be resident in the northern Gulf of Mexico, but does not define a separate stock in the Atlantic Ocean.
[5] Predicted mean abundance derived from Roberts *et. al.* (2016)

NOTE - Italicized species in the "Common Name" column are not expected to be taken, and no takes are authorized.

3.2.2.1 ESA-Listed Species

Sei Whale
The sei whale occurs in all ocean basins (Horwood 2009) but appears to prefer mid-latitude temperate waters (Jefferson *et al.*, 2008). It undertakes seasonal migrations to feed in subpolar latitudes during summer and returns to lower latitudes during winter to calve (Horwood 2009). The sei whale is pelagic and generally not found in coastal waters (Harwood and Wilson 2001). It occurs in deeper waters characteristic of the continental shelf edge region (Hain *et al.*, 1985) and in other regions of steep bathymetric relief such as seamounts and canyons (Kenney and Winn 1987; Gregr and Trites 2001).

Based on density modeling by Mannocci *et al*. (2017) for the western North Atlantic, higher densities are expected to occur north of 40°N during the summer; very low densities are expected south of 40°N, where the USGS surveys are entirely located.

Of the more than 11,000 sightings of sei whale individuals or groups dating back more than 50 years in the OBIS database, only seven occurred within a rectangular block containing the exemplary proposed USGS seismic survey lines. Of these, only two sightings, comprising three individuals in total, occurred between in July, August, or September (See Figure 6 IHA Application). Sei whales could be encountered in the proposed project area during an August survey, but this would be an extremely rare occurrence.

Sperm Whale
Sperm whales are found throughout the world's oceans in deep waters between about 60° N and 60° S latitudes. Their distribution is dependent on their food source and suitable conditions for breeding, and varies with the sex and age composition of the group. They are generally distributed over large areas that have high secondary productivity and steep underwater

topography, in waters at least 1,000 m deep (Jaquet and Whitehead 1996; Whitehead 2009). Based on density modeling by Mannocci et al. (2017), sperm whale are expected to occur throughout the deeper offshore waters of the western North Atlantic.

The survey slightly intersects with a core abundance area for sperm whales. This area is centered on a large, deepwater valley system that is fed by a complex series of canyons and gullies incising the slope between Hendrickson and Baltimore Canyons (NMFS 2017). In the OBIS database, 686 sperm whale sightings occur within a rectangular area encompassing the survey area, and 395 occurred during July through September. As shown in Figure 6 of the IHA Application, most of these sightings are seaward of the shelf-break in deepwater, overlapping the area of the Proposed Action. Thus, sperm whales are likely to be encountered in the proposed project area during August 2018.

Fin Whale

Fin whales are found throughout all oceans from tropical to polar latitudes. The species occurs most commonly offshore but can also be found in coastal areas (Aguilar, 2009). Most populations migrate seasonally between temperate waters where mating and calving occur in winter, and polar waters where feeding occurs in summer (Aguilar, 2009). However, recent evidence suggests that some animals may remain at high latitudes in winter or low latitudes in summer (Edwards *et al.*, 2015).

Based on density modeling by Mannocci *et al*. (2017) for the western North Atlantic, higher densities are expected to occur north of 40°; very low densities are expected south of 40°, where the USGS surveys are entirely located. Of the more than 68,000 sightings of fin whale individuals or groups dating back more than 50 years in the OBIS database, 131 occurred within a rectangular block containing the exemplary proposed USGS seismic survey lines. Of these, 29 sightings, comprising 60 individuals in total, occurred during July, August, or September (See Figure 6 of IHA Application). Fin whales could be encountered during the proposed August surveys, particularly closer to the shelf edge and near the uppermost continental slope.

3.2.2.2 Non-ESA Listed Species

Humpback Whale

Humpback whales inhabit all major ocean basins from the equator to subpolar latitudes. They generally follow a predictable migratory pattern in both hemispheres, feeding during the summer in the higher latitudes (40 to 70 degrees latitude) and migrating to lower latitudes (10 to 30 degrees latitude) where calving and breeding take place in the winter (Perry *et al.*, 1999, NOAA Fisheries 2006a). During the spring, summer, and fall, humpback whales in the North Atlantic Ocean feed over a range that includes the eastern coast of the United States, the Gulf of St. Lawrence, Newfoundland/Labrador, and western Greenland.

Based on density modeling by Mannocci *et al*. (2017) for the western North Atlantic, higher densities are expected to occur north of 40°N during the summer; very low densities are expected south of 40°N, and the USGS proposed survey is entirely south of this latitude.
Of the more than 43,000 global sightings of humpback whale individuals or groups dating back more than 50 years in the Ocean Biogeographic Information System (OBIS) database (2017),

only 79 occurred within a rectangular block containing the exemplary proposed USGS seismic survey lines. Of these, fourteen sightings occurred during July, August, or September, primarily on the continental shelf between north of Washington Canyon and the mouth of Delaware Bay (See Figure 6 of IHA Application). Three of these sightings have been at or seaward of the shelf break, near the landward ends of the two northernmost exemplary USGS seismic lines. Humpback whales could be encountered in the proposed project area during an August survey, but this would be an extremely rare occurrence.

Pygmy/Dwarf Sperm Whale

Pygmy sperm whales are found in tropical and warm-temperate waters throughout the world (Ross and Leatherwood 1994) and prefer deeper waters with observations of this species in greater than 4,000 m depth (Baird *et al.*, 2013). Both Kogia species are sighted primarily along the continental shelf edge and slope and over deeper waters off the shelf (Hansen *et al.*, 1994; Davis *et al.*, 1998). Several studies have suggested that pygmy sperm whales live mostly beyond the continental shelf edge, whereas dwarf sperm whales tend to occur closer to shore, often over the continental shelf (Rice 1998; Wang *et al.*, 2002; MacLeod *et al.*, 2004). Barros *et al*. (1998), on the other hand, suggested that dwarf sperm whales could be more pelagic and dive deeper than pygmy sperm whales. It has also been suggested that the pygmy sperm whale is more temperate and the dwarf sperm whale more tropical, based at least partially on live sightings at sea from a large database from the eastern tropical Pacific (Wade and Gerrodette 1993). This idea is also supported by the distribution of strandings in South American waters (Muñoz-Hincapié *et al.*, 1998).

Only four pygmy sperm whale sightings in the OBIS database occurred within the general area of the survey, and three of these were during the July through September period. Pygmy and dwarf sperm whales would likely be rare in the proposed project area.

Cuvier's Beaked Whale

Cuvier's beaked whale is the most widespread of the beaked whales occurring in almost all temperate, subtropical, and tropical waters and even some sub-polar and polar waters (MacLeod *et al.*, 2006). It is found in deep water over and near the continental slope (Jefferson *et al.*, 2008). It is mostly known from strandings and strands more commonly than any other beaked whale (Heyning 1989). Its inconspicuous blows, deep-diving behavior, and tendency to avoid vessels all help to explain the infrequent sightings (Barlow and Gisiner 2006).

Of the usable records in the OBIS database, 155 sightings of Cuvier's beaked whales overlap with the survey area, and 76 of these were during the July to September period. Cuvier's beaked whales could be encountered in the proposed project area.

Mesoplodont Beaked Whales (including True's, Gervais', Sowerby's, and Blainville's beaked whale)

Mesoplodont beaked whales are distributed throughout deep waters and along the continental slopes of the North Atlantic Ocean. True's beaked whale is mainly oceanic and occurs in warm temperate waters of the North Atlantic and southern Indian oceans (Pitman 2009). Gervais' beaked whale is mainly oceanic and occurs in tropical and warmer temperate waters of the Atlantic Ocean (Jefferson *et al.*, 2015). Sowerby's beaked whale occurs in cold temperate waters of the Atlantic from the Labrador Sea to the Norwegian Sea, and south to New England, the

Azores, and Madeira (Mead 1989). Blainville's beaked whale is found in tropical and warm temperate waters of all oceans; it has the widest distribution throughout the world of all mesoplodont species and appears to be relatively common (Pitman 2009).

Records of Mesoplodont beaked whale observations in the proposed survey area are varied. There are two sightings of Trues beaked whale in the OBIS database which occured in the general survey area, but only one of these was during the summer season that overlaps the Proposed Action. As a result, True's beaked whale would likely be rare in the proposed project area. No OBIS sightings of the Gervais' beaked whale have occurred in the survey area. However, given the geographic and depth range of the species, Gervais' beaked whale could be encountered in the proposed project area.

There are eleven OBIS database sightings of Sowerby's beaked whale in the polygon enclosing the larger area of the proposed surveys, and nine of these were during the summer months. Due to this, Sowerby's beaked whale could be encountered in the proposed project area. In addition, one sighting of Blainsvill occurred in the survey area during the summer months. Blainville's beaked whale could be encountered in the proposed project area.

Northern Bottlenose Whale

Northern bottlenose whales are distributed in the North Atlantic from Nova Scotia to about 70º N in the Davis Strait, along the east coast of Greenland to 77º N and from England, Norway, Iceland and the Faroe Islands to the south coast of Svalbard. It is largely a deep-water species and is very seldom found in waters less than 2,000 m deep (Mead, 1989; Whitehead and Hooker, 2012). Of the sightings in the OBIS database, one occurred within the survey area and none during July through September. Nonetheless, northern bottlenose whales could be encountered in the proposed project area.

Rough-Toothed Dolphin

The rough-toothed dolphin occurs in tropical and subtropical waters, rarely ranging farther north than 40º N (Jefferson *et al.,* 2015). It is considered a pelagic species, but it can also occur in shallow coastal waters (Jefferson *et al.,* 2015). Nine sightings in the OBIS database occur within the survey area, and seven of these were doing the summer. Rough-toothed dolphins could occur in the proposed project area.

Common Bottlenose Dolphin

Bottlenose dolphins are widely distributed throughout the world in tropical and warm-temperate waters (Perrin *et al.,* 2009). Generally, there are two distinct bottlenose dolphin ecotypes: one mainly found in coastal waters and one mainly found in oceanic waters (Duffield *et al.,* 1983; Hoelzel *et al.,* 1998; Walker *et al.,* 1999). As well as inhabiting different areas, these ecotypes differ in their diving abilities (Klatsky 2004) and prey types (Mead and Potter 1995). Only the offshore ecotype is expected to occur in the proposed survey area. In the OBIS database, 1873 sightings of bottlenose dolphins occurred within a polygon enclosing the general survey area, and 776 are within the summer months. Common bottlenose dolphins are very likely to be encountered in the proposed project area.

Clymene Dolphin

The Clymene dolphin only occurs in tropical and subtropical waters of the Atlantic Ocean

(Jefferson *et al.*, 2008). In the western Atlantic, it occurs from New Jersey to Florida, the Caribbean Sea, the Gulf of Mexico, and south to Venezuela and Brazil (Würsig *et al.*, 2000; Fertl *et al.*, 2003). It is generally sighted in deep waters beyond the shelf edge (Fertl *et al.*, 2003). Based on the USGS analyses, 23 sightings of the 140 that are usable in the OBIS database are within the overall rectangular area that encloses the surveys, and 14 of these are during the summer months.

