Final Environmental Assessment of a Marine Geophysical Survey (MATRIX) by the US Geological Survey in the Northwestern Atlantic Ocean, August 2018

Prepared by the U.S. Geological Survey,
Coastal and Marine Geology Program
(now the Coastal and Marine Hazards and Resources Program)

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TABLE OF CONTENTS

ABSTRACT

The U.S. Geological Survey (USGS) plans to conduct a seismic survey aboard the oceanographic research vessel *R/V Hugh R. Sharp*, owned by University of Delaware, in the northwestern Atlantic offshore the Mid-Atlantic Bight in August 2018. The survey will take place in the U.S. Exclusive Economic Zone (EEZ) in water depths of 100 to 3500 m from 35 nm south of Hudson Canyon to approximately Cape Hatteras. The seismic study will be conducted soley from the *R/V Hugh R. Sharp* using as seismic sources two to four GI airguns, each with a discharge volume of 105 in^3. The GI guns will generate a total air volume of 420 in^3 in the base configuration and 840 in^3 in the so-called GG configuration, which could be used at water depths greater than 1000 m during recording of seismic arrivals on sonobuoys. A backup configuration would use only 2 GI guns, each firing at 105 in^3.

The purpose of this survey is to acquire up to 2400 line-kilometers of modern multichannel seismic data to constrain the distribution of gas hydrates and shallow gas, particularly in areas considered highly prospective for methane hydrate deposits. The data would also be used to support USGS mission goals related to the study of submarine hazards (e.g., slides). The survey will fill a gap in modern seismic data on the Mid-Atlantic part of the margin and yield data that are likely to be used by the research community on a multidecadal time scale.

The USGS will be requesting an Incidental Harassment Authorization (IHA) from the U.S. National Marine Fisheries Service (NMFS) to authorize the incidental, i.e., not intentional, harassment of small numbers of marine mammals (should this occur) during the seismic survey. The information in this Environmental Assessment (EA) supports the IHA application process and provides information on marine species that are not addressed by the IHA application, including seabirds and sea turtles that are listed under the U.S. Endangered Species Act (ESA) and candidate species, fish, and Essential Fish Habitat (EFH). The EA explicitly addresses the requirements of the National Environmental Policy Act (NEPA). Alternatives addressed in this EA consist of conducting the same geophysical program at a different time, along with issuance of an associated IHA; and the no action alternative, with no IHA and no seismic survey.

In accordance with priorities articulated by the Council on Environmental Quality and the Secretary of the Interior in an order of August 2017, this EA attempts to streamline to the extent possible, while also providing a document complete enough to fully represent the Proposed Action. This EA is tiered to, and incorporates by reference, material from the *Final Programmatic Environmental Impact Statement/Overseas Environmental Impact Statement for Marine Seismic Research Funded by the National Science Foundation or Conducted by the U.S. Geological Survey* (NSF and USGS 2011; termed the NSF-USGS PEIS) and the corresponding USGS *Record of Decision* (2013). To reduce repetition among EAs for similar actions, portions of this EA (including this abstract) are adopted with small modifications or taken verbatim from the Draft EA prepared for the 2017 NSF-funded program for low-energy seismics to be conducted by Scripps Institute of Oceanography (LGL, 2017) in the Northwestern Atlantic. That Draft EA (LGL, 2017) is also incorporated herein by reference, as are other EAs produced for U.S. Atlantic margin projects conducted by NSF and the USGS since 2014.

Numerous species of marine mammals could be present in the proposed project area in the Northwest Atlantic Ocean. Under the U.S. ESA, several of these species are listed as ***endangered***, including the North Atlantic right, sei, fin, blue, and sperm whales. ESA-listed sea turtle species that could occur in the project area include the ***endangered*** leatherback, hawksbill, Kemp's ridley, and loggerhead (Northeast Atlantic Ocean Distinct Population Segment or DPS) turtles and the ***threatened*** green (North Atlantic DPS) and loggerhead (Northwest Atlantic Ocean DPS) turtles. ESA-listed seabirds that could be encountered in the area include the ***endangered*** Bermuda petrel, black capped petrel, and roseate tern. In addition, the ***endangered*** Atlantic sturgeon and shortnose sturgeon could be present, as well as the ***threatened*** giant manta ray and oceanic whitetip shark.

Potential impacts of the seismic survey on the environment would be primarily a result of the operation of the GI airguns. A 38 kHz fisheries sonar would also be operated during the surveys at water depths shallower than ~1800 m. Impacts that could be associated with particularly the airguns are mostly due to increased underwater noise, which may result in avoidance behavior by marine mammals, sea turtles, seabirds, and fish, and other forms of disturbance. An integral part of the planned survey is a monitoring and mitigation program designed to (a) minimize impacts of the proposed activities on marine animals present during the proposed research and (b) document as much as possible the nature and extent of any effects. Injurious impacts to marine mammals, sea turtles, and seabirds have not been proven to occur near airgun arrays, including high-energy airgun arrays generating air volumes over five times as large as those planned for the Proposed Action. Nor are effects likely to be caused by the other type of sound source to be used. However, despite the relatively low levels of sound emitted the GI airguns, a precautionary approach would still be taken. The planned monitoring and mitigation measures would reduce the possibility of injurious effects.

Protection measures designed to mitigate the potential environmental impacts to marine mammals, sea turtles, and seabirds would include the following: ramp ups; typically two, but a minimum of one observer maintaining a visual watch during all daytime airgun operations; two observers 30 min before and during ramp ups during the day; no start ups during poor visibility or at night unless at least one airgun (mitigation gun) has been operating; and shut downs when marine mammals or sea turtles are detected in or about to enter designated exclusion zones. The acoustic source would also be powered or shut down in the event an ESA-listed seabird were observed diving or foraging within the designated exclusion zone. Observers would also watch for any impacts the acoustic sources may have on fish. The USGS is committed to applying these measures in order to minimize effects on marine mammals, sea turtles, seabirds, and fish, and other environmental impacts. Survey operations would be conducted in accordance with all applicable U.S. federal regulations, including IHA and Incidental Take Statement (ITS) requirements.

With the planned monitoring and mitigation measures, unavoidable impacts to each species of marine mammal and turtle that could be encountered would be expected to be limited to short-term, localized changes in behavior and distribution near the seismic vessel. At most, effects on marine mammals may be interpreted as falling within the U.S. MMPA definition of "Level B Harassment" for those species managed by NMFS; however, the USGS is required to request, and NMFS may issue, Level A take for some marine mammal species. No long-term or significant effects would be expected on individual marine mammals, sea turtles, seabirds, fish, the populations to which they belong, or their habitats.

LIST OF ACRONYMS

AEP	Auditory evoked potential
AMVER	Automated Mutual-Assistance Vessel Rescue System
ArcGIS	Arc-Geographic Information Systems (software)
BOEM	Bureau of Ocean Energy Management
CFR	Code of Federal Regulations
CITES	Convention on International Trade in Endangered Species
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
COST	Continental offshore stratigraphic test
CPA	Closest point of approach
CPUE	Catch per unit effort
CTD	Conductivity-temperature-depth sensor
DAA	Detailed Analysis Area (from the NSF-USGS PEIS)
dB	decibel
DD	data deficient
DE	Delaware
DOE	U.S. Department of Energy
DoW	Defenders of Wildlife
DPS	distinct population segment
DSV	Deep Submergence Vehicle
EA	Environmental Assessment
EBSA	Ecologically or Biologically Significant Area
ECS	Extended Continental Shelf
EDGE	NSF-funded Mid-Atlantic seismic experiment 1990
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
EN	Endangered
ENAM	Eastern North American Margin (2014 NSF-funded seismic experiment)
ESA	(U.S.) Endangered Species Act
EZ	Exclusion Zone
FR	Federal Register
GARFO	Greater Atlantic Regional Fishery Office (NOAA)
GG	Generator-generator mode on a GI gun
GI	Generator-Injector
GIS	Geographic Information System
GOM	Gulf of Mexico
GPS	Global Positioning System
HAPC	Habitat of Particular Concern
HF	High Frequency
IHA	Incidental Harassment Authorization (under MMPA)
IHAA	IHA Application
IMG	Imagine raster file
IODP	Integrated Ocean Drilling Program

ITS	Incidental Take Statement
IUCN	International Union for the Conservation of Nature
IWC	International Whaling Commission
kHz	kiloHertz
kJ	kiloJoule
km	kilometer
kt	knot
LC	Least Concern
L-DEO	Lamont-Doherty Earth Observatory
LF	Low Frequency
LORAN	long-range navigation
m	meter
MAB	Mid-Atlantic Bight
MAFMC	Mid-Atlantic Fishery Management Council
MATRIX	**Proposed Action: Mid-Atlantic Resource Imaging Experiment (USGS 2018)**
MCS	multichannel seismic
MD	Maryland
MDAT	Marine-life Data and Analysis Team
MMPA	(U.S.) Marine Mammal Protection Act
MPA	Marine Protected Area
MRFSS	Marine Recreational Fisheries Statistics Survey (NMFS)
MRIP	Marine Recretional Information Program (NFMS)
NAMMCO	North Atlantic Marine Mammal Commission
NAMSS	National Archive of Marine Seismic Surveys (walrus.wr.usgs.gov/NAMSS/)
NC	North Carolina
NEFSC	Northeast Fisheries Science Center
NEPA	(U.S.) National Environmental Policy Act
NJ	New Jersey
NL	not listed (for ESA)
NMFS	(U.S.) National Marine Fisheries Service
NOAA	(U.S.) National Oceanographic and Atmospheric Administration
NODES	(U.S.) Navy OPAREA Density Estimates
NOPP	National Oceanographic Partnership Program
NSF	National Science Foundation
NY	New York
OBIS	Ocean Biographic Information System
ODP	Ocean Drilling Program
OEIS	Overseas Environmental Impact Statement
OPR	Office of Protected Resources (NMFS)
OW	Otariids underwater
p or pk	peak
PEIS	Programmatic Environmental Impact Statement
PTS	Permanent Threshold Shift
PSO	Protected Species Observer
PW	Phocids underwater
QAA	Qualitative Analysis Area

rms	root-mean-square
ROD	Record of Decision
ROV	Remotely-operated vehicle
R/V	Research vessel
s	second
SAFMC	South Atlantic Fishery Management Council
SEL	Sound Exposure Level
SIGH	Seismic Imaging of Gas Hydrate (USGS Gulf of Mexico, 2013)
SIO	Scripps Institute of Oceanography
SL	Sound level
SPL	Sound pressure level
TED	turtle excluder device
TEWG	Technical Expert Working Group—Greater Atlantic Regional Fisheries
TTS	Temporary Threshold Shift
UNOLS	University-National Oceanographic Laboratory System
U.S.	United States of America
USGS	U. S. Geological Survey
USFWS	U.S. Fish and Wildlife Service
µPa	microPascal
VA	Virginia
VU	vulnerable

I. PURPOSE AND NEED

This Environmental Analysis (EA) provides information needed to assess the potential environmental impacts associated with the U.S. Geological Survey's (USGS's) Proposed Northwest Atlantic Action, which includes the use of as many as four Generator-Injector (GI) airguns operated mostly at 420 to 840 in^3 during seismic surveying in August 2018. The EA was prepared under the National Environmental Policy Act (NEPA). In accordance with CFR §46.120 and §46.140, this EA tiers to the Final Programmatic Environmental Impact Statement (EIS)/Overseas Environmental Impact Statement (OEIS) for Marine Seismic Research funded by the National Science Foundation or Conducted by the U.S. Geological Survey (NSF and USGS 2011; henceforth referred to as the NSF-USGS PEIS) and USGS Record of Decision on the NSF-USGS PEIS (USGS, 2013; henceforth referred to as the USGS ROD). This EA incorporates by reference the "Draft Environmental Analysis of a Low-Energy Marine Geophysical Survey by *R/V Atlantis* in the Northwest Atlantic Ocean, June-July 2018," (LGL Report FAO139-1, 2017) as prepared for Scripps Institute of Oceanography and the National Science Foundation and as submitted to NMFS in December 2017." That Draft EA is henceforth referred to at the "Draft Scripps EA (LGL, 2017)." Long passages of this EA are taken verbatim from the Draft Scripps EA or used verbatim with small modifications to represent the USGS activity. Passages from other EAs prepared for research seismic programs on the U.S. Atlantic margin are also used here verbatim or with small modifications.