Atlantic Spotted Dolphin

The Atlantic spotted dolphin is distributed in tropical and warm temperate waters of the North Atlantic from Brazil to New England and to the coast of Africa (Jefferson *et al.*, 2015). There are two forms of Atlantic spotted dolphin – a large, heavily spotted coastal form that is usually found in shelf waters, and a smaller and less-spotted offshore form that occurs in pelagic offshore waters and around oceanic islands (Jefferson *et al.*, 2015). In the OBIS database, 125 sightings are in the general area of the surveys, and 58 were during the summer. Atlantic spotted dolphins would likely be encountered in the proposed project area.

Pantropical Spotted Dolphin

The pantropical spotted dolphin is distributed worldwide in tropical and some sub-tropical oceans (Perrin *et al.*, 1987; Perrin and Hohn 1994). In the Atlantic, it can occur from ~40°N to 40°S but is much more abundant in the lower latitudes (Jefferson *et al.*, 2015). Pantropical spotted dolphins are usually pelagic, although they occur close to shore where water near the coast is deep (Jefferson *et al.*, 2015). Of over 4200 usable sightings in the OBIS database, 48 were in the polygon encompassing the entire survey area, and 29 of these were during the summer months. Pantropical spotted dolphins could be encountered in the proposed project area.

Spinner Dolphin

The spinner dolphin is pantropical in distribution, with a range nearly identical to that of the pantropical spotted dolphin, including oceanic tropical and sub-tropical waters between 40º N and 40º S (Jefferson *et al.*, 2008). The distribution of spinner dolphins in the Atlantic is poorly known, but they are thought to occur in deep waters along most of the U.S. coast; sightings off the northeast U.S. coast have occurred exclusively in offshore waters >2000 m (Waring *et al.*, 2010). Within the OBIS database of over 2000 usable sightings, the USGS found that none occurred in the survey area in any season. However, based on the abundance grids from Roberts *et al*. (2016), spinner dolphins could be encountered in the survey area in August 2018. Note that spinner and Clymene dolphins are often considered together in analyses, but were separated here due to the availability of density grids for each species.

Striped Dolphin

Striped dolphins are found in tropical to warm-temperate waters throughout the world (Carretta *et al.*, 2016). Striped dolphins are a deep water species, preferring depths greater than 3,500 m (Baird 2016), but have been observed approaching shore where there is deep water close to the coast (Jefferson *et al.*, 2008). The striped dolphin is typically found in waters outside the continental shelf and is often associated with convergence zones and areas of upwelling (Archer 2009). However, it has also been observed approaching shore where there is deep water close to the coast (Jefferson *et al.*, 2015). Of over 15600 sightings in the OBIS database, 183 were in the area of the survey, and 95 of these were during the summer. Striped dolphins would likely be encountered in the proposed project area.

Short-Beaked Common Dolphin

The short-beaked common dolphin is distributed in tropical to cool temperate waters of the Atlantic and the Pacific oceans from 60º N to ~50º S (Jefferson *et al.,* 2015). It is common in coastal waters 200–300 m deep (Evans 1994), but it can also occur thousands of kilometers offshore; the pelagic range in the North Atlantic extends south to ~35º N (Jefferson *et al.,* 2015). It appears to have a preference for areas with upwelling and steep sea-floor relief (Doksæter *et al.,* 2008; Jefferson *et al.,* 2015). Fewer than 0.1 percent of the nearly 43,000 of short-beaked common dolphins in the OBIS database occur in the general area of the survey, and only three were during the summer months. Short-beaked common dolphins could be encountered in the proposed project area.

Fraser's Dolphin

Fraser's dolphin is a deepwater (> 1000 m) species that occurs in subtropical to tropical waters, nominally as far north as 30° N. This species can dive to substantial water depths in search of prey. The dolphins often occur in large groups (100 or more). The OBIS database has fewer than 200 sightings of Fraser dolphins. Only three sightings were within the larger project area, and only two of those were during the summer months. Fraser's dolphins could be encountered within the survey area during the Proposed Action.

Atlantic White-Sided Dolphin

White-sided dolphins are found in temperate and sub-polar waters of the North Atlantic, primarily in continental shelf waters to the 100-m depth contour. In the western North Atlantic the species inhabits waters from central West Greenland to North Carolina (about 35° N) and perhaps as far east as 29° W in the vicinity of the mid-Atlantic Ridge (Evans 1987; Hamazaki 2002; Doksaeter *et al.*, 2008; Waring *et al.*, 2008). Based on density modeling by Mannocci *et al*. (2017) for the western North Atlantic, densities are highest north of 40° N, with densities gradually decreasing to the south. In the OBIS database, 28 sightings of the Atlantic white-sided dolphin occur in the general area of the survey, and nine of these are during the summer months. Atlantic white-sided dolphins could be encountered in the proposed project area.

Risso's Dolphin

Risso's dolphins are found in tropical to warm-temperate waters (Carretta *et al.,* 2016). The species occurs from coastal to deep water but is most often found in depths greater than 3,000 m with the highest sighting rate in depths greater than 4,500 m (Baird 2016). It primarily occurs between 60º N and 60º S where surface water temperatures are at least 10ºC (Kruse *et al.,* 1999). Based on density modeling by Mannocci *et al*. (2017) for the western North Atlantic, higher densities are expected to occur north of 40° N; very low densities are expected south of 40° N. There were 471 sightings of Risso's dolphins in the general area of the project in the OBIS database, and 238 of these were during the summer. Risso's dolphin is likely to be encountered in the proposed project area during August.

Melon-Headed Whale

The melon-headed whale is a pantropical species usually occurring between 40º N and 35º S (Jefferson *et al.,* 2008). Occasional occurrences in temperate waters are extralimital, likely associated with warm currents (Perryman *et al.,* 1994; Jefferson *et al.*, 2008). Melon-headed whales are oceanic and occur in offshore areas (Perryman *et al.*, 1994), as well as around oceanic islands. Off the east coast of the United States, sightings have been made of two groups (20 and 80) of melon-headed whales off Cape Hatteras in waters 2500 m deep during vessel surveys in 1999 and 2002 (NMFS 1999, 2002 in Waring *et al.*, 2010). The OBIS database contains more than 300 sightings records for the melon-headed whale, and none of these are within the survey area.

The Roberts *et al*. (2015b) model density grid for the melon-headed whale has only two values for abundance: zero in most of the U.S. EEZ and 0.240833 animals per 100 square kilometers (km^2) in the rest of the modeled area. There are no melon-headed whales in waters shallower than 1000 m in the model in the area of the Proposed Action, meaning that take calculations only capture potential animals in deeper waters. Melon-headed whales may be encountered during the seismic surveys, but they would likely be almost exclusively in deeper water and are more likely near the southern survey transects than the northern ones.

Killer Whale

Killer whales have been observed in all oceans and seas of the world (Leatherwood and Dahlheim 1978). Killer whale distribution in the Western Atlantic extends from the Arctic ice edge to the West Indies. Although reported from tropical and offshore waters (Heyning and Dahlheim 1988), killer whales prefer the colder waters of both hemispheres, with greatest abundances found within 800 km of major continents (Mitchell 1975). Killer whales have been sighted in shelf and offshore waters of Newfoundland and Labrador during June to September (DFO Sightings Database 2017; OBIS 2017).

Killer whales are large and conspicuous, often traveling in close-knit matrilineal groups of a few to tens of individuals (Dahlheim and Heyning 1999). Killer whales appear to prefer coastal areas, but are also known to occur in deep water (Dahlheim and Heyning 1999). In over 3000 usable killer whale sightings in the OBIS database, only 0.1 percent were within the larger rectangular area enclosing the survey, and none was during the summer months. Killer whales could be encountered within the proposed project area.

False Killer Whale

The false killer whale is distributed worldwide throughout warm temperate and tropical oceans (Jefferson *et al*., 2008). This species is usually sighted in offshore waters but in some cases inhabits waters closer shore (*e.g.*, Hawaii, Baird *et al*., 2013). While records from the U.S. western North Atlantic have been uncommon, the combination of sighting, stranding and bycatch records indicates that this species routinely occurs in the western North Atlantic. The pelagic range in the North Atlantic is usually southward of ~30° N but wanderers have been recorded as far north as Norway (Jefferson *et al*., 2015). Of more than 1100 usable sightings recorded in the OBIS database, two occurred within the rectangle enclosing the survey area, and one of those was during the summer months. False killer whales could be encountered in the proposed project area.

Pygmy Killer Whale

The pygmy killer whale is distributed worldwide in temperate to tropical waters (Caldwell and Caldwell, 1989; McAlpine, 2002). Sightings in the western North Atlantic occur in oceanic waters (Mullin and Fulling, 2003). Pygmy killer whales are usually found in deep water and rarely are found close to shore except where deepwater approaches the shore (Jefferson *et al.*, 2015).

Three sightings of pygmy killer whales are found in the OBIS database for the general area of the survey, and all of these occurred during the summer. Pygmy killer whales could occur in the survey area.

Short-Finned Pilot Whale

Short-finned pilot whales are found in all oceans, primarily in tropical and warm-temperate waters (Carretta *et al.*, 2016). The species prefers deeper waters, ranging from 324 m to 4,400 m, with most sightings between 500 m and 3,000 m (Baird 2016). Pilot whales are generally nomadic, but may be resident in certain locations (Olson 2009). There is some overlap of range with *G. melas* in temperate waters (Jefferson *et al.*, 2015). Water temperature appears to be the primary factor determining the relative distribution of these two species (Fullard *et al.*, 2000). The short-finned pilot whale inhabits pelagic as well as nearshore waters (Olson 2009). Of over 2500 usable sightings in the OBIS database, 414 were within the rectangular area encompassing the survey lines, and 105 of these were during the summer months. Thus, short-finned pilot whales would likely be encountered in the proposed project area. Note that pilot whales are dealt with as an entire guild by Roberts *et al*. (2015), meaning that there are no specific model density grids applicable to short-finned pilot whales.

Long-Finned Pilot Whale

Long-finned pilot whales occur in temperate and sub-polar zones (Jefferson *et al.*, 2015) and can be found in inshore or offshore waters of the North Atlantic (Olson 2009). In the Northern Hemisphere, their range includes the U.S. east coast, Gulf of St. Lawrence, the Azores, Madeira, North Africa, western Mediterranean Sea, North Sea, Greenland and the Barents Sea. Despite this range, which would appear to overlap with that of the Proposed Action, over 9000 records in the OBIS database yielded 51 that occurred in the rectangular box enclosing the larger survey area. Sixteen of these occurred during the summer months, mostly on the upper continental slope. The long-finned pilot whale could be encountered in the proposed study area. Note that pilot whales are dealt with as an entire guild by Roberts *et al*. (2015c), meaning that there are no specific model density grids applicable to short-finned pilot whales.

3.3. Socioeconomic Environment

3.3.1. Subsistence

There are no subsistence harvests for marine mammals within the action area. Therefore, we anticipate no impacts to the subsistence harvest of marine mammals during the proposed marine geophysical survey.