This EA provides details of the Proposed Action at the site-specific level and addresses potential impacts of the proposed seismic surveys on marine mammals, as well as other species of concern in the area, including sea turtles, seabirds, fish, and marine invertebrates. The Draft EA on which this Final EA is based was also used in support of an application for an Incidental Harassment Authorization (IHA) from the National Marine Fisheries Service (NMFS) and Section 7 consultations under the Endangered Species Act (ESA). The requested IHA would allow the non-intentional, non-injurious "take by harassment" of small numbers of marine mammals during the proposed seismic surveys conducted by the USGS on *R/V Hugh R. Sharp* in the Northwest Atlantic Ocean during August 2018.

To be eligible for an IHA under the U.S. MMPA, the proposed "taking" (with mitigation measures in place) must not cause serious physical injury or death of marine mammals, must have negligible impacts on the species and stocks, must "take" no more than small numbers of those species or stocks, and must not have an unmitigable adverse impact on the availability of the species or stocks for legitimate subsistence uses.

Mission of the U.S. Geological Survey

The U.S. Geological Survey (USGS) is a science mission agency within the U.S. Department of the Interior and has no regulatory responsibility. The USGS mission is to "provide reliable scientific information to describe and understand the Earth; minimize loss of life and property from natural disasters; manage water, biological, energy, and mineral resources; and enhance and protect our quality of life." The objectives of this proposed seismic research program also coincide with the goals articulated in the USGS Energy and Minerals Science Strategy (Ferrero et al., 2012). This strategy states that the USGS conducts research to enhance understanding of the geologic occurrence, formation, and evolution of oil, gas, coal, and uranium resources. The USGS is responsible for applying the results of this research to the assessment of the economic and environmental impact of development of these resources and making this knowledge public. As an agency whose mission is entirely scientific, the USGS has no authority to exploit natural resources.

Purpose of and Need for the Proposed Action

The USGS intends to conduct a seismic survey aboard the *R/V Hugh R. Sharp*, a University National Oceanographic Laboratory (UNOLS) federal fleet vessel that is 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 seismic survey will take place in water depths ranging from ~100 m to more than 3500 m, entirely within the U.S. Exclusive Economic Zone (EEZ), and acquire dip lines (roughly perpendicular to the orientation of the shelf-break) and strike lines (roughly parallel to the shelf-break) roughly between 35 nm south of Hudson Canyon on the north and Cape Hatteras on the south (Figure 1).

The purpose of the Proposed MATRIX Action 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. The Proposed Action would be conducted in partial fulfillment of the scientific objectives of the USGS Gas Hydrates Project, which has contributed to the advancement of the understanding of natural gas hydrate systems at the national and international level for more than three decades. The USGS Gas Hydrates Project is jointly supported by the USGS Coastal and Marine Hazards and Resources Program in the Natural Hazards Mission and by the USGS Energy Resources Program within the Energy and Minerals Mission.

The Proposed Action is primarily funded by the USGS Coastal and Marine Hazards and Resources Program, and the USGS is the action agency responsible for planning the activity, conducting the work at sea, and processing the data after the cruise. Additional funding is provided by the Resource Evaluation Division of the Bureau of Ocean Energy Management (BOEM), U.S. Department of the Interior, and the U.S. Department of Energy's National Energy Technology Laboratory, which manages the National Methane Hydrates R&D Program. BOEM has a long history of involvement in assessing gas hydrate resources (e.g., BOEM, 2012a) and participating in activities to investigate the resource potential of these deposits in the northern Gulf of Mexico and on the Atlantic, and Pacific. The U.S. DOE has been the agency charged with implementing the National Methane Hydrates Act of 2000 and its renewal in 2005.

The need for this activity is related to the inadequacy of existing seismic data to characterize geologic structures and shallow gas and gas hydrate deposits within the study area. The proposed survey fills a gap in modern multichannel seismic data (MCS) between roughly 36.2°N (surveyed by the NSF Eastern North American Margin (ENAM) project in 2014; RPS, 2014c) and 39.2°N (surveyed by the USGS Extended Continental Shelf in 2014; RPS, 2014a). In the area of the proposed survey, the most recent non-industry airgun surveys were acquired by the USGS in the 1970s and earliest 1980s with the exception of the NSF-funded EDGE survey, which was acquired in 1990. Into the early 1980s, industry acquired a dense series of airgun surveys in the proposed study area. These data, which have been released by the Bureau of Ocean Energy Management (BOEM) through the USGS National Archive of Marine Seismic Surveys (Triezenberg et al., 2016; NAMSS; walrus.er.usgs.gov/NAMSS/), extend seaward to only ~2000 m water depth in most cases, suffer from irreconciliable navigation errors for some surveys, often lack velocity control, and are typically of such poor quality that features related to gas hydrates cannot be easily delineated or traced laterally. The modern airgun data that the USGS would collect as part of the Proposed Action will be acquired using state-of-the-art source and receiver technology and modern navigation techniques and will extend the seaward reach of high-quality MCS data to 3500 m water depth. If these data are not acquired, most of the mid-Atlantic part of the U.S. Atlantic margin will remain characterized only by seismic information that is 35 to 45 years old. Thus, this Proposed Action fills a national need for better characterization of the U.S. Atlantic continental margin.

Background for USGS Marine Seismic Research

The background for USGS-led and NSF-funded marine seismic research is described in § 1.6 of the NSF-USGS PEIS.

Regulatory Setting

The regulatory setting of this EA is described in § 1.8 of the NSF-USGS PEIS, including

- National Environmental Protection Act (NEPA);
- Marine Mammal Protection Act (MMPA); and
- Endangered Species Act (ESA).

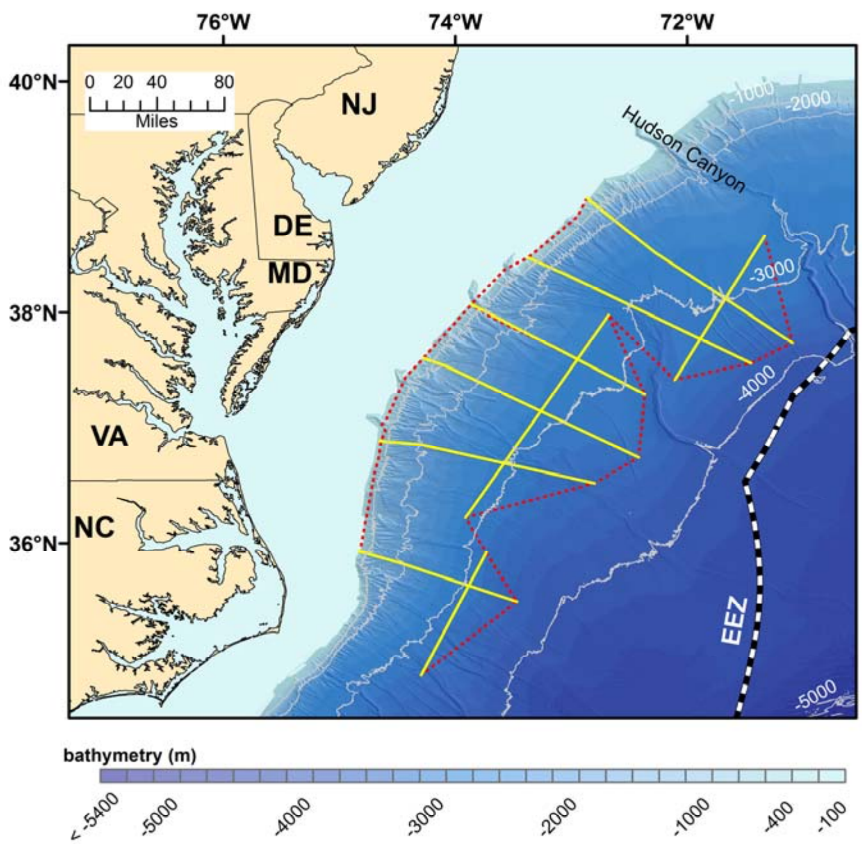

Figure 1. Exemplary seismic lines (yellow) to be acquired by the USGS during the Proposed Action, superposed on the USGS high-resolution bathymetric grid (Andrews et al., 2016). Red dashed lines are linking/transit/interseismic lines, and data will be acquired along only half of these lines. The dashed curve on the right side denotes the EEZ.

II. Alternatives Including Proposed Action

In this EA, three alternatives are evaluated: (1) the proposed seismic survey and issuance of an associated IHA; (2) a corresponding seismic survey at an alternative time, along with issuance of an associated IHA; and (3) no action alternative. Additionally, two alternatives were considered but were eliminated from further analysis. A summary table of the proposed action, alternatives, and alternatives eliminated from further analysis is provided at the end of this section.

Proposed Action

The project objectives and context, activities, and mitigation measures for USGS's planned seismic survey are described in the following subsections.

(1) Project Objectives and Context

USGS scientists propose to conduct a seismic survey (MATRIX) in the northwest Atlantic Ocean (Fig. 1) to acquire data on ~6 exemplary dip lines (down the continental slope) and ~3 exemplary strike lines parallel to the shelf-break from the *R/V Hugh R. Sharp*. The goal of the proposed research is to characterize marine gas hydrates and associated shallow free gas deposits and their connection to widespread seafloor methane seepage, large-scale slope failures and erosional processes, and other geological features. To achieve the program's goals, Drs. Carolyn Ruppel and Nathan C. Miller, both of the USGS Woods Hole Coastal and Marine Science Center, propose to collect up to 9 long (80 nm or more) high-resolution MCS profiles and linking/transit/interseismic lines constituting up to ~2400 km total of new seismic data.

(2) Proposed Activities

(a) Location of the Activities

The survey is bound within the region ~34.75ºN–40°N, ~71–75°W in the northwest Atlantic Ocean (Fig. 1), with the closest approach to the U.S. coastline 70 km (North Carolina) to 130 km (New Jersey). The survey area starts 35 nm 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 with the exception of one line that goes a few hundred meters deeper. The seismic survey will be conducted entirely within the U.S. EEZ, with airgun operations scheduled to occur for up to 19 days of a cruise that may be as long as 21 days, departing port on August 8, 2018. Some minor deviation from these dates is possible, depending on logistics and especially weather.

(b) Description of the Activities

The survey will involve one source vessel, the R/V *Hugh R. Sharp*. The source vessel will deploy two to four low-energy Generator-Injector (GI) airguns (each has discharge volume of 105 in^3) as an energy source. An 120-channel, 1.2-km-long hydrophone streamer will be continuously towed to receive the seismic signals. In addition, up to 90 disposable sonobuoy receivers will be deployed only at water depths greater than 1000 m to provide velocity control and possibly wide-angle reflections along the highest priority transects.

The energy to the airguns is compressed air supplied by compressors on board the source vessel. As the airguns are towed along the survey lines, the hydrophone streamer will receive the returning acoustic signals and transfer the data to the on-board processing system. The sonobuoys, which will be deployed as frequently as every 15 km along high-priority lines, record the returning acoustic signals at larger offsets than are possible with the streamer and transmit the information at radio frequencies to receivers on the ship. A maximum of

~2400 km of data will be collected (Fig. 1). Most lines are oriented subperpendicular to the strike of the margin (dip lines), but data will be acquired along some linking/interseismic lines oriented roughly parallel to the margin (strike lines) and along short strike interseismic/linking lines that connect the dip lines. Table 1 summarizes the survey plan.

The **Optimal Survey** for the Proposed Action would acquire the portion of the solid lines greater than 1000 m water depth as shown in Figure 1 using the GI-guns in "GG" mode. In this mode, the 4 GI guns would produce a total of 840 in^3 of air (see (e) below), and sonobuoys would be deployed to passively record data at long distances. The rest of the survey, including the portion shallower than 1000 m water depth on the uppermost slope and the interseismic linking lines (dashed red in Figure 1), would be acquired with 4 GI guns operated in normal mode (also called GI mode), producting a total of 420 in^3 of air.

The **Base Survey** assumes that all of the solid lines in Figure 1, as well as all of the interseismic connecting lines, would be acquired using 4 GI guns operating in GI mode (see (e) below), producing a total air volume of 420 in^3.

Takes were calculated separately for these two surveys. However, the takes given in Table 10 are those for the Optimal Survey, representing the maximum calculated takes and a conservative approach.

Note that only a maximum of half of the dashed lines in Figure 1 would be acquired and that these lines are longer and geometrically more complex at the deepwater side than near the shelf-break. To allow operational flexibility, takes are calculated in this EA assuming **all** of the linking/interseismic lines would be shot, yielding an overestimate of takes, but also ensuring that the linking lines that make the most sense based on weather, sea state, and other logistical considerations could be the ones actually completed.

Table 1. General characteristics of exemplary survey scenarios for the Proposed Action.

	GI mode (4x105 in^3)		**GG mode (4x210 in^3)**	
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 its fisheries 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 Sharp*'s retractable keel and would typically ping as often as 0.5 to 2 Hz with pings of 0.256 to 1.024 ms 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. No takes are requested for use of the fisheries echosounder.

All planned geophysical data acquisition activities would be conducted by the USGS PIs, technical staff, and marine operations group, with support from UNOLS technical staff for use of borrowed streamer sections. The vessel will be self-contained, and the scientific party and crew will live aboard the vessel for the entire cruise.

(c) Schedule

The survey would commence on 8 August and may continue as long as 28 August. Total time during which the airguns would be fired is anticipated to be < 396 hours. The remainder of the cruise would consist of transits, including transits to refuel once or twice at either Norfolk or Lewes, Delaware, depending on the combined fuel needs of the ship and the compressors. The exact dates of the activities depend on logistics and weather conditions.

(d) Source Vessel Specifications

The *R/V Hugh R. Sharp* would be used for this survey. The R/V *Hugh R. Sharp* has an overall length of 46 m, a beam of 9.8 m, and a full load draft of 2.95 m (3.9 m with retractable keel positioned at 1 m down). The vessel is equipped with four Cummins KTA-19D diesel engines. Diesel-electric power is provided by two Schottel SRP 330 Z-drives. The ship also has a Schottel tunnel bow thruster operated with the S Green dynamic positioning system. An operation speed of up to ~7.4 km/h (4 kt) will be used during seismic acquisition. When not towing seismic survey gear, the R/V *Hugh R. Sharp* typically cruises at 14.8 to 16.7 km/h (8-9 kt). It has a normal operating range of ~6500 km (~3500 nm).

The R/V *Hugh R. Sharp* will also serve as the platform from which vessel-based protected species observers (PSOs) will watch for marine mammals and sea turtles before and during airgun operations. The PSO platform is an area covered by an awning and equipped with chairs and Big Eye binocular stands, located on the flying bridge of the *R/V Hugh R. Sharp*, 10.6 m above the water's surface. This area has previously been used by NMFS scientists for beaked whale observations during research cruises (e.g., Cholewiak, September 2017). The vantage point provides a 360° view of the water's surface. During inclement weather too challenging to remain on the flying bridge, the PSOs have access to the bridge of the vessel for their activities. In addition, crew members on the bridge and on other parts of the vessel will be instructed to keep a watch for protected species.

Other details of the R/V *Hugh R. Sharp* include the following:

Owner:	University of Delaware
Operator:	University of Delaware
Flag:	United States of America
Launch Date:	2006
Domestic Tonnage:	256 T
Accommodation Capacity:	22, including 14 scientists

(e) Airgun Description

The R/V *Hugh R. Sharp* will tow two or four 105-in^3 Sercel generator-injector (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 kt), the shot intervals correspond to a spacing of ~25 m. Shots will actually be done based on distance (25 m), not time, for the bulk of the cruise.

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. When shooting to sonobuoys during the Proposed Action, the GI guns will also sometimes be operated with both chambers releasing air simultaneously (i.e., "generator-generator" or "GG" mode). In GG mode, each gun simultaneously releases an air volume of 105 in^3 + 105 in^3= 210 in^3. On this cruise, 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 backup mode is described in Appendix A. The text below describes the two preferred modes for operations.

The **Base Configuration**, **Configuration 1,** will use 4 GI guns and generate 420 in^3 total volume, as shown in Figure 2. Guns 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.

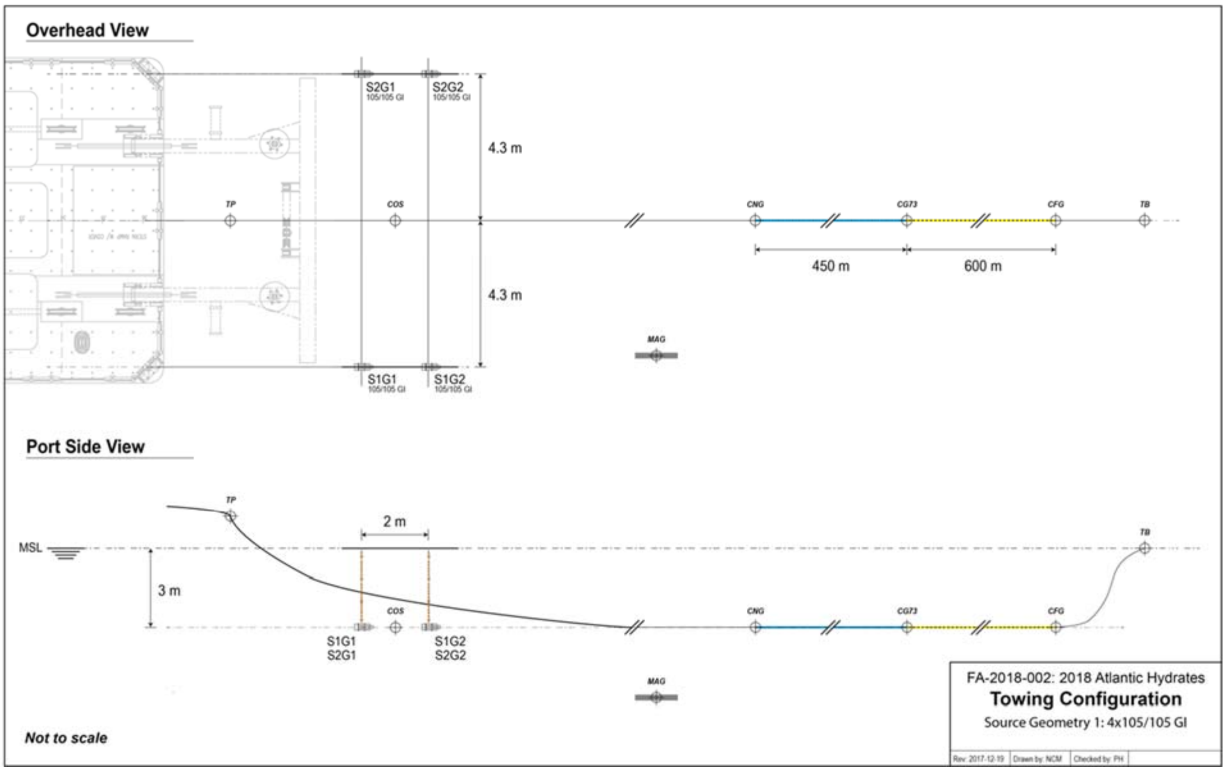

Figure 2. Base configuration (Source configuration 1): 420 in^3 total volume consisting of 4x105/105in^3 GI guns (S#G*, where # is the side and * is the gun number) firing in standard GI mode.

The **GG Configuration, Configuration 2,** will use 4 GI guns and generate 840 in^3 total volume, as shown in Figure 3. In this configuration, the guns will be fired in GG mode, as described above. Guns 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 would be used **only at greater than 1000 m water depth** and on specific exemplary lines on which sonobuoy data are being collected.

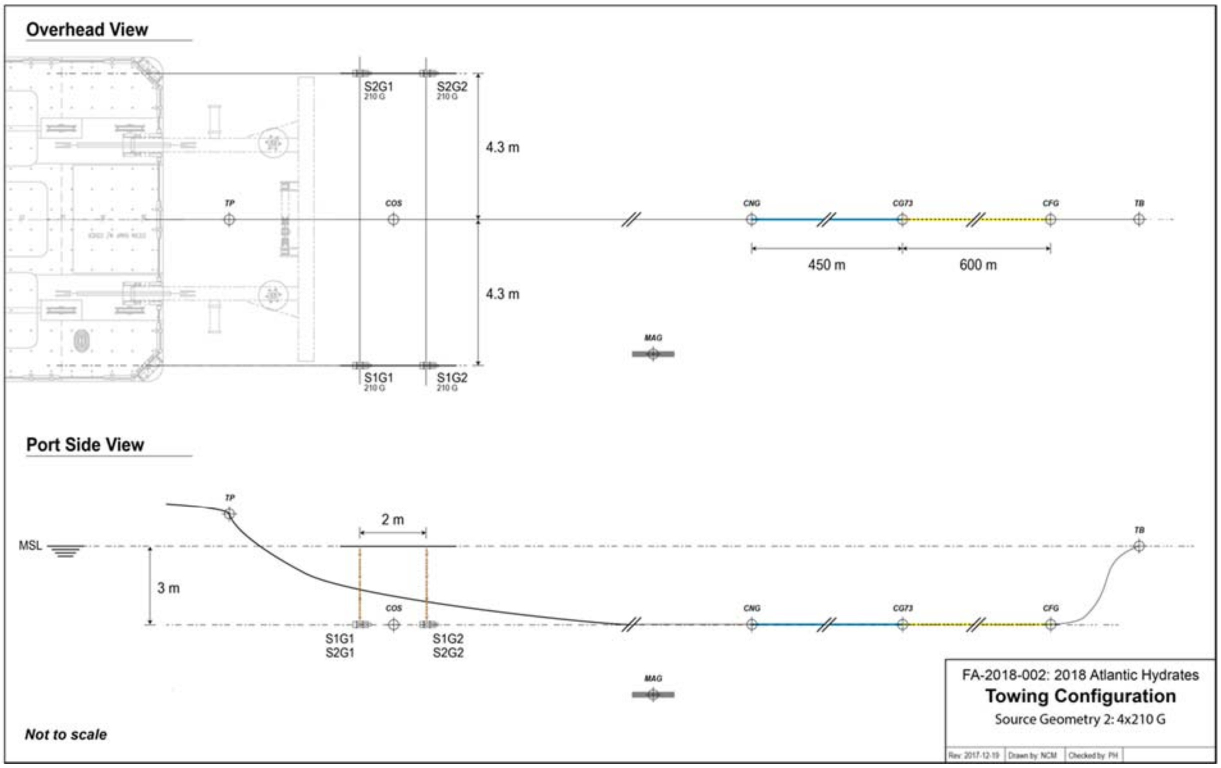

Figure 3. GG Configuration (Source configuration 2): 840 in^3 total volume consisting of 4x105/105in^3 GI guns firing both chambers simultaneously (i.e. GG mode). Guns are labelled as S#G*, where # is the side and * is the gun number.

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 (1200 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.

GI Airgun Specifications

Energy Source	Two (backup configuration, Appendix A) 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 Hz
Firing pressure per gun	2000 psi
Pulse duration	30-100 ms

The source levels for the GI gun configurations can be derived from the modeled farfield source signature, which was determined for the USGS by L-DEO using the PGS Nucleus software. Modeling information is provided below, with more complete details in Appendices B and C.

(f) Sonobuoy Description and Deployment

The Proposed Action would deploy up to 72 disposable sonobuoys from the R/V *Hugh R. Sharp* during surveys along higher priority seismic lines at **water depths greater than 1000 m** (Fig. 1). These sonobuoys consist of hydrophones suspended ~30-90 m below the surface from a free-floating buoy. Data are transmitted to the ship via radio frequency.

(g) EK60/80 Fisheries Split-Beam Echosounder (38 kHz)

During the cruise, the USGS would continuously monitor the water column at water depths less than 1800 m using its EK80 broadband transceiver. The active acoustic component is a 38 kHz split-beam transducer mounted in the retractable keel of the *R/V Hugh R. Sharp*. These sources have been extensively used in fisheries science for estimating biomass and are routinely used by NOAA, the USGS, and other research agencies for detecting fish, whales, and water column anomalies, such as bubbles emitted from the seafloor at seeps. The sound source level for the EK60/80 transducers is nominally 228 dB/1 µPa. Modeling of the 38 kHz signal yields the sound pressure levels (SPL) shown in Figure 4. The area ensonified at >160 dB is 0.0407 km^2, corresponding to a maximum of ~72 m athwartship and ~650 m below the ship. The USGS also modeled the 175 dB isopleth during consultations with NMFS. The distance to the 175 dB isopleth is 0 m at the surface and at depth is a maximum of 10 m from the vertical line extending from the transducer.