Chapter 4 Environmental Consequences

NMFS 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 the potential environmental consequences for the affected resources described in Chapter 3 for each alternative. In addition, we rely on and incorporate by reference, certain information from USGS's IHA applications and the proposed IHA. Impacts are categorized as follows:

- **Minor impacts** are generally those that might be perceptible but, in their context, are not amenable to measurement because of their relatively minor character;
- **Moderate impacts** are those that are more perceptible and, typically, more amenable to quantification or measurement;
- **Major impacts** are those that, in their context and due to their intensity (severity), have the potential to meet the thresholds for significance set forth in CEQ regulations (40 CFR 1508.27) and, thus, warrant heightened attention and examination for potential means for mitigation to fulfill the requirements of NEPA; and
- **Short-term or long-term impacts**. These characteristics are determined on a case-by-case basis and do not refer to any rigid time period. In general, short-term impacts are those that would occur only with respect to a particular activity or for a finite period. Long-term impacts are those that are more likely to be persistent and chronic.

4.1. Effects of Alternative 1 – Issuance of an IHA with Mitigation Measures

Under the Preferred Alternative, we would propose to issue an IHA to USGS allowing the take, by Level B harassment only, of 29 species of marine mammals incidental to the proposed marine geophysical survey, subject to the mandatory mitigation and monitoring measures and reporting requirements set forth in the IHA, if issued.

4.1.1. Impacts to Marine Mammal Habitat

Effects to Prey

Marine mammal prey varies by species, season, and location and, for some, it is not well documented. Fish react to sounds which are especially strong and/or intermittent low-frequency sounds. Short duration, sharp sounds can cause overt or subtle changes in fish behavior and local distribution. Hastings and Popper (2005) identified several studies that suggest fish may relocate to avoid certain areas of sound energy. Additional studies have documented effects of pulsed sound on fish, although several are based on studies in support of construction projects (*e.g.*, Scholik and Yan 2001, 2002; Popper and Hastings 2009). Sound pulses at received levels of 160 dB may cause subtle changes in fish behavior. SPLs of 180 dB may cause noticeable changes in behavior (Pearson *et al.*, 1992; Skalski *et al.*, 1992). SPLs of sufficient strength have been known to cause injury to fish and fish mortality. The most likely impact to fish from the propose marine geophysical survey would be temporary avoidance of the survey area. The duration of fish avoidance of the survey area after the marine geophysical survey stops is unknown, but a rapid return to normal recruitment, distribution and behavior is anticipated.

Information on seismic airgun impacts to zooplankton, which represent an important prey type for mysticetes, is limited. However, McCauley *et al.* (2017) reported that experimental exposure to a pulse from a 150 in^3 airgun decreased zooplankton abundance when compared with controls, as measured by sonar and net tows, and caused a two- to threefold increase in dead adult and larval zooplankton. Although no adult krill were present, the study found that all larval krill were killed after airgun passage. Impacts were observed out to the maximum 1.2 km range sampled.

In general, impacts to marine mammal prey are expected to be limited due to the relatively small temporal and spatial overlap between the proposed marine geophysical survey and any areas used by marine mammal prey species. The proposed marine geophysical survey would occur over a relatively short time (22 days) and would occur over a very small area relative to the area available as marine mammal habitat in the Northwest Atlantic Ocean. Accordingly, we believe any impacts to marine mammals due to adverse effects to their prey would be insignificant due to the limited spatial and temporal impact of the proposed survey. However, adverse impacts may occur to a few species of fish and to zooplankton.

Acoustic Habitat

Acoustic habitat is the soundscape that encompasses all of the sound present in a particular location and time, as a whole—when considered from the perspective of the animals experiencing it. 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). Together, sounds made by animals and the geophysical environment (*e.g.*, produced by earthquakes, lightning, wind, rain, waves) make up the natural contributions to the total acoustics of a place. These acoustic conditions, termed acoustic habitat, are one attribute of an animal's total habitat.

Soundscapes are also defined by, and acoustic habitat influenced by, the total contribution of anthropogenic sound. This may include incidental emissions from sources such as vessel traffic, or may be intentionally introduced to the marine environment for data acquisition purposes (as in the use of airgun arrays). Anthropogenic noise varies widely in its frequency content, duration, and loudness and these characteristics greatly influence the potential habitat-mediated effects to marine mammals (please see also the discussion on masking under "Impacts to Marine Mammals"), which may range from local effects for brief periods of time to chronic effects over large areas and for long durations. Depending on the extent of effects to habitat, animals may alter their communication signals (thereby potentially expending additional energy) or miss acoustic cues (either conspecific or adventitious). For more detail on these concepts see, *e.g.*, Barber *et al*. 2010; Pijanowski *et al*. 2011; Francis and Barber 2013; Lillis *et al*. 2014.

Problems arising from a failure to detect cues are more likely to occur when noise stimuli are chronic and overlap with biologically relevant cues used for communication, orientation, and predator/prey detection (Francis and Barber 2013). Although the signals emitted by seismic airgun arrays are generally low frequency, they would also likely be of short duration and transient in any given area due to the nature of these surveys. Exploratory surveys such as these would be transient rather than focused in a given location over time and therefore would not be considered chronic in any given location.

In summary, activities associated with the proposed action are not likely to have a permanent, adverse effect on any fish habitat or populations of fish species or on the quality of acoustic habitat. Thus, any impacts to marine mammal habitat are not expected to cause significant or long-term consequences for individual marine mammals or their populations.

4.1.2. Impacts to Marine Mammals

Potential Effects of Underwater Sound

Anthropogenic sounds cover a broad range of frequencies and sound levels and can have a range of highly variable impacts on marine life, from none or minor to potentially severe responses, depending on received levels, duration of exposure, behavioral context, and various other factors. The potential effects of underwater sound from active acoustic sources can potentially result in one or more of the following: temporary or permanent hearing impairment, non-auditory physical or physiological effects, behavioral disturbance, stress, and masking (Richardson *et al*., 1995; Gordon *et al*., 2004; Nowacek *et al*., 2007; Southall *et al*., 2007; Götz *et al*., 2009). The degree of effect is intrinsically related to the signal characteristics, received level, distance from the source, and duration of the sound exposure. In general, sudden, high level sounds can cause hearing loss, as can longer exposures to lower level sounds. Temporary or permanent loss of hearing will occur almost exclusively for noise within an animal's hearing range. We first describe specific manifestations of acoustic effects before providing discussion specific to the use of airguns.

Richardson *et al*. (1995) described zones of increasing intensity of effect that might be expected to occur, in relation to distance from a source and assuming that the signal is within an animal's hearing range. First is the area within which the acoustic signal would be audible (potentially perceived) to the animal, but not strong enough to elicit any overt behavioral or physiological response. The next zone corresponds with the area where the signal is audible to the animal and of sufficient intensity to elicit behavioral or physiological responsiveness. Third is a zone within which, for signals of high intensity, the received level is sufficient to potentially cause discomfort or tissue damage to auditory or other systems. Overlaying these zones to a certain extent is the area within which masking (*i.e.*, when a sound interferes with or masks the ability of an animal to detect a signal of interest that is above the absolute hearing threshold) may occur; the masking zone may be highly variable in size.

We describe the more severe effects certain non-auditory physical or physiological effects only briefly below as we do not expect that use of airgun arrays are reasonably likely to result in such effects. Potential effects from impulsive sound sources can range in severity from effects such as behavioral disturbance or tactile perception to physical discomfort, slight injury of the internal organs and the auditory system, or mortality (Yelverton *et al*., 1973). Non-auditory physiological effects or injuries that theoretically might occur in marine mammals exposed to high level underwater sound or as a secondary effect of extreme behavioral reactions (*e.g.*, change in dive profile as a result of an avoidance reaction) caused by exposure to sound include neurological effects, bubble formation, resonance effects, and other types of organ or tissue damage (Cox *et al*., 2006; Southall *et al*., 2007; Zimmer and Tyack, 2007; Tal *et al*., 2015). The survey activities considered here do not involve the use of devices such as explosives or mid-frequency tactical sonar that are associated with these types of effects.

Threshold Shift

Marine mammals exposed to high-intensity sound, or to lower-intensity sound for prolonged periods, can experience hearing threshold shift (TS), which is the loss of hearing sensitivity at certain frequency ranges (Finneran, 2015). TS can be permanent (PTS), in which case the loss of hearing sensitivity is not fully recoverable, or temporary (TTS), in which case the animal's hearing threshold would recover over time (Southall *et al*., 2007). Repeated sound exposure that leads to TTS could cause PTS. In severe cases of PTS, there can be total or partial deafness, while in most cases the animal has an impaired ability to hear sounds in specific frequency ranges (Kryter, 1985).

When PTS occurs, there is physical damage to the sound receptors in the ear (*i.e.*, tissue damage), whereas TTS represents primarily tissue fatigue and is reversible (Southall *et al*., 2007). In addition, other investigators have suggested that TTS is within the normal bounds of physiological variability and tolerance and does not represent physical injury (*e.g.*, Ward, 1997). Therefore, NMFS does not consider TTS to constitute auditory injury.

Relationships between TTS and PTS thresholds have not been studied in marine mammals, and there is no PTS data for cetaceans but such relationships are assumed to be similar to those in humans and other terrestrial mammals. PTS typically occurs at exposure levels at least several decibels above (a 40-dB TS approximates PTS onset; *e.g.*, Kryter *et al*., 1966; Miller, 1974) that inducing mild TTS (a 6-dB threshold shift approximates TTS onset; *e.g.*, Southall *et al.*, 2007). Based on data from terrestrial mammals, a precautionary assumption is that the PTS thresholds for impulse sounds (such as airgun pulses as received close to the source) are at least 6 dB higher than the TTS threshold on a peak-pressure basis and PTS cumulative sound exposure level (SEL_{cum}) thresholds are 15 to 20 dB higher than TTS SEL_{cum} thresholds (Southall *et al*., 2007). Given the higher level of sound or longer exposure duration necessary to cause PTS as compared with TTS, it is considerably less likely that PTS could occur.

For mid-frequency cetaceans in particular, potential protective mechanisms may help limit onset of TTS or prevent onset of PTS. Such mechanisms include dampening of hearing, auditory adaptation, or behavioral amelioration (*e.g.*, Nachtigall and Supin, 2013; Miller *et al*., 2012; Finneran *et al*., 2015; Popov *et al*., 2016).

TTS is the mildest form of hearing impairment that can occur during exposure to sound (Kryter, 1985). While experiencing TTS, the hearing threshold rises, and a sound must be at a higher level in order to be heard. In terrestrial and marine mammals, TTS can last from minutes or hours to days (in cases of strong TTS). In many cases, hearing sensitivity recovers rapidly after exposure to the sound ends. Few data on sound levels and durations necessary to elicit mild TTS have been obtained for marine mammals.

Marine mammal hearing plays a critical role in communication with conspecifics, and interpretation of environmental cues for purposes such as predator avoidance and prey capture. Depending on the degree (elevation of threshold in dB), duration (*i.e.*, recovery time), and frequency range of TTS, and the context in which it is experienced, TTS can have effects on marine mammals ranging from discountable to serious. For example, a marine mammal may be able to readily compensate for a brief, relatively small amount of TTS in a non-critical frequency range that occurs during a time where ambient noise is lower and there are not as many competing sounds present. Alternatively, a larger amount and longer duration of TTS sustained during time when communication is critical for successful mother/calf interactions could have more serious impacts.