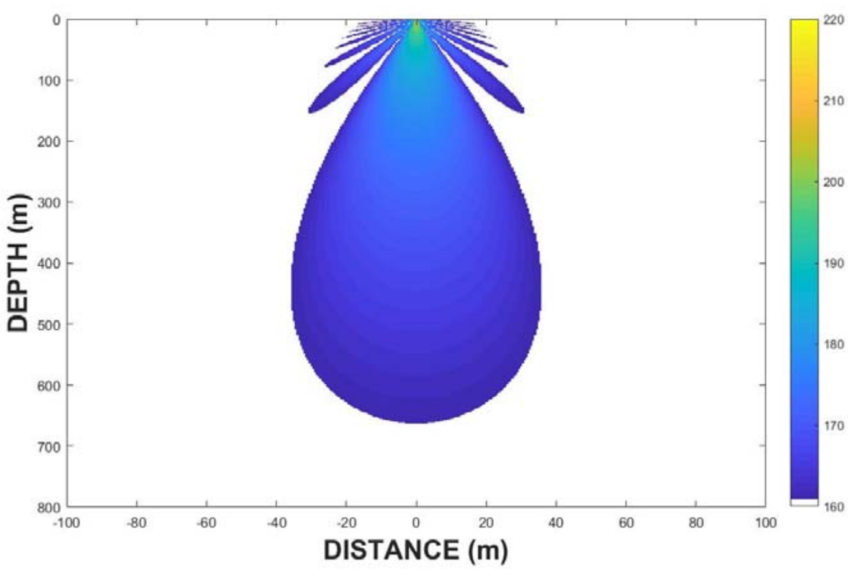

Figure 4. 160 dB SEL modeled for the 38 kHz transducer for the EK60/EK80 system.

(3) Monitoring and Mitigation Measures

Section § 2.4.4.1 of the NSF-USGS PEIS describes standard monitoring and mitigation measures for seismic surveys and the two phases: pre-cruise planning and during operations. The sections below describe the measures taken in each phase for the 2018 USGS Proposed Action. Some of the text below is adapted or taken verbatim from the Draft Scripps EA (LGL, 2017).

(a) Planning Phase

The initial mitigation of the impacts of the Proposed Action occurred during planning.

***Energy Source*.—**The energy source was chosen to be the lowest practical to meet the scientific objectives. Since the dataset to be acquired during MATRIX (Proposed Action) is expected to be used for 30 years or more, the USGS also assessed how to minimize the source size while ensuring maximum penetration, highest resolution, and appropriate imaging of the hydrate stability zone and shallow natural gas distributions and to produce data of high enough quality for the results to still be considered useful in the multidecadal timeframe. The USGS settled on a range of sources and potential configurations, with the base configuration of four airguns operated at 105 in^3. The largest source that could be used is four airguns operated at 210 in^3 and towed at 3 m depth, which would be used only at water depths > 1000 m when recording data on sonobuoys. The total air volume associated with these sources is ~6 to 17% of those used for most modern 2D and 3D seismic programs (usually > 6000 in^3).

***Survey Timing*.—**When choosing the timing of the survey, the USGS took into consideration environmental conditions (e.g., the seasonal presence of marine mammals), weather, vessel availability, and optimal timing for this and other proposed research cruises on the *R/V Hugh R. Sharp* . Some marine mammal species are expected to occur in the area year-round, so altering the timing of the proposed project likely would result in no net benefits for those species.

Mitigation Zones.

During the planning phase, mitigation zones for the proposed marine seismic surveys were calculated based on modeling by L-DEO for both the exclusion (Level A) and safety (Level B) zones. Received sound levels have been predicted by L-DEO's model (Diebold et al. 2010, provided as Appendix H in the NSF-USGS PEIS), as a function of distance from the airguns, for the three potential airgun configurations: (1) **Base configuration**: 4 GI guns producing a total of 420 in^3 of air; (2) **GG configuration**: 4 GI guns producing a total of 840 in^3 of air, which will be used only to shoot to sonobuoys along certain lines at water depths greater than 1000 m; and (3) **Backup configuration**: 2 GI guns producing a total of 210 in^3 of air. To streamline this EA, all information about the backup configuration has been moved to Appendix A.

The L-DEO modeling approach uses ray tracing for the direct wave traveling from the array to the receiver and its associated source ghost (reflection at the air-water interface in the vicinity of the array), in a constant-velocity half-space (infinite homogeneous ocean layer, unbounded by a seafloor). In addition, propagation measurements of pulses from the 36-airgun array at a tow depth of 6 m have been reported in deep water (~1600 m), intermediate water depth on the slope (~600–1100 m), and shallow water (~50 m) in the Gulf of Mexico (GoM) in 2007–2008 (Tolstoy et al. 2009; Diebold et al. 2010).

For deep and intermediate-water cases, the field measurements in the Gulf of Mexico cannot be easily used to derive mitigation radii. This is due to the fact that, at those sites, the calibration hydrophone for the 36-gun study was located at a roughly constant depth of 350–500 m, which may not intersect all the sound pressure level (SPL) isopleths at their widest point from the sea surface down to the maximum relevant water depth for marine mammals of ~2000 m. Figures 2 and 3 in Appendix H of the NSF-USGS PEIS show how the values along the maximum SPL line that connects the points where the isopleths attain their maximum width (providing the maximum distance associated with each sound level) may differ from values obtained along a constant depth line. At short ranges, where the direct arrivals dominate and the effects of seafloor interactions are minimal, the data recorded at the deep and slope sites are suitable for comparison with modeled levels at the depth of the calibration hydrophone. At longer ranges, the comparison with the mitigation model—constructed from the maximum SPL through the entire water column at varying distances from the airgun array—is the most relevant. The results are summarized below.

In deep and intermediate water depths, comparisons at short ranges between sound levels for direct arrivals recorded by the calibration hydrophone and model results for the same array tow depth are in good agreement (Fig. 12 and 14 in Appendix H of the NSF-USGS PEIS). Consequently, isopleths falling within this domain can be predicted reliably by the L-DEO model, although they may be imperfectly sampled by measurements recorded at a single depth. At greater distances, the calibration data show that seafloor-reflected and sub-seafloor-refracted arrivals dominate, whereas the direct arrivals become weak and/or incoherent (Fig. 11, 12, and 16 in Appendix H of the NSF-USGS PEIS). Aside from local topography effects, the region around the critical distance (~5 km in Fig. 11 and 12, and ~4 km in Fig. 16 in Appendix H of the NSF-USGS PEIS) is where the observed levels rise closest to the mitigation model curve. However, the observed sound levels are found to fall almost entirely below the mitigation model curve (Fig. 11, 12, and 16 in Appendix H of the NSF-USGS PEIS). Thus, analysis of the GoM calibration measurements demonstrates that although simple, the L-DEO model is a robust tool for conservatively estimating mitigation radii. In shallow water (<100 m), the depth of the calibration hydrophone (18 m) used during the GoM calibration survey was appropriate to sample the maximum sound level in the water column, and the field measurements reported in Table 1 of Tolstoy et al. (2009) for the 36-airgun array at a tow depth of 6 m can be used to derive mitigation radii. (Note, however, that none of the Proposed Action would be carried out at less than 100 m water depth.)

The proposed survey would acquire data with up to four airguns, each with 210 in^3 of air, operated at a tow depth of 3 m. For deep water (>1000 m), we use the deep-water radii obtained from L-DEO model results down to a maximum water depth of 2000 m (Figures 5 through 7). The radii for intermediate water depths (100–1000 m) are derived from the deep-water ones by applying a correction factor (multiplication) of 1.5, such that observed levels at very near offsets fall below the corrected mitigation curve (Fig. 16 in Appendix H of the NSF-USGS PEIS).

Although the USGS does not intend to operate the source at less than 100 m water depth, shallow-water radii were still calculated by scaling the empirically derived measurements from the GoM calibration survey (Appendix B) to account for the differences in volume and tow depth between the calibration survey (6600 cu.in at 6 m tow depth) and the proposed surveys (three different configurations; backup configuration information is Appendix A); whereas the shallow water GOM may not exactly replicate the shallow water environment at the proposed survey sites, it has been shown to serve as a good and very conservative proxy (Crone et al. 2014). A simple scaling factor is calculated from the ratios of the isopleths derived from the deep-water L-DEO model. These isopleths are essentially a measure of the energy radiated by the source array

For the **Base Configuration** (Configuration 1):

- the 150-decibel (dB) Sound Exposure Level (SEL)[1] corresponds to deep-water maximum radii of 1090.6 m for the four 105 in^3 airguns at 3 m tow depth (Fig. 5), and 7,244 m for the 6600 in^3 airgun array at 6-m tow depth (Appendix B), yielding scaling factors of 0.151 to be applied to the shallow-water 6-m tow depth results.

[1] SEL (measured in dB re 1 μ$Pa^2 \cdot s$) is a measure of the received energy in the pulse and represents the SPL that would be measured if the pulse energy were spread evenly across a 1-s period. Because actual seismic pulses are less than 1 s in duration in most situations, this means that the SEL value for a given pulse is usually lower than the SPL calculated for the actual duration of the pulse. In this EA, we assume that rms pressure levels of received seismic pulses would be 10 dB higher than the SEL values predicted by L-DEO's model.

- the 165-decibel (dB) Sound Exposure Level (SEL) corresponds to deep-water maximum radii of 193.94 m for the four 105 in^3 airguns at 3 m tow depth, and 1,284 m for a 6-m tow depth, yielding a scaling factor of 0.151 to be applied to the shallow-water 6-m tow depth results.

- Similarly, the 170 dB SEL corresponds to deep-water maximum radii of 109.72 for the four 105 in^3 airguns at 3 m tow depth (Fig. 2) and 719 m for the 6600 in^3 at 6-m tow depth (Fig. 4), yielding the same 0.152 scaling factor.

- the 185-decibel (dB) Sound Exposure Level (SEL) corresponds to deep-water maximum radii of 19.89 m for the four 105 in^3 at 3-m tow depth, and 126.3 m for a 6-m tow depth, yielding a scaling factor of 0.157 to be applied to the shallow-water 6-m tow depth results.

Measured 160-, 175-, 180-, 190- and 195-dB re 1µPa_{rms} distances in shallow water for the 36-airgun *R/V Langseth* array towed at 6 m depth were 17.5 km, 2.84 km, 1.6 km, 458 m and 240 m, respectively, based on a 95th percentile fit (Tolstoy et al. 2009). Multiplying by the scaling factors to account for the tow depth and discharge volume differences between the 6600 cu.in airgun array at 6 m tow depth and the USGS Proposed Action Base Configuration, the 420 cu.in airgun array at 3 m tow depth yields distances of 2.642 km, 429 m, 243 m, 71 m and 38 m, respectively.

For the **GG Configuration** (Configuration 2):

- the 150-decibel (dB) Sound Exposure Level (SEL) corresponds to deep-water maximum radii of 1,244 m for the four 210 in^3 airguns at 3 m tow depth (Fig. 6), and 7,244 m for the L-DEO 6600 in^3 airgun array at 6-m tow depth (Fig. 8), yielding scaling factors of 0.172 to be applied to the shallow-water 6-m tow depth results.

- the 165-decibel (dB) Sound Exposure Level (SEL) corresponds to deep-water maximum radii of 219.54 m for the four 210 in^3 airguns at 3 m tow depth, and 1,284 m for a 6-m tow depth, yielding a scaling factor of 0.171 to be applied to the shallow-water 6-m tow depth results.

- Similarly, the 170 dB SEL corresponds to deep-water maximum radii of 124.72 for the four 210 in^3 airguns at 3 m tow depth (Fig. 2) and 719 m for the 6600 in^3 at 6-m tow depth (Fig. 4), yielding the same 0.173 scaling factor.

- the 185-decibel (dB) Sound Exposure Level (SEL) corresponds to deep-water maximum radii of 22.69 m for the four 210 in^3 at 3-m tow depth, and 126.3 m for a 6-m tow depth, yielding a scaling factor of 0.179 to be applied to the shallow-water 6-m tow depth results.

Measured 160-, 175-, 180-, 190- and 195-dB re 1µPa_{rms} distances in shallow water for the 36-airgun *R/V Langseth* array towed at 6 m depth were 17.5 km, 2.84 km, 1.6 km, 458 m and 240 m, respectively, based on a 95th percentile fit (Tolstoy et al. 2009). Multiplying by the scaling factors to account for the tow depth and discharge volume differences between the 6600 cu.in airgun array at 6 m tow depth and the 840 cu.in airgun array at 3 m tow depth yields distances of 3.01 km, 485 m, 277 m, 80 m and 43 m, respectively.