Finneran *et al*. (2015) measured hearing thresholds in three captive bottlenose dolphins before and after exposure to ten pulses produced by a seismic airgun in order to study TTS induced after exposure to multiple pulses. Exposures began at relatively low levels and gradually increased over a period of several months, with the highest exposures at peak SPLs from 196 to 210 dB and cumulative (unweighted) SELs from 193-195 dB. No substantial TTS was observed. 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 this study). The authors note that the failure to induce more significant auditory effects 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.

Currently, TTS data only exist for four species of cetaceans (bottlenose dolphin, beluga whale, harbor porpoise, and Yangtze finless porpoise) 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 measured cetacean species (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 (2016).

Behavioral Effects

Behavioral disturbance may include a variety of effects, including subtle changes in behavior (*e.g.*, minor or brief avoidance of an area or changes in vocalizations), more conspicuous changes in similar behavioral activities, and more sustained and/or potentially severe reactions, such as displacement from or abandonment of high-quality habitat. 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). Behavioral reactions can vary not only among individuals but also within an individual, depending on previous experience with a sound source, context, and numerous other factors (Ellison *et al*., 2012), and can vary depending on characteristics associated with the sound source (*e.g.*, whether it is moving or stationary, number of sources, distance from the source). Please see

Appendices B-C of Southall *et al*. (2007) for a review of studies involving marine mammal behavioral responses to sound.

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. It is important to note that habituation is appropriately considered as a "progressive reduction in response to stimuli that are perceived as neither aversive nor beneficial," rather than as, more generally, moderation in response to human disturbance (Bejder *et al*., 2009). The opposite process is sensitization, when an unpleasant experience leads to subsequent responses, often in the form of avoidance, at a lower level of exposure. As noted, behavioral state may affect the type of response. For example, animals that are resting may show greater behavioral change in response to disturbing sound levels than animals that are highly motivated to remain in an area for feeding (Richardson *et al*., 1995; NRC, 2003; Wartzok *et al*., 2003). Controlled experiments with captive marine mammals have showed pronounced behavioral reactions, including avoidance of loud sound sources (Ridgway *et al*., 1997). Observed responses of wild marine mammals to loud pulsed sound sources (typically seismic airguns or acoustic harassment devices) have been varied but often consist of avoidance behavior or other behavioral changes suggesting discomfort (Morton and Symonds, 2002; see also Richardson *et al*., 1995; Nowacek *et al*., 2007). However, many delphinids approach acoustic source vessels with no apparent discomfort or obvious behavioral change (*e.g.*, Barkaszi *et al*., 2012).

Available studies show wide variation in response to underwater sound; therefore, it is difficult to predict specifically how any given sound in a particular instance might affect marine mammals perceiving the signal. If a marine mammal does react briefly to an underwater sound by changing its behavior or moving a small distance, the impacts of the change are unlikely to be significant to the individual, l*et al*one the stock or population. However, if a sound source displaces marine mammals from an important feeding or breeding area for a prolonged period, impacts on individuals and populations could be significant (*e.g.*, Lusseau and Bejder, 2007; Weilgart, 2007; NRC, 2005). However, there are broad categories of potential response, which we describe in greater detail here, that include alteration of dive behavior, alteration of foraging behavior, effects to breathing, interference with or alteration of vocalization, avoidance, and flight.

Changes in dive behavior can vary widely, and may consist of increased or decreased dive times and surface intervals as well as changes in the rates of ascent and descent during a dive (*e.g.*, Frankel and Clark 2000; Ng and Leung 2003; Nowacek *et al.*, 2004; Goldbogen *et al.*, 2013). Variations in dive behavior may reflect interruptions in biologically significant activities (*e.g.*, foraging) or they may be of little biological significance. The impact of an alteration to dive behavior resulting from an acoustic exposure depends on what the animal is doing at the time of the exposure and the type and magnitude of the response.

Disruption of feeding behavior can be difficult to correlate with anthropogenic sound exposure, so it is usually inferred by observed displacement from known foraging areas, the appearance of secondary indicators (*e.g.*, bubble nets or sediment plumes), or changes in dive behavior. As for other types of behavioral response, the frequency, duration, and temporal pattern of signal presentation, as well as differences in species sensitivity, are likely contributing factors to differences in response in any given circumstance (*e.g.*, Croll *et al.*, 2001; Nowacek *et al.*, 2004; Madsen *et al.*, 2006; Yazvenko *et al.*, 2007). A determination of whether foraging disruptions incur fitness consequences would require information on or estimates of the energetic requirements of the affected individuals and the relationship between prey availability, foraging effort and success, and the life history stage of the animal.

Visual tracking, passive acoustic monitoring, and movement recording tags were used to quantify sperm whale behavior prior to, during, and following exposure to airgun arrays at received levels in the range 140-160 dB at distances of 7-13 km, following a phase-in of sound intensity and full array exposures at 1-13 km (Madsen *et al*., 2006; Miller *et al*., 2009). Sperm whales did not exhibit horizontal avoidance behavior at the surface. However, foraging behavior may have been affected. The sperm whales exhibited 19 percent less vocal (buzz) rate during full exposure relative to post exposure, and the whale that was approached most closely had an extended resting period and did not resume foraging until the airguns had ceased firing. The remaining whales continued to execute foraging dives throughout exposure; however, swimming movements during foraging dives were six percent lower during exposure than control periods (Miller *et al*., 2009). These data raise concerns that seismic surveys may impact foraging behavior in sperm whales, although more data are required to understand whether the differences were due to exposure or natural variation in sperm whale behavior (Miller *et al*., 2009).

Variations in respiration naturally vary with different behaviors and alterations to breathing rate as a function of acoustic exposure can be expected to co-occur with other behavioral reactions, such as a flight response or an alteration in diving. However, respiration rates in and of themselves may be representative of annoyance or an acute stress response. Various studies have shown that respiration rates may either be unaffected or could increase, depending on the species and signal characteristics, again highlighting the importance in understanding species differences in the tolerance of underwater noise when determining the potential for impacts resulting from anthropogenic sound exposure (*e.g.*, Kastelein *et al*., 2001, 2005, 2006; Gailey *et al*., 2007; Gailey *et al*., 2016).

Marine mammals vocalize for different purposes and across multiple modes, such as whistling, echolocation click production, calling, and singing. Changes in vocalization behavior in response to anthropogenic noise can occur for any of these modes and may result from a need to compete with an increase in background noise or may reflect increased vigilance or a startle response. For example, in the presence of potentially masking signals, humpback whales and killer whales have been observed to increase the length of their songs (Miller *et al*., 2000; Fristrup *et al*., 2003; Foote *et al*., 2004), while right whales have been observed to shift the frequency content of their calls upward while reducing the rate of calling in areas of increased anthropogenic noise (Parks *et al*., 2007). In some cases, animals may cease sound production during production of aversive signals (Bowles *et al*., 1994).

Cerchio *et al*. (2014) used passive acoustic monitoring to document the presence of singing humpback whales off the coast of northern Angola and to opportunistically test for the effect of seismic survey activity on the number of singing whales. Two recording units were deployed between March and December 2008 in the offshore environment; numbers of singers were counted every hour. Generalized Additive Mixed Models were used to assess the effect of survey day (seasonality), hour (diel variation), moon phase, and received levels of noise (measured from a single pulse during each ten minute sampled period) on singer number. The number of singers significantly decreased with increasing received level of noise, suggesting that humpback whale breeding activity was disrupted to some extent by the survey activity.

Castellote *et al*. (2012) reported acoustic and behavioral changes by fin whales in response to shipping and airgun noise. Acoustic features of fin whale song notes recorded in the Mediterranean Sea and northeast Atlantic Ocean were compared for areas with different shipping noise levels and traffic intensities and during a seismic airgun survey. During the first 72 hours of the survey, a steady decrease in song received levels and bearings to singers indicated that whales moved away from the acoustic source and out of the study area. This displacement persisted for a time period well beyond the 10-day duration of seismic airgun activity, providing evidence that fin whales may avoid an area for an extended period in the presence of increased noise. The authors hypothesize that fin whale acoustic communication is modified to compensate for increased background noise and that a sensitization process may play a role in the observed temporary displacement.

Seismic pulses at average received levels of 131 dB re 1 μPa^2-s caused blue whales to increase call production (Di Iorio and Clark, 2010). In contrast, McDonald *et al*. (1995) tracked a blue whale with seafloor seismometers and reported that it stopped vocalizing and changed its travel direction at a range of 10 km from the acoustic source vessel (estimated received level 143 dB pk-pk). Blackwell *et al*. (2013) found that bowhead whale call rates dropped significantly at onset of airgun use at sites with a median distance of 41-45 km from the survey. Blackwell *et al*. (2015) expanded this analysis to show that whales actually increased calling rates as soon as airgun signals were detectable before ultimately decreasing calling rates at higher received levels (*i.e.*, 10-minute SEL_{cum} of ~127 dB). Overall, these results suggest that bowhead whales may adjust their vocal output in an effort to compensate for noise before ceasing vocalization effort and ultimately deflecting from the acoustic source (Blackwell *et al*., 2013, 2015). These studies demonstrate that even low levels of noise received far from the source can induce changes in vocalization and/or behavior for mysticetes.

Avoidance is the displacement of an individual from an area or migration path as a result of the presence of a sound or other stressors, and is one of the most obvious manifestations of disturbance in marine mammals (Richardson *et al*., 1995). For example, gray whales are known to change direction—deflecting from customary migratory paths—in order to avoid noise from seismic surveys (Malme *et al*., 1984). Humpback whales showed avoidance behavior in the presence of an active seismic array during observational studies and controlled exposure experiments in western Australia (McCauley *et al*., 2000). Avoidance may be short-term, with animals returning to the area once the noise has ceased (*e.g.*, Bowles *et al*., 1994; Stone *et al*., 2000; Morton and Symonds, 2002; Gailey *et al*., 2007). Longer-term displacement is possible, however, which may lead to changes in abundance or distribution patterns of the affected species in the affected region if habituation to the presence of the sound does not occur (*e.g.*, Bejder *et al*., 2006; Teilmann *et al*., 2006).

A flight response is a dramatic change in normal movement to a directed and rapid movement away from the perceived location of a sound source. The flight response differs from other avoidance responses in the intensity of the response (*e.g.*, directed movement, rate of travel). Relatively little information on flight responses of marine mammals to anthropogenic signals exist, although observations of flight responses to the presence of predators have occurred (Connor and Heithaus, 1996). The result of a flight response could range from brief, temporary exertion and displacement from the area where the signal provokes flight to, in extreme cases, marine mammal strandings (Evans and England, 2001). However, it should be noted that response to a perceived predator does not necessarily invoke flight (Ford and Reeves, 2008), and whether individuals are solitary or in groups may influence the response.

Behavioral disturbance can also impact marine mammals in more subtle ways. Increased vigilance may result in costs related to diversion of focus and attention (*i.e.*, when a response consists of increased vigilance, it may come at the cost of decreased attention to other critical behaviors such as foraging or resting). These effects have generally not been demonstrated for marine mammals, but studies involving fish and terrestrial animals have shown that increased vigilance may substantially reduce feeding rates (*e.g.*, Beauchamp and Livoreil 1997; Fritz *et al.*, 2002; Purser and Radford 2011). In addition, chronic disturbance can cause population declines through reduction of fitness (*e.g.*, decline in body condition) and subsequent reduction in reproductive success, survival, or both (*e.g.*, Harrington and Veitch 1992; Daan *et al.*, 1996; Bradshaw *et al.*, 1998). However, Ridgway *et al*. (2006) reported that increased vigilance in bottlenose dolphins exposed to sound over a five-day period did not cause any sleep deprivation or stress effects.

Many animals perform vital functions, such as feeding, resting, traveling, and socializing, on a diel cycle (24-hour cycle). Disruption of such functions resulting from reactions to stressors such as sound exposure are more likely to be significant if they last more than one diel cycle or recur on subsequent days (Southall *et al*., 2007). Consequently, a behavioral response lasting less than one day and not recurring on subsequent days is not considered particularly severe unless it could directly affect reproduction or survival (Southall *et al*., 2007). Note that there is a difference between multi-day substantive behavioral reactions and multi-day anthropogenic activities. For example, just because an activity lasts for multiple days does not necessarily mean that individual animals are either exposed to activity-related stressors for multiple days or, further, exposed in a manner resulting in sustained multi-day substantive behavioral responses.

Stone (2015) reported data from at-sea observations during 1,196 seismic surveys from 1994 to 2010. When large arrays of airguns (considered to be 500 in^3 or more) were firing, lateral displacement, more localized avoidance, or other changes in behavior were evident for most odontocetes. However, significant responses to large arrays were found only for the minke whale and fin whale. Behavioral responses observed included changes in swimming or surfacing behavior, with indications that cetaceans remained near the water surface at these times. Cetaceans were recorded as feeding less often when large arrays were active. Behavioral observations of gray whales during a seismic survey monitored whale movements and respirations pre-, during and post-seismic survey (Gailey *et al*., 2016). Behavioral state and water depth were the best ‘natural’ predictors of whale movements and respiration and, after considering natural variation, none of the response variables were significantly associated with seismic survey or vessel sounds.

Stress Responses

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). In many cases, an animal's first and sometimes most economical (in terms of energetic costs) response is behavioral avoidance of the potential stressor. Autonomic nervous system responses to stress typically involve changes in heart rate, blood pressure, and gastrointestinal activity. These responses have a relatively short duration and may or may not have a significant long-term effect on an animal's fitness.

Neuroendocrine stress responses often involve the hypothalamus-pituitary-adrenal system. Virtually all neuroendocrine functions that are affected by stress – including immune competence, reproduction, metabolism, and behavior – are regulated by pituitary hormones. Stress-induced changes in the secretion of pituitary hormones have been implicated in failed reproduction, altered metabolism, reduced immune competence, and behavioral disturbance (*e.g.*, Moberg 1987; Blecha 2000). Increases in the circulation of glucocorticoids are also equated with stress (Romano *et al.*, 2004).

The primary distinction between stress (which is adaptive and does not normally place an animal at risk) and "distress" is the cost of the response. During a stress response, an animal uses glycogen stores that can be quickly replenished once the stress is alleviated. In such circumstances, the cost of the stress response would not pose serious fitness consequences. However, when an animal does not have sufficient energy reserves to satisfy the energetic costs of a stress response, energy resources must be diverted from other functions. This state of distress will last until the animal replenishes its energetic reserves sufficiently to restore normal function.

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 (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).

Auditory Masking

Sound can disrupt behavior through masking, or interfering with, an animal's ability to detect, recognize, or discriminate between acoustic signals of interest (*e.g.*, those used for intraspecific communication and social interactions, prey detection, predator avoidance, navigation) (Richardson *et al*., 1995; Erbe *et al*., 2016). Masking occurs when the receipt of a sound is interfered with by another coincident sound at similar frequencies and at similar or higher intensity, and may occur whether the sound is natural (*e.g.*, snapping shrimp, wind, waves, precipitation) or anthropogenic (*e.g.*, shipping, sonar, seismic exploration) in origin. 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.

Under certain circumstances, marine mammals experiencing significant masking could also be impaired from maximizing their performance fitness in survival and reproduction. Therefore, when the coincident (masking) sound is man-made, it may be considered harassment when disrupting or altering critical behaviors. It is important to distinguish TTS and PTS, which persist after the sound exposure, from masking, which occurs during the sound exposure. Because masking (without resulting in TS) is not associated with abnormal physiological function, it is not considered a physiological effect, but rather a potential behavioral effect.

The frequency range of the potentially masking sound is important in determining any potential behavioral impacts. For example, low-frequency signals may have less effect on high-frequency echolocation sounds produced by odontocetes but are more likely to affect detection of mysticete communication calls and other potentially important natural sounds such as those produced by surf and some prey species. The masking of communication signals by anthropogenic noise may be considered as a reduction in the communication space of animals (*e.g.*, Clark *et al*., 2009) and may result in energetic or other costs as animals change their vocalization behavior (*e.g.*, Miller *et al.*, 2000; Foote *et al.*, 2004; Parks *et al.*, 2007; Di Iorio and Clark 2009; Holt *et al.*, 2009). Masking can be reduced in situations where the signal and noise come from different directions (Richardson *et al.*, 1995), through amplitude modulation of the signal, or through other compensatory behaviors (Houser and Moore 2014). Masking can be tested directly in captive species (*e.g.*, Erbe 2008), but in wild populations it must be either modeled or inferred from evidence of masking compensation. There are few studies addressing real-world masking sounds likely to be experienced by marine mammals in the wild (*e.g.*, Branstetter *et al.*, 2013).

Masking affects both senders and receivers of acoustic signals and can potentially have long-term chronic effects on marine mammals at the population level as well as at the individual level. Low-frequency ambient sound levels have increased by as much as 20 dB (more than three times in terms of SPL) in the world's ocean from pre-industrial periods, with most of the increase from distant commercial shipping (Hildebrand 2009). All anthropogenic sound sources, but especially chronic and lower-frequency signals (*e.g.*, from vessel traffic), contribute to elevated ambient sound levels, thus intensifying masking.

Ship 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). An animal at the surface may be struck directly by a vessel, a surfacing animal may hit the bottom of a vessel, or an animal just below the surface may be cut by a vessel's propeller. Superficial strikes may not kill or result in the death of the animal. These interactions are typically associated with large whales (*e.g.*, fin whales), which are occasionally found draped across the bulbous bow of large commercial ships upon arrival in port. Although smaller cetaceans are more maneuverable in relation to large vessels than are large whales, they may also be susceptible to strike. 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). Impact forces increase with speed, as does the probability of a strike at a given distance (Silber *et al.,* 2010; Gende *et al.,* 2011).

Pace and Silber (2005) also found that the probability of death or serious injury increased rapidly with increasing vessel speed. Specifically, the predicted probability of serious injury or death increased from 45 to 75 percent as vessel speed increased from 10 to 14 kn, and exceeded 90 percent at 17 kn. Higher speeds during collisions result in greater force of impact, but higher speeds also appear to increase the chance of severe injuries or death through increased likelihood of collision by pulling whales toward the vessel (Clyne, 1999; Knowlton *et al.,* 1995). In a separate study, Vanderlaan and Taggart (2007) analyzed the probability of lethal mortality of large whales at a given speed, showing that the greatest rate of change in the probability of a lethal injury to a large whale as a function of vessel speed occurs between 8.6 and 15 kn. The chances of a lethal injury decline from approximately 80 percent at 15 kn to approximately 20 percent at 8.6 kn. At speeds below 11.8 kn, the chances of lethal injury drop below 50 percent, while the probability asymptotically increases toward one hundred percent above 15 kn.

The *R/V Hugh R. Sharp* would travel at a speed of ~7.4 km/h (4 kn) while towing seismic survey gear (LGL, 2018). At these speeds, both the possibility of striking a marine mammal and the possibility of a strike resulting in serious injury or mortality are discountable. At average transit speed, the probability of serious injury or mortality resulting from a strike is less than 50 percent. However, the likelihood of a strike actually happening is again discountable. Ship strikes, as analyzed in the studies cited above, generally involve commercial shipping, which is much more common in both space and time than is geophysical survey activity. Jensen and Silber (2004) summarized ship strikes of large whales worldwide from 1975-2003 and found that most collisions occurred in the open ocean and involved large vessels (*e.g.*, commercial shipping). Commercial fishing vessels were responsible for three percent of recorded collisions, while no such incidents were reported for geophysical survey vessels during that time period.

It is possible for ship strikes to occur while traveling at slow speeds. For example, a hydrographic survey vessel traveling at low speed (5.5 kn) while conducting mapping surveys off the central California coast struck and killed a blue whale in 2009. The State of California determined that the whale had suddenly and unexpectedly surfaced beneath the hull, with the result that the propeller severed the whale's vertebrae, and that this was an unavoidable event. This strike represents the only such incident in approximately 540,000 hours of similar coastal mapping activity ($p = 1.9 \times 10^{-6}$; 95% CI = 0-5.5 x 10^{-6}; NMFS, 2013b). In addition, a research vessel reported a fatal strike in 2011 of a dolphin in the Atlantic, demonstrating that it is possible for strikes involving smaller cetaceans to occur. In that case, the incident report indicated that an animal apparently was struck by the vessel's propeller as it was intentionally swimming near the vessel. While indicative of the type of unusual events that cannot be ruled out, neither of these instances represents a circumstance that would be considered reasonably foreseeable or that would be considered preventable.

Although the likelihood of the vessel striking a marine mammal is low, we require a robust ship strike avoidance protocol (see "Proposed Mitigation"), which we believe eliminates any foreseeable risk of ship strike. Given the required mitigation measures, the relatively slow speed of the vessel towing gear, the presence of bridge crew watching for obstacles at all times (including marine mammals), the presence of marine mammal observers, and the short duration of the survey (22 days), we believe that the possibility of ship strike is discountable and, further, that were a strike of a large whale to occur, it would be unlikely to result in serious injury or mortality. No incidental take resulting from ship strike is anticipated or authorized, and this potential effect of the specified activity will not be discussed further in the following analysis.

Stranding

When a living or dead marine mammal swims or floats onto shore and becomes "beached" or incapable of returning to sea, the event is a "stranding" (Geraci *et al.*, 1999; Perrin and Geraci 2002; Geraci and Lounsbury 2005; NMFS, 2007). The legal definition for a stranding under the MMPA is (A) a marine mammal is dead and is (i) on a beach or shore of the United States; or (ii) in waters under the jurisdiction of the United States (including any navigable waters); or (B) a marine mammal is alive and is (i) on a beach or shore of the United States and is unable to return to the water; (ii) on a beach or shore of the United States and, although able to return to the water, is in need of apparent medical attention; or (iii) in the waters under the jurisdiction of the United States (including any navigable waters), but is unable to return to its natural habitat under its own power or without assistance.