Information for the **Backup Configuration** is given in Appendix A.

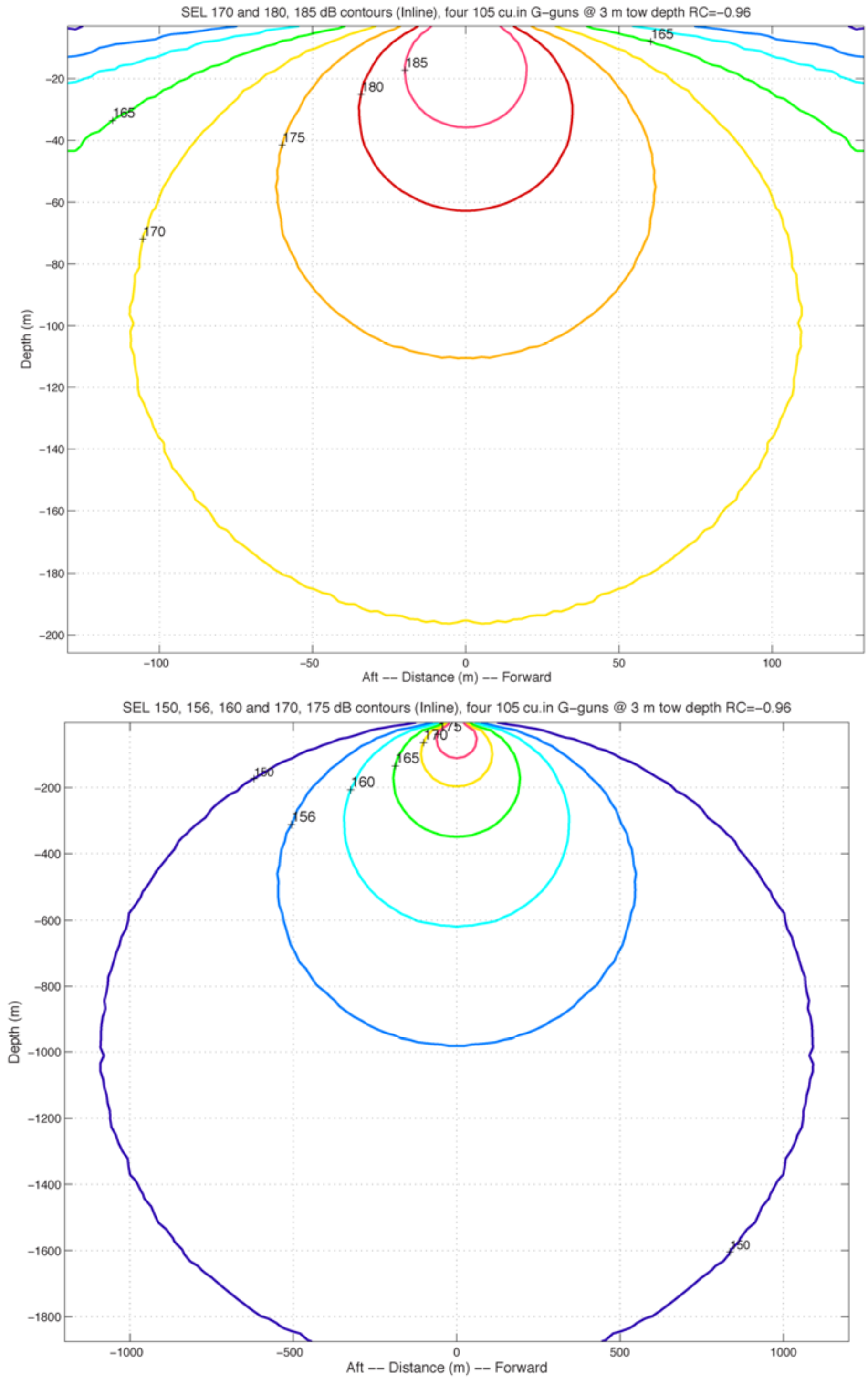

Figure 5. Modeled deep-water received sound exposure levels (SELs) from the Base Configuration (Configuration 1; four 105 in^3 GI-guns) towed at 3-m depth. Received rms levels (SPLs) are expected to be ~10 dB higher. The plot at the top provides the radius to the 170-dB SEL isopleth as a proxy for the 180-dB rms isopleth, and the plot at the bottom provides the radius to the 150 and 165-dB SEL isopleths as a proxy for the 160 and 175-dB rms isopleths, respectively. The top diagram is a blow-up of the bottom one.

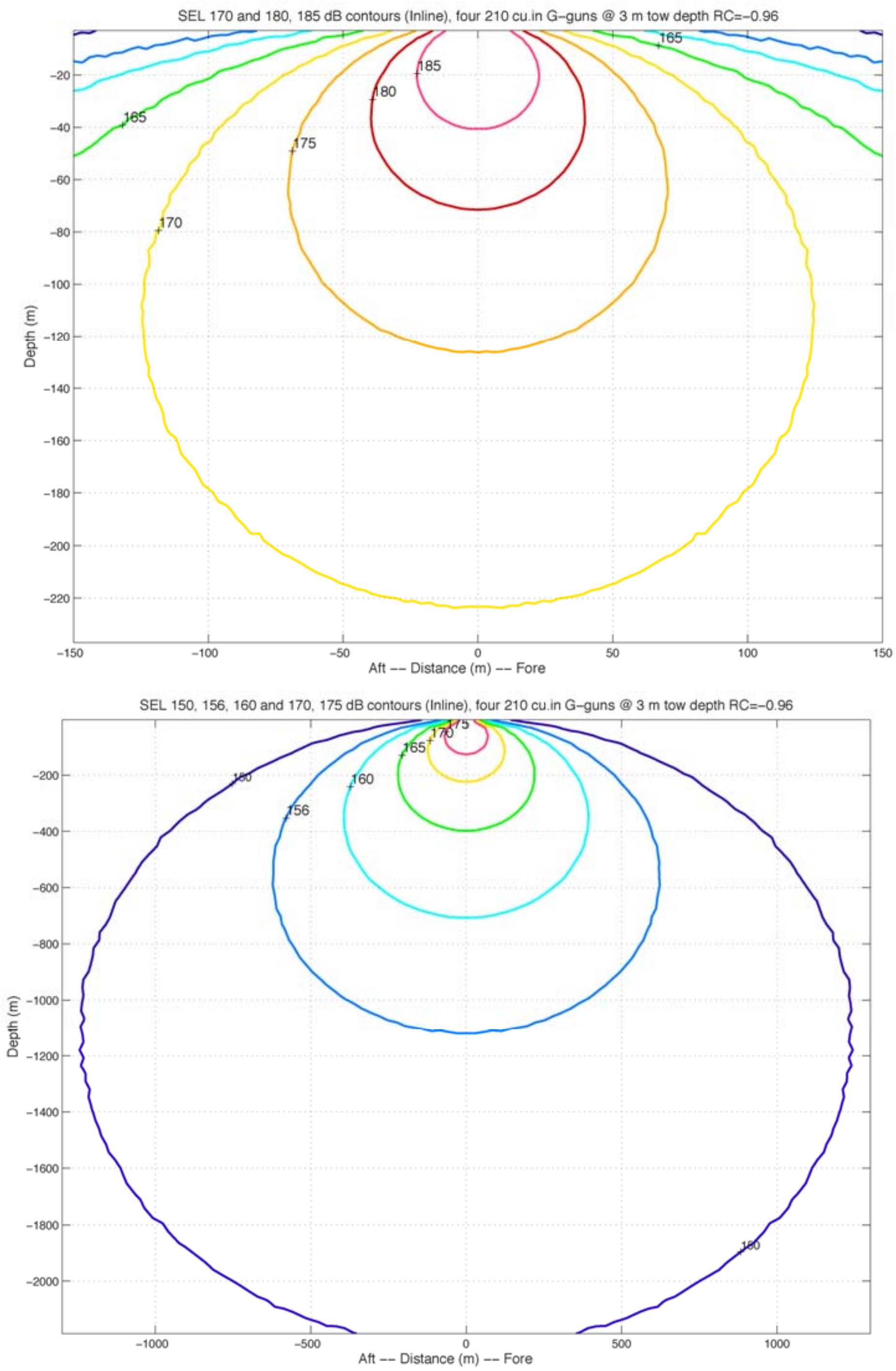

Figure 6. Modeled deep-water received sound exposure levels (SELs) from the GG configuration (Configuration 2), with four 210 in^3 GI-guns towed at 3-m depth and generating a total of 840 in^3. Received rms levels (SPLs) are expected to be ~10 dB higher. The plot at the top provides the radius to the 170-dB SEL isopleth as a proxy for the 180-dB rms isopleth, and the plot at the bottom provides the radius to the 150 and 165-dB SEL isopleths as a proxy for the 160 and 175-dB rms isopleths, respectively. The upper plot is a zoomed-in version of the lower plot.

Table 2 shows the distances at which the 160- and 175-dB re 1µPa_{rms} sound levels are expected to be received for the Base and GG source configurations. The 160-dB level is the behavioral disturbance criterion (Level B) that is used by NMFS to estimate anticipated takes for marine mammals; a 175-dB level is used by the National Marine Fisheries Service (NMFS) to determine behavioral disturbance for sea turtles.

It should be noted that the RMS (root mean square; average pressure over a pulse duration) received levels that are used as impact criteria for marine mammals are not directly comparable to the peak (p or 0–p) or peak to peak (p–p) values normally used to characterize source levels of airgun arrays. The measurement units used to describe airgun sources, peak or peak-to-peak decibels, are always higher than the rms decibels referred to in biological literature. A measured received sound pressure level (SPL) of 160 dB re 1 µPa_{rms} in the far field would typically correspond to ~170 dB re 1 µPa_p or 176–178 dB re 1 µPa_{p-p}, as measured for the same pulse received at the same location (Greene 1997; McCauley et al. 1998, 2000). The precise difference between rms and peak or peak-to-peak values depends on the frequency content and duration of the pulse, among other factors. However, the rms level is always lower than the peak or peak-to-peak level for an airgun-type source.

A recent retrospective analysis of acoustic propagation of *R/V Langseth* sources in a coastal/shelf environment from the Cascadia Margin off Washington suggests that predicted (modeled) radii (using an approach similar to that used here) for *Langseth* sources were 2–3 times larger than measured in shallow water, so in fact, as expected, were very conservative (Crone et al. 2014). Similarly, analysis (Crone et al., 2017) of data collected during a survey off New Jersey in 2014 and 2015 confirmed that *in situ* measurements and estimates of the 160- and 180-dB distances collected by the *Langseth* hydrophone streamer were similarly 2–3 times smaller than the predicted operational mitigation radii. In fact, five separate comparisons conducted of the L-DEO model with *in situ* received levels[2] have confirmed that the L-DEO model generated conservative exclusion zones, resulting in significantly larger EZs than necessary.

Southall et al. (2007) made detailed recommendations for new science-based noise exposure criteria. In July 2015, NOAA published a revised version of its 2013 draft guidance for assessing the effects of anthropogenic sound on marine mammals (NOAA 2015). At the time of preparation of this EA, the content of the final guidelines and how they would be implemented are uncertain. As such, this EA was prepared in accordance with the current NOAA acoustic practices, and the procedures are based on best practices noted by Pierson et al. (1998), Weir and Dolman (2007), Nowacek et al. (2013), Wright (2014), and Wright and Cosentino (2015).

Enforcement of mitigation zones via power ramp-up procedures and shut downs would be implemented in the Operational Phase.

[2] L-DEO surveys off the Yucatán Peninsula in 2004 (Barton et al. 2006; Diebold et al. 2006), in the Gulf of Mexico in 2008 (Tolstoy et al. 2009; Diebold et al. 2010), off Washington and Oregon in 2012 (Crone et al. 2014), and off New Jersey in 2014 and 2015 (Crone 2015, L-DEO, pers. comm.)

Table 2. Predicted distances to which sound levels ≥ 175- and 160-dB re 1 μPa_{rms} would be expected to be received during the proposed surveys in the Northwest Atlantic Ocean for the Base and GG configuration. Refer to Appendix A for the Backup Configuration. The Proposed Action would not involve ensonifying the seafloor at water depths shallower than 100 m. Further calculations and information are given in Appendix B. The GG Configuration will not be used at less than 1000 m water depth, so the shaded portions of the table are not applicable to this analysis.