Marine mammals strand for a variety of reasons, such as infectious agents, biotoxicosis, starvation, fishery interaction, ship strike, unusual oceanographic or weather events, sound exposure, or combinations of these stressors sustained concurrently or in series. However, the cause or causes of most strandings are unknown (Geraci *et al.*, 1976; Eaton, 1979; Odell *et al.*, 1980; Best 1982). Numerous studies suggest that the physiology, behavior, habitat relationships, age, or condition of cetaceans may cause them to strand or might pre-dispose them to strand when exposed to another phenomenon. These suggestions are consistent with the conclusions of numerous other studies that have demonstrated that combinations of dissimilar stressors commonly combine to kill an animal or dramatically reduce its fitness, even though one exposure without the other does not produce the same result (Chroussos 2000; Creel 2005; DeVries *et al.*, 2003; Fair and Becker 2000; Foley *et al.*, 2001; Moberg, 2000; Relyea 2005; Romero 2004; Sih *et al.*, 2004).

Use of military tactical sonar has been implicated in a majority of investigated stranding events, although one stranding event was associated with the use of seismic airguns. This event occurred in the Gulf of California, coincident with seismic reflection profiling by the *R/V Maurice Ewing* operated by Lamont-Doherty Earth Observatory (LDEO) of Columbia University and involved two Cuvier's beaked whales (Hildebrand 2004). The vessel had been firing an array of 20 airguns with a total volume of 8,500 in^3 (Hildebrand 2004; Taylor *et al.*, 2004). Most known stranding events have involved beaked whales, though a small number have involved deep-diving delphinids or sperm whales (*e.g.*, Mazzariol *et al.*, 2010; Southall *et al.*, 2013). In general, long duration (~1 second) and high-intensity sounds (>235 dB SPL) have been implicated in stranding events (Hildebrand 2004). With regard to beaked whales, mid-frequency sound is typically implicated (when causation can be determined) (Hildebrand 2004). Although seismic airguns create predominantly low-frequency energy, the signal does include a mid-frequency component. We have considered the potential for the proposed survey to result in marine mammal stranding and have concluded that, based on the best available information, stranding is not expected to occur.

Other Potential Impacts

Here, we briefly address the potential risks due to entanglement and contaminant spills. We are not aware of any records of marine mammal entanglement in towed arrays such as those considered here. The discharge of trash and debris is prohibited (33 CFR 151.51-77) unless it is passed through a machine that breaks up solids such that they can pass through a 25- milimeter (mm) mesh screen. All other trash and debris must be returned to shore for proper disposal with municipal and solid waste. Some personal items may be accidentally lost overboard. However, U.S. Coast Guard and Environmental Protection Act regulations require ship crews to become proactive in avoiding accidental loss of solid waste items by developing waste management plans, posting informational placards, manifesting trash sent to shore, and using special precautions such as covering outside trash bins to prevent accidental loss of solid waste. There are no meaningful entanglement risks posed by the described activity, and entanglement risks are not discussed further in this document.

Marine mammals could be affected by accidentally spilled diesel fuel from a vessel associated with the proposed survey activities. Quantities of diesel fuel on the sea surface may affect marine mammals through various pathways: surface contact of the fuel with skin and other mucous membranes, inhalation of concentrated petroleum vapors, or ingestion of the fuel (direct ingestion or by the ingestion of oiled prey) (*e.g.*, Geraci and St. Aubin, 1980, 1985, 1990). However, the likelihood of a fuel spill during any particular geophysical survey is considered to be remote, and the potential for impacts to marine mammals would depend greatly on the size and location of a spill and meteorological conditions at the time of the spill. Spilled fuel would rapidly spread to a layer of varying thickness and break up into narrow bands or windrows parallel to the wind direction. The rate at which the fuel spreads would be determined by the prevailing conditions such as temperature, water currents, tidal streams, and wind speeds. Lighter, volatile components of the fuel would evaporate to the atmosphere almost completely in a few days. Evaporation rate may increase as the fuel spreads because of the increased surface area of the slick. Rougher seas, high wind speeds, and high temperatures also tend to increase the rate of evaporation and the proportion of fuel lost by this process (Scholz *et al*., 1999). We do not anticipate potentially meaningful effects to marine mammals as a result of any contaminant spill resulting from the proposed survey activities, and contaminant spills are not discussed further in this document.

4.1.3. Estimated Takes of Marine Mammals by Level B Harassment

USGS has requested take, by Level B harassment only, as a result of the acoustic stimuli generated by their proposed marine geophysical survey. As mentioned previously, we estimate that the activities could potentially result in the incidental take of 29 species of marine mammals under NMFS jurisdiction by Level B harassment. For each species, estimates of take are small numbers relative to the population sizes. Table 6 describes the number of takes that we propose to authorize for the IHA as a result of USGS's activities.

Table 6 Numbers of Incidental Take Proposed for Authorization.

Species	Proposed Level B take	Proposed Level A take
Humpback whale	3	0
Sei whale	3	0

Fin whale	5	0
Sperm whale	161	0
Kogia spp.	9	0
Beaked whales	128	0
Northern bottlenose whale*	4	0
Rough-toothed dolphin	10	0
Common bottlenose dolphin	757	0
Clymene dolphin	122	0
Atlantic spotted dolphin	1598	0
Pantropical spotted dolphin	50	0
Spinner dolphin*	91	0
Striped dolphin	1459	0
Short-beaked common dolphin	1620	0
Fraser's dolphin*	204	0
Atlantic white-sided dolphin*	48	0
Risso's dolphin	237	0
Melon-headed whale*	50	0
Pygmy killer whale*	6	0
False killer whale*	28	0
Killer whale*	7	0
Pilot whales	288	0

*Proposed Level B take for rare species represent take of a single group. The value given for the proposed Level B take is the maximum group size allowed for take.

To estimate marine mammal exposures, the USGS used published, quantitative density models by Roberts *et al*. (2016) for the survey area, which is entirely within the U.S. EEZ. These models are provided at 10 km x 10 km resolution in ArcGIS compatible IMG grids on the Duke University cetacean density website (*http://seamap.env.duke.edu/models/Duke-EC-GOM-2015*). When available, the cetacean density models for Month 8 (August) were used. Otherwise, the generic annual density model was employed. Only a single density model is provided for the *Kogia* guild (dwarf and sperm pygmy whales), beaked whale guild (Blainville's, Cuvier's, Gervais', Sowerby's, and True's beaked whales), and for pilot whales.

To determine takes, the USGS combined the Duke density grids with Level A and B zones (See Tables 7 and 9) arrayed on either side of each exemplary seismic line and linking/interseismic line. The Level B and Level A takes for each species in each 10 km x 10 km block of the IMG density grids were calculated based on the fractional area of each block intersected by the Level A and Level B harassment zones for low-frequency, mid-frequency, and high-frequency cetaceans. Summing takes along all of the lines yields the total take for each species for the Proposed Action for the Base (Configuration 1) and Optimal (GG Configuration) surveys. The method also yields take for each survey line individually, allowing examination of those exemplary lines that will yield the largest or smallest take. No Level A takes were calculated while using this method.

Estimated numbers of individuals potentially exposed to sound above the Level B harassment threshold are based on the 160-dB re 1µPa (rms) criterion for all cetaceans. It is assumed that marine mammals exposed to airgun sounds that strong could change their behavior sufficiently to be considered "taken by harassment". Table 6 shows the estimates of the number of cetaceans that potentially could be exposed to ≥160 dB re 1 µPa rms (Level B take) during the USGS's proposals for the Base Survey and the Optimal Survey if no animals moved away from the survey vessel. The proposed takes in Table 6 represents 25 percent more than the number of takes calculated using the ArcGIS-based quantitative method devised by the USGS. This was used as a precautionary measure to account for potential additional seismic operations that may occur after repeat coverage of any areas where initial data quality is sub-standard.

In addition, for some species, takes were increased to account for average animal group size. These species include sei whale, humpback whale, rough toothed dolphin, northern bottlenose whale, killer whale, false killer whale, pygmy killer whale, melon-headed whale, spinner dolphin, Fraser's dolphin, and Atlantic white-sided dolphin. These species (except for rough toothed dolphin, sei whale, and humpback whale) are considered rare in the action area as shown in the density estimates in Roberts (2016). Due to this, it is only predicted and proposed that take of no more than a single group of these would occur. NMFS believes that a single incident of take of one group of any of these species represents take of small numbers for the species.

Table 7 Modeled radial distances (m) from R/V Hugh R. Sharp's airgun array to isopleths corresponding to Level B harassment thresholds.

Source and Volume	Tow Depth (m)	Water Depth (m)	Predicted RMS Radii (m) 160 dB
Base Configuration (Configuration 1) Four 105 in^3 GI-guns	3	>1000 m	1091m (3.7km^2)[1]
		100–1000 m	1637(8.42 km^2)[2]
GG Configuration (Configuration 2) Four 210 in^3 GI-guns	3	>1000 m	1244(4.86km^2)[1]
		100–1000 m	1866(10.94km^2)[2]

Table 8 Modeled Source Levels (dB) for the R/V Hugh R. Sharp's Airgun Array.

Functional Hearing Group	Configuration 1* 4x105cu^3 SEL_{cum}	Configuration 1* 4x105cu^3 Peak SPL_{flat}	Configuration 2* 4x210cu^3 SEL_{cum}	Configuration 2* 4x210cu^3 Peak SPL_{flat}	Configuration 3* 2x105cu^3 SEL_{cum}	Configuration 3* 2x105cu^3 Peak SPL_{flat}
Low frequency cetaceans ($L_{pk,flat}$: 219 dB; $L_{E,LF,24h}$: 183 dB)	213.7196	239	214.9147	240.2	208.0968	235.3
Mid frequency cetaceans ($L_{pk,flat}$: 230 dB; $L_{E,MF,24h}$: 185 dB)	213.9598	N/A	214.7985	N/A	208.2425	234.0
High frequency cetaceans ($L_{pk,flat}$: 202 dB; $L_{E,HF,24h}$: 155 dB)	214.1582	239	215.2492	240.1	208.2464	234.5

Table 9 Modeled radial distances [m(m2)] from R/V Hugh R. Sharp's airgun array to isopleths corresponding to Level A harassment thresholds.

Functional Hearing Group	Configuration 1 4x105cu^3 SEL_{cum}	Configuration 1 4x105cu^3 3m tow depth, Peak SPL_{flat}	Configuration 2 4x210cu^3 SEL_{cum}	Configuration 2 4x210cu^3 Peak SPL_{flat}	Configuration 3 2x105cu^3 SEL_{cum}	Configuration 3 2x105cu^3 Peak SPL_{flat}

Low frequency cetaceans ($L_{pk,flat}$: 219 dB; $L_{E,LF,24h}$: 183 dB)	31m (3,019m^2)	10.03m(316m^2)	39.5m(4,902m^2)	11.56m(420m^2)	10.6m(353m^2)	6.52m(134m^2)
Mid frequency cetaceans ($L_{pk,flat}$: 230 dB; $L_{E,MF,24h}$: 185 dB)	0	0	0	0	0	1.58m(8m^2)
High frequency cetaceans ($L_{pk,flat}$: 202 dB; $L_{E,HF,24h}$: 155 dB)	0	70.426m(15,582m^2)	0.1(.03m^2)	80.50m(20,358m^2)	0	42.32m(5,627m^2)

4.2. Effects of Alternative 2- 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 applicant would choose to undertake its action in compliance with the law rather than proceed without the take authorization. Under the No Action Alternative, NMFS would not issue the IHA to USGS for 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 USGS would not conduct their proposed marine geophysical survey 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.

4.3. 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.

For purposes of this analysis, the range of past, present, and reasonably foreseeable activities that have the potential to result in cumulative impacts to marine mammal populations in the proposed survey area include: climate change; marine pollution; disease; vessel traffic; marine mammal watching; past, present, and future marine geophysical survey activities in the survey area; military training and testing, and fisheries. These activities account for cumulative impacts to regional and worldwide populations of marine mammals, many of which are a small fraction of their former abundance. Available trend information indicates that most local populations of marine mammals in the action area and authorized for take are stable or increasing (Hayes *et al*., 2017).

Quantifying the biological costs for marine mammals within an ecological framework is a critical missing link to our assessment of cumulative impacts in the marine environment and assessing cumulative effects on marine mammals (Clark et al., 2009). However, based on the best available scientific information, NMFS does not expect its IHA for the USGS's MATRIX Survey to have effects or contribute to cumulative effects that could cause significant or long-term consequences for individual marine mammals or their populations. NMFS's IHA is limited to a relatively small area in the northwest Atlantic Ocean and authorizes harassment for a relatively short period of time. Further, we only anticipate and only authorize lower-level behavioral harassment of marine mammals. This section provides a brief summary of the human-related activities affecting the marine mammal species in the action area.

4.3.1. Past, Present, and Future Marine Geophysical Survey Activities in the Survey Area

Industry has not acquired any airgun seismic data on the U.S Atlantic margin between Cape Hatteras and Hudson Canyon for at least 30 years (Figure 1), except for work under contract to the academic community for acquisition of the EDGE line in 1990 (see below). The legacy industry data released by BOEM through the USGS NAMSS portal over the past few years show that the industry lines acquired between ~1975 and 1985 do not extend beyond 1500 m or occasionally 2000 m water depth in most cases.

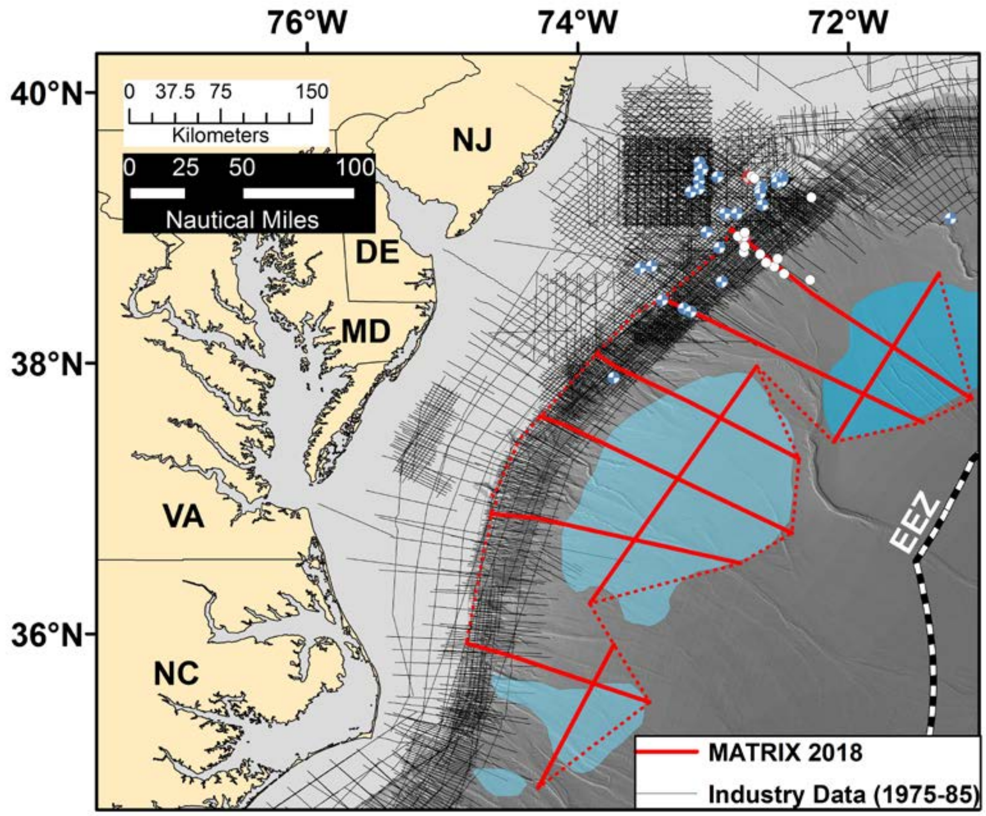

Figure 1 Industry seismic lines acquired primarily from 1975 to 1982 (some as late as 1985) are shown in black relative to the MATRIX seismic survey (Proposed Action). The industry data were released by BOEM through the USGS NAMSS portal over the past few years. The blue polygons were identified by BOEM as moderately to highly prospective for gas hydrates (BOEM, 2012a). White circles indicate research boreholes (e.g., Ocean Drilling Program and other), and blue wells were drilled by industry, including some COST wells.

In 2015, NSF funded a 540 km^2 airgun survey (700 in^3 air volume) that was carried out by the *R/V Langseth* on the New Jersey shelf between 27 and 64 m water depth (Crone et al., 2017), about 25 nm landward of the shelf-break end of the northernmost exemplary dip line (Figure 2). This survey covered an area where IODP Expedition 313 had drilled to investigate a long-term sea level rise record in 2009 (Expedition 313 Scientists, 2010).

In 2014, the USGS acquired seismic data with the 36-gun *R/V Langseth* seismic array between the northernmost exemplary line for this Proposed Action and Hudson Canyon as part of the Extended Continental Shelf (ECS) project (RPS, 2014a) in support of the U.S. Law of the Sea effort (Figure 16). The ECS line is 30 nm NNW of the landward side of the northernmost dip line for the Proposed Action and 15 nm NNW at the distal end of that dip line. The ECS cruise traveled far seaward of the EEZ and went much farther out to sea than data will be acquired in the Proposed Action.

The last extensive airgun seismic research program on the Mid-Atlantic part of the margin was carried out by the USGS in 1979 (gray lines; Figure 16). Working with partner organizations such as the BGR (Bundesanstalt fur Geowissenschaften und Rohstaffe; Hannover, Germany), the USGS acquired a grid of seismic lines within the Proposed Action area. These data have been used, and in some cases, reprocessed by BOEM to delineate some aspects of deepwater areas where gas hydrates may be present (blue polygons in Figure 2), but the data are considered too incomplete to be definitive. Navigation on these lines was before the Global Positioning System and did not even use the LORAN standard.

In 1990, NSF funded the acquisition of the EDGE seismic survey (Figure 2), which comprised one long dip line and two shorter, mostly shelf, lines shot as part of an onshore-offshore experiment (e.g., Holbrook et al., 1994). Acquisition was conducted by an industry operator (Geco). The landward end of the primary dip line is just south of Chesapeake Bay. The data along this line are of much higher quality than legacy industry data released by BOEM and significantly improved relative to the older USGS data described above. The Proposed Action has exemplary dip lines that bound the 1990 EDGE line, but do not overlap it since the EDGE data are considered good enough to contribute to better constraints on gas hydrate distributions, particularly if the data can eventually be commercially reprocessed.

In 2014, the NSF-funded ENAM project used the *R/V Langseth* to acquire MCS data between the Currituck and Cape Fear slides, north and south of Cape Hatteras (purple lines in Fig. 16). The southernmost exemplary dip line for the Proposed Action is ~10 nm north of one of the ENAM dip lines. No other MATRIX dip lines are planned by the USGS near the ENAM survey since the area has already been well-described by the 2014 seismic data, which are openly available to the marine community. The USGS plans a strike line through a deepwater hydrate feature identified by BOEM and not surveyed by ENAM in the area of the ENAM surveys and at water depths of ~2000-3000 m. This strike line will also cross an important fracture zone that played a key role in opening of this part of the Atlantic Ocean during the Mesozoic rifting event that created the ocean basin.

In June and July 2018, Scripps Institute of Oceanography (LGL, 2017) plans to collect MCS data with two 45 in^3 GI-guns aboard the *R/V Atlantis* on a NSF-funded cruise in the northwest Atlantic, outside the US EEZ. None of the area ensonified by that survey will also be ensonified by the USGS's Proposed Action.

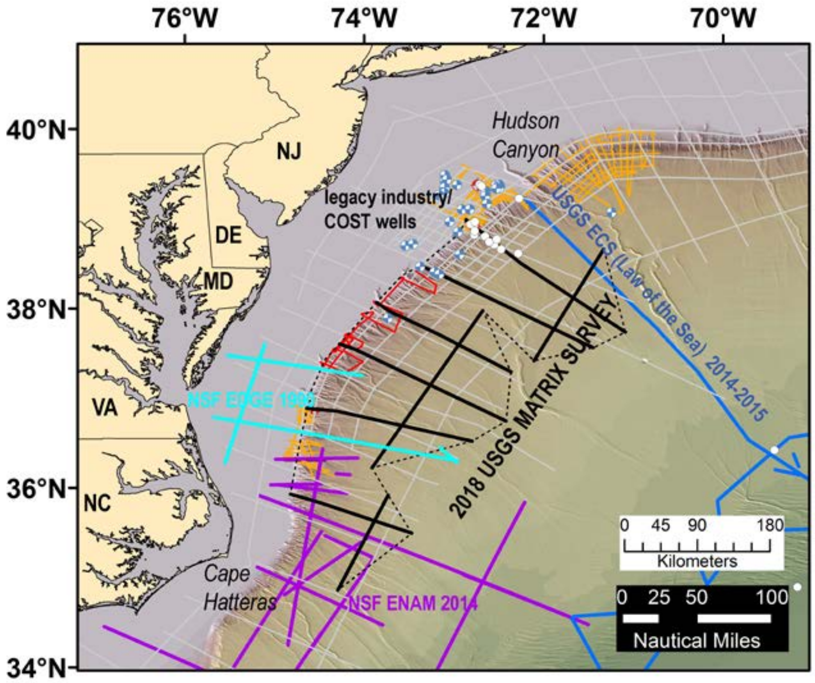

Figure 2 Past airgun seismic surveys conducted by the research community on the northern part of the U.S. Atlantic margin, along with some high-resolution (non-airgun) surveys. The gray lines show legacy USGS data, mostly from the late 1970s. Purple lines are the 2014 NSF ENAM cruise (RPS, 2014c), and navy blue lines denote the USGS-led ECS acquisition in 2014 and 2015 (RPS, 2014a, b). Light blue lines are data acquired for the NSF EDGE program by an industry operator in 1990. Also shown are the the positions of high-resolution seismic data (red, orange) acquired by the USGS with towed sparker sources on the upper slope over the past decade.