Source and Volume	Tow Depth (m)	Water Depth (m)	Predicted RMS Radii (m)	
			175 dB	160 dB
Base Configuration (Configuration 1) Four 105 in^3 G-guns	3	>1000 m	194[1]	1091[1]
		100–1000 m	291[2]	1637[2]
GG Configuration (Configuration 2) Four 210 in^3 G-guns	3	>1000 m	220[1]	1244[1]
		100–1000 m	330[2]	1866[2]

[1] Distance is based on L-DEO model results.
[2] Distance is based on L-DEO model results with a 1.5 x correction factor between deep and intermediate water depths.
[3] Distance is based on empirically derived measurements in the GoM with scaling applied to account for differences in tow depth.

In July 2016, the National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service (NMFS) released new technical guidance for assessing the effects of anthropogenic sound on marine mammal hearing (NMFS 2016a). The guidance was updated, but effectively remained the same, in June 2018 (NMFS 2018). The guidance established thresholds for permanent threshold shift (PTS) onset or Level A Harassment (injury), for marine mammal species. The 2016 noise exposure criteria for marine mammals account for the newly-available scientific data on temporary threshold shifts (TTS), the expected offset between TTS and PTS thresholds, differences in the acoustic frequencies to which different marine mammal groups are sensitive, and other relevant factors, as summarized by Finneran (2016). Onset of PTS was assumed to be 15 dB or 6 dB higher when considering SEL_{cum} and SPL_{flat}, respectively. For impulsive sounds, such airgun pulses, the new guidance incorporates marine mammal auditory weighting functions (Fig. 4) and dual metrics of cumulative sound exposure level (SEL_{cum} over 24 hours) and peak sound pressure levels (SPL_{flat}). Different thresholds are provided for the various hearing groups, including low-frequency (LF) cetaceans (e.g., baleen whales), mid-frequency (MF) cetaceans (e.g., most delphinids), high-frequency (HF) cetaceans (e.g., porpoise and *Kogia* spp.), phocids underwater (PW), and otariids underwater (OW). As required by NMFS (2016a), the largest distance of the dual criteria (SEL_{cum} or Peak SPL_{flat}) would be used as the EZ and for calculating takes. For LF cetaceans the PTS SEL_{cum} criterion is used. For MF and HF cetaceans, the Peak SPL_{flat} yields a larger exclusion zone and is therefore used. Pinnipeds are not considered since they do not occur in the area of the Proposed Survey.

The SEL_{cum} and Peak SPL (Appendix C) for the planned airgun configurations are derived from calculating the modified farfield signature. The farfield signature is often used as a theoretical representation of the source level. To compute the farfield signature, the source level is estimated at a large distance below the array (e.g., 9 km), and this level is back projected mathematically to a notional distance of 1 m from the array's geometrical center. However, it has been recognized that the source level from the theoretical farfield signature is never physically achieved at the source when the source is an array of multiple airguns separated in space (Tolstoy et al. 2009). Near the source (at short ranges, distances <1 km), the pulses of sound pressure from each individual airgun in the source array do not stack constructively as they do for the theoretical farfield signature. The pulses from the different airguns spread out in time such that the source levels observed or modeled are the result of the summation of pulses from a few airguns, not the full array (Tolstoy et al. 2009). At larger distances, away from the source array center, sound pressure of all the airguns in the array stack coherently only in the vertical direction. In the horizontal direction, the sound pressure does not always constructively interfere and stack coherently, resulting in smaller source levels (a few dB) than the source level derived from the farfield signature. Because the farfield signature does not take into account the interactions of the two airguns that occur near the source center and is calculated as a point source (single airgun), the modified farfield signature is a more appropriate measure of the sound source level for large arrays. For this smaller array, the modified farfield changes will be correspondingly smaller as well, but we use this method for consistency across all array sizes.

To estimate SEL_{cum} and Peak SPL, we used the acoustic modeling developed at L-DEO (same as used for Level B takes) with a small grid step to provide better resolution in both the inline and depth directions, with results shown in Appendix C. The propagation modeling takes into account all airgun interactions at short distances from the source including interactions between subarrays. This is done by using the NUCLEUS software to estimate the notional signature and the MATLAB software to calculate the pressure signal at each mesh point of a grid.

PTS onset acoustic thresholds estimated in the 2016 version of the NMFS User Spreadsheet rely on overriding default values and calculating individual adjustment factors (dB) and by using the difference between levels with and without weighting functions for each of the five categories of hearing groups. The new adjustment factors in the spreadsheet allow for the calculation of SEL_{cum} isopleths in the spreadsheet and account for the accumulation (Safe Distance Methodology) using the source characteristics (duty cycle and speed) after Sivle et al. (2014). The methodology (input) for calculating the distances to the SEL_{cum} PTS thresholds (Level A) for the airgun array is shown in Table 2.

Appendix C provides detailed information about the acoustic modeling used for Level A takes, including NMFS spreadsheet-based calculations using the 2016 versions. Appendix C also gives a summary of all of the SEL SL modeling with and without applying the weighting function for the 5 hearing groups and the full calculations for the PTS SEL_{cum} and the Peak SPL_{flat}.

TABLE 3. SEL_{cum} Methodology Parameters (Sivle et al. 2014)†.

Airgun Configuration	Source Velocity (meters/second)	1/Repetition rate^ (seconds)
All Configurations	2.05778*	12.149&

†Methodology assumes propagation of 20 log R; Activity duration (time) independent

^ Time between onset of successive pulses.

*Equivalent to 4 kts

&The USGS intends to use a nominal shot interval of 25 m (~12 s at 4 kts).

As shown in Appendix A, a new adjustment value is determined by computing the distance from the geometrical center of the source to where the 183 dB SEL_{cum} isopleth is the largest for LF cetaceans. The modeling is first run for one single shot without applying any weighting function. The maximum 183dB SEL_{cum} isopleth is located at 34.35 m, 39.42 m, and 17.98 m from the source for Configurations 1 through 3, respectively. We then run the modeling for one single shot with the low frequency cetaceans weighting function applied to the full spectrum. The maximum 183 dB SEL_{cum} isopleth is located at 15.7 m, 17.7 m, and

9.2 m from the source for source Configurations 1 through 3, respectively. The difference between these values for each of the source configurations yields adjustment factors of -6.8 dB, -6.9 dB, and -5.8 dB, respectively, assuming a propagation of $20\log_{10}R$.

For MF and HF cetaceans, the modeling for a single shot with the weighted function applied leads to 0-m isopleths; the adjustment factors thus cannot be derived the same way as for LF cetaceans. Hence, for MF and HF cetaceans, and OW and PW pinnipeds, the difference between weighted and unweighted spectral source levels at each frequency up to 3 kHz was integrated to actually calculate these adjustment factors in dB. These calculations also account for the accumulation (Safe Distance Methodology) using the source characteristics (duty cycle and speed) after Sivle et al. (2014).

Table 4. Summary Level A acoustic thresholds in meters for each source configuration and hearing group relevant to acquisition of the Base/Optimal surveys for the Proposed Action. Corresponding values for the backup configuration of airguns, are provided in Appendix C.

	Hearing Group		
	Low-Frequency Cetaceans	**Mid-Frequency Cetaceans**	**High-Frequency Cetaceans**
Threshold	183 dB (SEL_{cum})	230 dB (Peak SPL_{flat})	202 dB (Peak SPL_{flat})
Base Configuration	*31.0 m*	*0.0*	*70.43 m*
GG Configuration	*39.5 m*	*0.0*	*80.5 m*

The NSF-USGS PEIS defined a low-energy source as any towed acoustic source whose received level is ≤180 dB re 1 μPa_{rms} (the Level A threshold under the former NMFS acoustic guidance) at 100 m. Table 3 of Appendix F of the NSF-USGS PEIS shows that a quadrilateral (4 GI gun) array of 105 in^3 guns would meet the low-energy criteria if towed at 3 m depth and separated by 8 m. Based on the modeling in Table 1 and the fact that the quadrilateral array of guns to be used for the Proposed Action would be separated by only 2 m front to back and 8.6 m side to side (and will be operated occasionally in GG mode, which generates 210 in^3 of air per GI gun), the Proposed Action slightly exceeds the criteria of a low-energy activity according to the NSF-USGS PEIS. Note that the sources to be used for the Proposed Action at maximum generate less than 20% of the air (usually > 6000 in^3) typically used for seismic surveys by a range of research and private sector operators.

In § 2.4.2 of the NSF-USGS PEIS, Alternative B (the Preferred Alternative) conservatively applied a 100-m EZ for low-energy acoustic sources in water depths >100 m. For the Proposed Action, which does not meet the ≤180 dB re 1 μPa_{rms} Level A criterion formerly applied by NMFS and outlined in Appendix F of the NSF-USGS PEIS, the actual calculated EZ (Table 4 and Appendix C) based on the 2016 NMFS Acoustic Guidance are substantially smaller than this prescribed 100 m EZ. Adopting the calculated EZ instead of the prescribed 100 m EZ would therefore result in a less conservative approach to protection of marine mammals (and turtles) and higher actual takes during the Proposed Action. Thus, the Proposed Action will voluntarily adopt a 100 m EZ for marine mammals.

The 100-m EZ would also be used as the EZ for sea turtles, although current guidance by NMFS suggests a Level A criterion of 195 dB re 1 μPa_{rms} or a *maximum* EZ of 21 m in deep water for the most impulsive (GG configuration) airgun array. If marine mammals or sea turtles are detected in or about to enter the EZ, the airguns would be shut down immediately. Enforcement of mitigation zones via shut downs would be implemented in the Operational Phase, as noted below. This EA has been prepared in accordance with the current NOAA acoustic practices as of March 2018, and the procedures are based on best practices noted by Pierson et al. (1998), Weir and Dolman (2007), Nowacek et al. (2013a), Wright (2014), and Wright and Cosentino (2015). For the 160-dB "Safety Zone," L-DEO model results for the GI gun configurations are used here to determine the 160-dB radius (Table 1).

(b) Operational Phase

The operational mitigation measures to be implemented by the USGS are described in § 2.4.1.1 of the NSF-USGS PEIS and include:

- monitoring by PSOs for marine species (including marine mammals, sea turtles, and ESA-listed seabirds diving near the vessel and also observing for potential impacts of acoustic sources on fish);
- PSVO data and documentation; and
- mitigation during operations (speed or course alteration; shut-down and ramp-up procedures, including for threatened/endangered seabirds; avoidance of concentrations of large whales; directional shooting to maximize protection of mammals in certain habitats).

The proposed operational mitigation measures are standard for all seismic cruises, per the NSF-USGS PEIS but have been adapted (adaptive mitigation per the NSF-USGS PEIS) to current best practices during the course of the consultation.. Special mitigation measures were considered for this cruise, but considered unnecessary due to the size of the sources, the operational area, and the season.

Mitigation measures that would be adopted include (1) vessel speed or course alteration, provided that doing so would not compromise operational safety requirements, (2) GI-airgun shut down when mammals or other protected species are within or about to enter EZs; (3) ramp-up procedures; and (4) establishment of a 100 m wide buffer zone starting at the edge of the EZ.

Speed or Course Alteration

If a marine mammal or sea turtle is detected outside the 100 m EZ and, based on its position and the relative motion is considered likely to enter the adopted 100 m EZ, the vessel's speed and/or direct course could be changed. This would be done if operationally practicable, while minimizing the effect on the planned science objectives. The activities and movements of the marine mammal or sea turtle (relative to the seismic vessel) would then be closely monitored to determine whether the animal is approaching the EZ. If the animal appears likely to enter the EZ, further mitigating actions would be taken, i.e., either further course alterations or a power down or shut down of the seismic source. Typically, during seismic operations, the source vessel is unable to change speed or course and one or more alternative mitigation measures (see below) would need to be implemented.

Power Down

During the course of consultation, it was determined that the calculated Level A zones for the largest source size that would be used during the proposed action were well within the 100 m mandated EZ for the survey. Powering down the array to fewer guns would reduce the actual Level A zone only further within the 100 m mandated EZ. Therefore, powering down to fewer guns will not be permitted as a mitigation measure due to the requirement that the 100 m mandated EZ be observed at all times. Furthermore, no mitigation gun may be used for sources of the size chosen for the Proposed Action.

Shut Down Procedures

If (a) a marine mammal or turtle is detected about to enter or is already within the EZ and (b) the vessel's movement cannot maintain the animal outside the EZ, the GI airguns would be shut down immediately. In consultation with NMFS, exceptions may be made for some delphinids that approach the vessel. The operating airguns would also be shut down in the event an ESA-listed seabird were observed diving or foraging within the designated EZ and power down will not reduce the size of the EZ enough to avoid the bird's activity counting as a "take." Following a shut down, PSOs will conduct observations for at least 30 minutes. Seismic activity would not resume until the marine mammal or turtle has cleared the EZ, the ship has moved away from the last sighting of the animal for 4 minutes, or the PSO is confident that the animal has left the vicinity of the vessel. As excerpted directly from the NSF-USGS PEIS (§ES6.1) and modified to exclude animals not relevant to the study area, the animal would be considered to have cleared the EZ zone if

- is visually observed to have left the EZ;
- has not been seen within the EZ for 15 min in the case of small odontocetes; or
- has not been seen within the EZ for 30 min in the case of mysticetes and large odontocetes, including sperm, pygmy sperm, dwarf sperm, and beaked whales; or
- the vessel has moved outside the applicable EZ in which the animal in question was last seen.

As noted above, when moving at 4 knots, the vessel progresses ~2 m/s. Thus, the 100 m EZ would be cleared in under 1 minute.

The airgun array will be shut down if a North Atlantic right whale is observed at any distance from the vessel and will remain shut down 30 minutes after the last sighting.

Ramp-Up Procedures

A ramp-up procedure would be followed when the GI airguns begins operating after a specified period without GI airgun operations. PSOs will conduct observations for at least 30 minutes prior to the initiation of the ramp up. The ramp-up period to use of the full 4 airguns would be 20 min, with one gun added every 5 minutes. If one gun had been operating during a power-down (see above), ramp up to the full array would take 15 minutes, with one additional gun added every 5 minutes. Ramp up would not occur if a marine mammal or sea turtle has not cleared the 100 m EZ, as described earlier. Ramp up would begin with one (additional) GI airgun at 105 in^3, and the second (additional) GI airgun would be added after 5 min and so forth. Only after all 4 guns were firing at 105 in^3 could power be increased to run the sources in GG mode (210 in^3 each). During ramp up, the PSOs would monitor the EZ. If marine mammals or turtles are sighted, a shut down would be implemented. Ramp-ups would be conducted at night in some cases under the precepts described in the IHA.

Marine mammals and sea turtles are known to occur in the proposed project area. However, the number of individual animals expected to be approached closely during the proposed activities would be relatively small in relation to regional population sizes, as shown in §IV. With the proposed monitoring and mitigation provisions, potential effects on most if not all individuals would be expected to be limited to minor behavioral disturbance. Those potential effects would be expected to have negligible impacts both on individual marine mammals and on the associated species and stocks. Survey operations would be conducted in accordance with all applicable U.S. federal regulations, including IHA and ITS requirements.

Alternative 1: Alternative Survey Timing

An alternative to issuing the IHA for the period requested and to conducting the project then would be to conduct the project at an alternative time, implementing the same monitoring and mitigation measures as under the Proposed Action, and requesting an IHA to be issued for that alternative time (Table 5). The proposed August 2018 timing for the cruise is the most suitable time logistically for R/V *Hugh R. Sharp* and the participating scientists. If the IHA is issued for another period, it could result in significant delay and disruption not only of this cruise, but also of additional studies that are planned using the equipment or the vessel in 2018 and beyond. An evaluation of the effects of this Alternative Action is given in § IV.

Alternative 2: No Action Alternative

An alternative to conducting the proposed activities is the "No Action" alternative, i.e., do not conduct the research operations; an IHA and ITS would not be necessary (Table 5). From NMFS' perspective, pursuant to its obligation to grant or deny permit applications under the MMPA, the "No Action" alternative entails NMFS denying the application for an IHA. If NMFS were to deny the application, action proponents would not be authorized to incidentally take marine mammals. If the research were not conducted, the "No Action" alternative would result in no disturbance to marine mammals from the proposed activities. The "No Action" alternative does not address the national need for new data about the distribution of gas hydrates on the Mid-Atlantic margin. The U.S. would continue to rely on data more than 30 years old to delineate these gas hydrate resources and associated shallow gas. The U.S. would not acquire data that could also be used for analysis of submarine slide hazards in this area.

The "No Action" alternative could also potentially affect other research community studies that would be carried out on the *R/V Hugh R. Sharp* in 2018 and later, depending on the timing of the decision. Not conducting this cruise (no action) would result in the U.S. continuing to lack modern multichannel seismic data for a significant portion of the mid-Atlantic margin and not having access to suitable information to constrain the distribution of methane hydrates and shallow gas. Data collection would be an essential first step for a much greater effort to analyze and report information related to the geological structure and distribution of gas/gas hydrate on the mid-Atlantic part of the U.S. Atlantic margin. The dataset that the USGS proposes to collect will likely be used for at least three decades into the future based on past experience. Effects of this Alternative Action are evaluated in § IV.

Alternatives Considered but Eliminated from Further Analysis

1. Alternative E1: Alternative Location

The survey area has been chosen based on an analysis of the locations of existing high-resolution modern multichannel seismic data, older "legacy" data, known gas hydrate features identified by BOEM (2012a) and the USGS (Ruppel et al., 2015), and the published locations of known methane seeps (Skarke et al., 2014). The U.S. Mid-Atlantic margin is the highest priority area for surveys delineating the locations of gas hydrate and free gas in sediments, studying the links between gas hydrate systems and widespread methane seeps, and acquiring modern MCS data. While there are other areas on the margin where surveys could be carried out, they have lower priority at present due either to the availability of more recently acquired MCS data, the highly-eroded nature of the sediments, and/or the absence of known methane hydrates/methane seeps.

2. Alternative E2: Use of Alternative Technologies

As described in § 2.6 of the NSF-USGS PEIS, alternative technologies to the use of airguns are typically investigated to conduct marine geophysical research. At the present time, these technologies are still not feasible, widely available, or appropriate to meet the Purpose and Need. Additional details about these technologies are given in the Final USGS EA (RPS 2013) for the 2013 Gulf of Mexico Gas Hydrates Project (SIGH). Table 5 provides a summary of the proposed action, alternatives, and alternatives eliminated from further analysis

TABLE 5. Summary of Proposed Action, Alternatives Considered, and Alternatives Eliminated.

Proposed Action	**Description/Analysis**
Proposed Action: Conduct marine geophysical surveys and associated activities in the Northwest Atlantic Ocean	Under this action, the use of GI gun seismic sources is proposed. When considering mobilization, demobilization, equipment maintenance, weather, marine mammal activity, and other contingencies, the proposed activities would be expected to be completed in a maximum of 21 days. The affected environment, environmental consequences, and cumulative impacts of the proposed activities are described in Sections III, IV, and V, respectively. The standard monitoring and mitigation measures identified in the NSF-USGS PEIS would apply, along with any additional requirements identified by regulating agencies. All necessary permits and authorizations, including an IHA, would be requested from regulatory bodies.
Alternatives	**Description/Analysis**
Alternative 1: Alternative Survey Timing	Under this Alternative, the USGS would conduct survey operations at a different time of the year to reduce potential impacts on marine resources and users, and improve monitoring capabilities. However, except for some migratory species, most marine mammal species occur in the project area year-round, so altering the timing of the proposed project likely would result in no net benefits for those species and could make it more likely that survey time is lost due to weather, meaning that surveys would have to be repeated in the future (greater sound exposure for mammals). Further, consideration would be needed for constraints for vessel operations and availability of equipment (including the vessel) and personnel. Limitations on scheduling the vessel include the additional research studies planned on the vessel for 2018 and beyond and the lack of equipment availability within the U.S. research fleet at other times. The standard monitoring and mitigation measures identified in the NSF-USGS PEIS would apply and are described in further detail in this document (Section II [3]) along with any additional requirements identified by regulating agencies. All necessary permits and authorizations, including an IHA, would be requested from regulatory bodies.
Alternative 2: No Action	Under this Alternative, no proposed activities would be conducted and seismic data would not be collected. Whereas this alternative would avoid impacts to marine resources, it would not meet the purpose and need for the proposed action. The collection of new data, interpretation of these data, and introduction of new results into the greater scientific community would not be achieved. No permits and authorizations, including an IHA, would be necessary from regulatory bodies as the proposed action would not be conducted.
Alternatives Eliminated from Further Analysis	**Description/Analysis**
Alternative E1: Alternative Location	The Survey Areas in the Northwest Atlantic Ocean are those in which modern MCS data on the distribution of gas hydrates and shallow natural gas are lacking, yet studies by BOEM and the USGS have identified areas likely to host widespread gas hydrate deposits. Since this is the part of the margin with the most active methane seepage, but lacking modern seismic data, a different site does not serve the goal of acquiring new data in the mid-Atlantic data gap.
Alternative E2: Alternative Survey Techniques	Under this alternative, the USGS would use alternative survey techniques, e.g., marine vibroseis, that could potentially reduce impacts on the marine environment. Alternative technologies were evaluated in the NSF-USGS PEIS, § 2.6. At the present time, these technologies are still in the testing phase. They are still not feasible, viable for routine seismic data acquisition, or appropriate to meet the Purpose and Need.

III. AFFECTED ENVIRONMENT

Parts of this section are adopted verbatim from the Draft Scripps EA (LGL, 2017). Based on the NSF-USGS PEIS, Chapter 3, the description of the affected environment focuses only on those resources potentially subject to impacts. Accordingly, the discussion of the affected environment (and associated analyses) focuses mainly on marine biological resources because the short-term seismic activities proposed by the USGS for the Northwest Atlantic in 2018 have the potential to affect marine biological resources within the project area. These resources are identified below in the following parts of § III, and the potential impacts on these resources are discussed in § IV. Initial review and analysis of the proposed project activities determined that the following resource issues did not require further analysis in this EA:

- *Transportation*—Only the *R/V Hugh R. Sharp* will be used during the seismic survey. This single ship represents a neglible amount of additional ship traffic in the analysis area, which is heavily used for commercial and military vessels;
- *Air Quality/Greenhouse Gases*—Vessel emissions would result from the proposed activities; however, these short-term emissions would not result in any exceedance of Federal Clean Air standards. Emissions would be expected to have a negligible impact on the air quality within the survey area. Per EPA requirements, the *R/V Hugh R. Sharp* is a low emissions vessel.
- *Land Use*—All activities are proposed to occur in the marine environment. Therefore, no changes to current land uses or activities within the survey area would result from the proposed activities;
- *Safety and Hazardous Materials and Management*—With the exception of lithium-ion batteries needed to power components of "birds" that stabilize the streamer, marine diesel fuel used to power the compressors, and synthetic lubricant used by the compressors, no hazardous materials would used during the Proposed Action. In hot, humid weather, the compressors produce significant quantities of oily wastewater that is collected in accumulators and then manually emptied. The oily wastewater is subject to rules requiring discharge to have less than 15 ppm oil. This cruise will collect the oily wastewater instead of treating it shipboard and have the material removed by a licensed firm post-cruise. All other Project-related wastes would also be disposed of in accordance with applicable laws.
- *Geological Resources (Topography, Geology and Soil)*—The Proposed Action would not result in the displacement or disruption of seafloor sediment. Proposed activities would not adversely affect geologic resources as only minor impacts would occur;
- *Water Resources*—There are no proposed discharges to the marine environment that would adversely affect marine water quality. Therefore, there would be no impacts to water resources resulting from the proposed Project activities;
- *Terrestrial Biological Resources*—All proposed Project activities would occur in the marine environment and would not affect terrestrial biological resources;
- *Socioeconomic and Environmental Justice*—Implementation of the proposed Project would not affect, beneficially or adversely, socioeconomic resources, environmental justice, or the protection of children. No changes in the population or additional need for housing or schools would occur. Human activities in the area around the survey vessel are expected to be limited to commercial and recreational fishing, shipping, and military traffic;
- *Visual Resources*—No visual resources should be negatively affected because the area of operation is significantly outside of the land and coastal view shed; and
- *Cultural Resources*—While the surveys may cross shipwrecks, no impacts are expected, nor will the sensing technology used even be able to locate these shipwrecks. For example, the ship will not be

conducting bathymetric or backscatter surveys of the seafloor. The proposed activities will not disturb shipwrecks.