In April 2015, the USGS Gas Hydrates Project used a mini-sparker operated at less than 2.9 kJ and a ~500 m streamer to collect ~550 line-km of high-resolution seismic data in the Proposed Action Area between Wilmington and Washington Canyons, from the shelf-break to ~1500 m water depth, using the *R/V Endeavor* as the platform (Ruppel et al., 2015; red lines Figure 16). These data cannot directly image the base of the gas hydrate stability zone without analysis of the seismic attributes, nor do they penetrate the sediments deeply enough to capture all the relevant shallow gas features. They provide a good complement to the lines to be acquired during the Proposed Action in some places, but cover less than a third of the along-margin sector and only a fraction of the water depth range to be imaged during the Proposed Action. Since the late 2000s, the USGS has also acquired other low-energy (e.g., mini-sparker source), high-resolution (not very deep penetration) MCS data from the *R/V Oceanus* and the contract vessel *Tiki*. These lines (orange on Figure 16) are on the upper slope or at the shelf-break near the Currituck slide and just to the south and across the outer shelf in the area near the landward end of the northernmost exemplary dip line, just seaward of the 2015 New Jersey shelf MCS survey. None of these USGS data are useful for constraining the distribution of continuous deepwater gas hydrates.

Because the cruise tracks for academic surveys are not always public knowledge, this subsection details only those activities about which the USGS has direct knowledge over the past few years. Activities whose primary focus was the shelf (e.g., NSF-funded project on the New Jersey margin in 2015), and thus landward of the Proposed Action, are not considered. Between 2011 and 2013, the NOAA vessel *Okeanos Explorer* mapped large swaths of the Proposed Area from the shelf-break to 1500 or 2000 m water depth using hull-mounted instrumentation. Most of the data were acquired with a Kongsberg EM302 hull-mounted multibeam (30 kHz), with additional information sometimes acquired using a Knudsen hull-mounted Chirp. An EK60 system with multiple transducers was operational during many of the activities, but did not yield useful data for most of them due to a calibration problem (T. Weber, pers. comm.). NOAA's Deep Discoverer ROV also conducted a few dives in the survey area during this period. The *Okeanos Explorer* will conduct expeditions that include MBES, EK60, and Knudsen mapping and D2 dives on the U.S. Atlantic margin starting in mid-2018, with some activities focused on the mid-Atlantic part of the margin, particularly if dives or additional MBES mapping are requested there by the larger marine community. The USGS participates in planning activities for the *Okeanos Explorer* program, and the only potential overlap in time is for the northernmost dip line in the survey area during August 2018. The USGS has already provided NOAA's Ocean Exploration and Research Program with the GIS file containing survey lines for the Proposed Action.

A pre-2015 NOPP activity that involved BOEM, NOAA, and the USGS conducted other ROV dives and AUV operations in localized areas to study corals, canyon habitats, and chemosynthetic communities at seep sites. The NOPP cruises typically used NOAA vessels (e.g., *R/V Nancy Foster*) or other available vessels. The full range of activities carried out by NMFS itself is unknown, but is believed to be often confined to the shelf and uppermost continental slope, with the exception of some specialized surveys (e.g., beaked whale surveys out of NEFSC; Cholewiak, 2017). A newly funded NOPP collaboration commenced in 2017 and conducted brief mapping offshore Cape Hatteras in 2017. The 2018 program will include *DSV Alvin* dives and more multibeam mapping in the southern part of the survey area during the summer. The Alvin expedition is co-led by a USGS investigator, with whom the lead MATRIX lead PI often collaborates and with whom the MATRIX program is coordinating.

Due to its involvement in the discovery of more than 570 seep sites on the US Atlantic margin as published in a 2014 paper and database (Skarke et al., 2014), the USGS has led or been a part of 6 cruises in the landward side of the Proposed Action area (shelf-break to upper slope depths of ~1500 m) since 2014. In July 2014, a NSF-sponsored cruise conducted CTDs, EK60 water column imaging, and Knudsen imaging in Hudson Canyon and at an adjacent control site on the upper continental slope as part of a methane flux and oxidation rate study aboard the *R/V Endeavor*. In April 2015, the USGS collected high-resolution (mini-sparker source) MCS data between Wilmington and Washington Canyons, as mentioned above. In September 2015, the USGS led a piston coring, multicoring, and EK60 survey that sampled sites from Washington Canyon to the New England margin. In March 2016, the USGS participated in a *R/V Neil Armstrong* science verification cruise that acquired multibeam and EK60 data along isolated tracklines from Cape Hatteras to Baltimore Canyon. In May 2017, the USGS conducted a ROV cruise sponsored primarily by NOAA OER, diving on sites from between just south of Norfolk Canyon to Baltimore Canyon and collecting authigenic carbonates, benthic community samples, water, and sediments. In August/September 2017, the USGS co-led a CTD, large volume water sampling, and EK60 cruise from Cape Hatteras to Baltimore Canyon. We are also aware of a DSV Alvin cruise led by Cindy Van Dover in 2015. In the area from north of Cape Hatteras and stretching nearly to Georges Bank, this cruise conducted about a dozen dives on seep sites originally described by Skarke et al. (2014).

The northernmost exemplary dip lines for MATRIX purposely intersect or come close to industry/research wells (e.g., COST B-3, completed in 1979) and some ODP upper continental slope boreholes (e.g., for ODP Leg 150 in 1993, ODP Leg 174A in 1997). Acquiring modern MCS data along these lines will enhance the utility of stratigraphic and timing data from these wells and advance the interpretation of the existing borehole logs.

Several IHAs for industry seismic activities have been considered by BOEM and NMFS over the past few years, and more could be anticipated with implementation of Executive Order 13795 of April 28, 2017. Nonetheless, the USGS MATRIX Survey is limited to a relatively small area in the Northwest Atlantic Ocean and will occur during a relatively short period of time. NMFS only anticipates and is only authorizing lower-level harassment of marine mammals, which should only result in temporary behavioral changes in marine mammals. Accordingly, the cumulative impacts of the IHA for the MATRIX Survey are negligible and will be mitigated consistent with the requirements of Section 101(a)(5)(D) of the MMPA. Future IHAs for similar surveys will likewise produce minor, mitigated impacts to marine mammals, consistent with the requirements of the MMPA.

4.3.2. Vessel Traffic

Several major ports are located between Cape Hatteras and Hudson Canyon, and traffic to Norfolk, Baltimore, and New York City and into Delaware Bay all crosses parts of the Proposed Action area. Vessel traffic in the project area would consist mainly of cargo vessels, commercial fishing vessels, and tankers, as well as U.S. Navy vessels (near Norfolk especially), and an occasional cruise ship and long-distance sailboat. As of 22 February, the Automated Mutual-Assistance Vessel Rescue (AMVER) site was unavailable (last attempted access on 3 March, 2018). This system, managed by the U.S. Coast Guard (USCG), provides information about all identified ship traffic. Live vessel traffic information is available from MarineTraffic, including vessel names, types, flags, positions, and destinations, but legacy information requires payment. Various types of vessels were within the total area of the Proposed Action when marinetraffic.com was accessed on March 3, 2018, including cargo vessels (16), tankers (4), and a passenger vessel. In August 2018, commercial fishing vessels are also expected to be in the area, and the USGS has frequently encountered Navy vessels and operations in the part of the survey area between Delaware Bay and Cape Hatteras on previous cruises. The *R/V Hugh R. Sharp's* expects to spend 1-2 days acquiring data on each of the exemplary seismic lines, meaning that it will add only negligible additional traffic. Analysis of the 2012 USCG Automatic Identification System (AIS) shipping density grid for the area north of the Maryland-Virginia border as provided by the Mid-Atlantic Ocean Data Portal from MARCO shows that the exemplary seismic lines for the Proposed Action intersect locations with up to six ship tracks per year on an annualized basis. Thus, the combination of the USGS operations with the existing shipping operations is expected to produce only a negligible increase in overall ship disturbance effects on marine mammals.

4.3.3. Fisheries

The primary contributions of fishing to potential cumulative impacts on marine mammals involve direct and indirect removal of prey items, sound produced during fishing activities, and potential entanglement (Reeves et al. 2003). There may be some localized avoidance or attraction by marine mammals of fishing vessels near the proposed project area. Fishing operations in the proposed project area are likely to be limited to the upper continental slope and locations near canyons.

The USGS's proposed operations are of limited duration (< 1 month), with only 1-2 days operating on a specific line. The combination of the USGS's operations with the existing commercial fishing operations is expected to produce only a negligible increase in overall disturbance effects on marine mammals and sea turtles. Proposed survey operations should not impede fishing operations, and the *R/V Hugh R. Sharp* would avoid fishing vessels when towing seismic equipment. Operation of the *R/V Hugh R. Sharp,* therefore, would not be expected to significantly impact commercial fishing operations in the area.

4.3.4. 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. Bottlenose dolphins in the western Atlantic experienced elevated strandings from 2013 to 2015, resulting in an Unusual Mortality Event (UME) event attributable to cetacean morbillivirus (Hayes *et al*., 2017). 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 (Hayes *et al*., 2017). There are no other known diseases threatening marine mammals in the survey area at this time. Issuance of IHAs will not result in any additive effects or spreading of disease. USGS's proposed marine geophysical survey activities are not expected to affect the disease rate among marine mammals in the project vicinity.

4.3.5. 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 marine geophysical surveys are not expected to cause increased exposure of persistent organic pollutants to marine mammals in the survey area, 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 survey area. Accidentally spilled diesel fuel from a vessel could pose a potential threat to marine mammals, but NMFS finds the likelihood of this 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). We acknowledge the transboundary nature of ocean noise and that it can cause many of the same impacts to marine mammals as contaminant pollution (e.g., physiological consequences, suppressed immune system response), but we do not consider it here as an actual form of pollution until it is formally recognized in a regulatory context applicable to our statutory authority under the MMPA.

4.3.6. Military Activities

The survey area 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 draft EIS/OEIS, published in June 2017: www.aftteis.com) and other documents related to previous phases of the Navy's activities in the AFTT Study Area on NMFS' website: www.fisheries.noaa.gov/national/marine-mammal-protection/incidental-take-authorizations-military-readiness-activities. Besides an increase in vessel traffic and temporary noise increases from airguns, USGS's proposed marine geophysical survey activities are not expected to significantly increase the cumulative impacts resulting from military activities in the survey area.

4.3.7. 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 survey area 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 survey area, whether positive or negative, cannot currently be predicted.

4.3.8. Marine Mammal Watching

Although marine mammal watching is considered by many to be a non-consumptive use of marine mammals with economic, recreational, educational and scientific benefits, it is not without potential negative impacts. One concern is that animals may become more vulnerable to vessel strikes once they habituate to vessel traffic (Swingle *et al*., 1993; Laist *et al*., 2001; Jensen and Silber, 2004). Another concern is that preferred habitats may be abandoned if disturbance levels are too high. Several recent research efforts have monitored and evaluated the impacts of people closely approaching, swimming, touching and feeding marine mammals and has suggested that marine mammals are at risk of being disturbed ("harassed"), displaced or injured by such close interactions. Researchers investigating the adverse impacts of marine mammal viewing activities have reported boat strikes, disturbance of vital behaviors and social groups, separation of mothers and young, abandonment of resting areas, and habituation to humans (Nowacek *et al*., 2001, Bejder et al 2006, Higham et al 2009).

While marine mammal watching operations may occur near the proposed project area, no marine mammal-watching operations are expected to occur within the survey area itself. The cumulative adverse effects of the proposed action on the affected populations when added to the effects of marine mammal watching are not expected to be significant.

Chapter 5 List of Preparers and Agencies Consulted

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