(1) Oceanography

The Study 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.

Much of the information below has been taken verbatim or adapted from the "Final Environmental Assessment for Seismic Reflection Scientific Research Surveys During 2014 and 2015 in Support of Mapping the U.S. Atlantic Seaboard Extended Continental Margin and Investigating Tsunami Hazards," prepared for the U.S. Geological Survey in 2014 (RPS, 2014a) or from the Draft ENAM EA (RPS, 2014c).

The area of the Proposed Action 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 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).

(2) Protected Areas

The Proposed Action, contained as it is within th EEZ, does not overlap with any international Ecologically or Biologically Significant Marine Areas (EBSAs). The action lies close to the region of the

North Atlantic called the Sargasso Sea, which is considered an EBSA, and intersects a U.S. Marine Protected Area (MPA) on the western side of the Sargasso Sea. More information about the Sargasso Sea is provided in the MPA section below.

The Proposed Action overlaps with several U.S. MPAs, although most of these are so designated based on restrictions in fishing activities, which are not the focus of the seismic surveys. The MPAs within the Proposed Action area include: Frank R. Lautenberg Deep Sea Coral Protection Area, Mid-Atlantic Coastal Waters Area, the Norfolk Canyon Gear Restricted Ara, Offshore Trap/Pot Waters, the "Other" Northeast Gillnet Waters Area, the Pelagic Sargassum Habitat Restricted Area, the Southern Mid-Atlantic Waters Closure Area, the New Jersey offshore closure area, and the Southern Nearshore Pot-Trap Pot Waters. All of these are considered fishery management areas except the Norfolk Canyon area (gear restriction) and the Lautenberg Deep Sea Coral area, which protects corals. All areas are subject to non-MPA Programmatic Species Management Plans. Commercial fishing is restricted in all areas, while both commercial and recreational fishing are restricted in the Lautenberg Deep Sea Coral Protection Area. Some of these MPA have seasonal restrictions, while others have year-round restrictions. The surveys are not located in *de facto* MPAs, although the ship will transit through these without seismic gear active on the way to and from ports in Norfolk or Lewes.

Frank R. Lautenberg Deep Sea Coral Protection Area

The northernmost 75% of the Proposed Action lies almost completely within the boundaries of the Frank R. Lautenberg Deep Sea Coral Protection Area. The area was designated by NOAA Fisheries and the Mid-Atlantic Fishery Management Council in 2016 to protect very slow-growing deep corals that live on the outer continental shelf and in some canyon areas. Within the protected area, fishing activities that interfere with the seabed are restricted, but recreational fishing and other activities may continue. The Proposed Action does not disrupt the seabed and is not expected to have an impact on deep sea corals within the Protection Area.

The Sargasso Sea

The Sargasso Sea occupies the area within the Northern Atlantic Subtropic Gyre, mostly on the high seas, outside the EEZs of most countries. The area is dynamically bound on the west by the Gulf Stream and on the north by the North Atlantic Current. The northwest corner of the Sargasso Sea therefore often lies within the US EEZ, depending on the course of the Gulf Stream. *Sargassum* is a floating algae that occurs only in the open ocean, and the Sargasso Sea is the only place in the world this ecosystem is found. Sargassum is particularly important for turtles, particularly loggerheads, but also plays a role in the life cycles of some crustaceans, fish, and marine mammals (e.g., humpbacks). The U.S. has designated the Pelagic Sargassum Habitat Restricted Area to regulate fishing in this area. The southernmost exemplary survey lines for the Proposed Action, as well as the deepwater portions of some of the exemplary lines in the Mid-Atlantic region, intersect the designated loggerhead sea turtle (Caretta caretta) critical habitat for the Northwest Atlantic Ocean Distinct Population (see below).

(3) Marine Mammals

Much of the following section is taken verbatim from the Draft Scripps EA (LGL, 2017). Thirty-four marine mammal species could occur in the general survey area, including 7 mysticetes (baleen whales) and 27 odontocetes (toothed whales, such as dolphins) (Table 6). To avoid redundancy, we have included the required information about the species and (insofar as it is known) numbers of these species in § IV, below. Five of the species that could occur in the proposed project area are listed under the ESA as ***endangered***, including the sperm, sei, fin, blue, and North Atlantic right whales. General information on the taxonomy, ecology, distribution and movements, and acoustic capabilities of marine mammals are given in § 3.6.1, § 3.7.1, and § 3.8.1 of the NSF-USGS PEIS.

One of the detailed analysis areas (DAAs) defined in the NSF-USGS PEIS §2.3.1.1 is in the Northwest (NW) Atlantic and lies at the northernmost end of the Survey Area for this Proposed Action, encompassing the area out to 1500 m water depth. The distributions of mysticetes, odontocetes, and pinnipeds in the NW Atlantic DAA are discussed in §3.6.2.1, §3.7.2.1, and §3.8.2.1 of the NSF-USGS PEIS, respectively. The rest of this section deals specifically with species distribution in the area of the Proposed Action.

Two cetacean species occur in Atlantic arctic waters, and their ranges do not extend as far south as the proposed project area: the narwhal, *Monodon Monoceros*; the beluga, *Delphinapterus leucas*; and the bowhead, *Balaena mysticetus*. Two additional Atlantic cetacean species, the Atlantic humpback dolphin (*Souza teuszii*) found in coastal waters of western Africa, and the long-beaked common dolphin (*Delphinus capensis*) found in coastal waters of South America and western Africa, do not occur in the study area.

Pinniped species that are known to occur in North Atlantic waters, but that will not occur in the area of the Proposed Action, include the gray seal (*Halichoerus grypus*), harbor seal (*Phoca vitulina*), and bearded seal (*Erignathus barbatus*). Pinniped species are not discussed further in this EA, nor are takes calculated for these species given that they would not be encountered.

3. Mysticetes

The following information has mostly been copied verbatim from the Draft Scripps EA (LGL, 2017) and then modified for the specific circumstances of the USGS Proposed Action, when appropriate. Table 6 summarizes the conservation status, estimated population, habitat, and survey specific information for each species.

North Atlantic Right Whale (*Eubalaena glacialis*)

The North Atlantic right whale occurs primarily in the continental shelf waters of the eastern U.S. and Canada, from Florida to Nova Scotia (Winn et al. 1986; Jefferson et al. 2015). Survey data have identified seven major habitats or congregation areas for North Atlantic right whales: coastal waters of the southeastern United States; Great South Channel; Jordan Basin; Georges Basin along the northern edge of Georges Bank; Cape Cod and Massachusetts Bays; Bay of Fundy; and Roseway Basin on the Scotian Shelf (Hayes et al. 2017). There is a general seasonal north-south migration between feeding and calving areas (Gaskin 1982). The migration route between the Cape Cod spring/summer feeding grounds and the Georgia/Florida winter calving grounds is known as the mid-Atlantic corridor, and whales move through these waters regularly in all seasons (Reeves and Mitchell 1986; Winn et al. 1986; Kenney et al. 2001; Reeves 2001; Knowlton et al. 2002; Whitt et al. 2013). The majority of sightings (94%) along the migration corridor are within 56 km of shore (Knowlton et al. 2002).

During the summer and into fall (June–November), right whales are most commonly seen on feeding grounds in Canadian waters off Nova Scotia, with peak abundance during August, September, and early October (Gaskin 1987). Some right whales, including mothers and calves, remain on the feeding grounds through the fall and winter. However, the majority of the right whale population leaves the feeding grounds for unknown wintering habitats and returns when the cow-calf pairs return. The majority of the right whale population is unaccounted for on the southeastern U.S. winter calving ground, and not all reproductively-active females return to the area each year (Kraus et al. 1986; Winn et al. 1986; Kenney et al. 2001). Other wintering areas have been suggested, based on sparse data or historical whaling logbooks; these include the Gulf of St. Lawrence, Newfoundland and Labrador, coastal waters of New York and between New Jersey and North Carolina, Bermuda, and Mexico (Payne and McVay 1971; Aguilar 1986; Mead 1986; Lien et al. 1989; Knowlton et al. 1992; Cole et al. 2009; Patrician et al. 2009).

In more than 5000 recorded global sightings of North Atlantic right whales, there have been 11 within the polygon that bounds the exemplary surveys (OBIS, 2017). No sightings have been reported in July, August or September within the survey area (Figure 7). Given the small size of the population and their typical summer range, North Atlantic right whales should not be encountered during the USGS surveys.

Humpback Whale (*Megaptera novaeangliae*)

The humpback whale is found throughout all of the oceans of the world (Clapham 2009). Although considered to be mainly a coastal species, humpbacks often traverse deep pelagic areas while migrating (Clapham and Mattila 1990; Norris et al. 1999; Calambokidis et al. 2001). Humpback whales migrate between summer feeding grounds in high latitudes and winter calving and breeding grounds in tropical waters (Winn and Reichley 1985; Clapham and Mead 1999; Smith et al. 1999). The summer feeding grounds in the North Atlantic range from the northeast coast of the U.S. to the Barents Sea (Katona and Beard 1990; Smith et al. 1999). Humpbacks in the North Atlantic primarily migrate to wintering areas in the West Indies (Jann et al. 2003), but some also migrate to Cape Verde (Carrillo et al. 1999; Wenzel et al. 2009). A small proportion of the Atlantic humpback whale population remains in high latitudes in the eastern North Atlantic during winter (e.g., Christensen et al. 1992).

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 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 (Figure 7). Three of these sitings have been at or seaward of the shelf break, near the landward ends of the two northernmost exemplay 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.

Minke Whale (*Balaenoptera acutorostrata*)

The minke whale has a cosmopolitan distribution that spans from tropical to polar regions in both hemispheres (Jefferson et al. 2015). Some populations migrate from high latitude summering grounds to lower latitude wintering grounds (Jefferson et al. 2015). In the Northern Hemisphere, the minke whale is usually seen in coastal areas, but can also occur in pelagic waters during northward migrations in spring and summer, and southward migration in autumn (Stewart and Leatherwood 1985; Perrin and Brownell 2009). There are four recognized minke whale populations in the North Atlantic: Canadian east coast, west Greenland, central North Atlantic, and northeast Atlantic (Donovan 1991). 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.

Most minke whale sitings south of 40°N have been on the continental shelf, at water depths shallower than the proposed USGS seismic lines. Minke whales may occasionally be encountered seaward of the shelf-break during the proposed USGS surveys. Of the more than 15,000 sightings of minke whale individuals or groups dating back more than 50 years in the OBIS database, 51 occurred within a rectangular block containing the exemplary proposed USGS seismic survey lines. Of these, twelve sightings comprising 21 individuals occurred during July, August, or September (Figure 7). Only two of the sightings were seaward of the shelf break, including one near Washington Canyon and another beyond the distal, deepwater termini of the three central USGS exemplary seismic transects.

Minke whales could be encountered near the survey lines in August, but this would be a rare occurrence.

Bryde's Whale (*Balaenoptera edeni/brydei*)

Bryde's whale is found in tropical and subtropical waters throughout the world between 40ºN and 40ºS, generally in waters warmer than 20ºC, but at minimum 15ºC (Reeves et al. 1999; Kanda et al. 2007; Kato and Perrin 2009). It can be pelagic as well as coastal (Jefferson et al. 2015). It does not undertake long north/south migrations, although local seasonal movements toward the Equator in winter and to higher latitudes in summer take place in some areas (Evans 1987; Jefferson et al. 2015). Of 914 usable sightings in the iOBIS database, none occurred within the larger box enclosing the proposed survey in any season (Figure 7). Still, Bryde's whales could possibly be encountered in the proposed project area.

Sei Whale (*Balaenoptera borealis*)

The distribution of the sei whale is not well known, but it is found in all oceans and appears to prefer mid-latitude temperate waters (Gambell 1985a). The sei whale is pelagic and generally not found in coastal waters (Harwood and Wilson 2001; Jefferson et al. 2015). It is found 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). On feeding grounds, sei whales associate with oceanic frontal systems (Horwood 1987). Sei whales migrate from temperate zones occupied in winter to higher latitudes in the summer, where most feeding takes place (Gambell 1985a). A small number of individuals have been sighted in the eastern North Atlantic between October and December, indicating that some animals may remain at higher latitudes during winter (Evans 1992). Sei whales have been seen from South Carolina south into the Gulf of Mexico and the Caribbean during winter (Rice 1998); however, the location of sei whale wintering grounds in the North Atlantic is unknown (Víkingsson et al. 2010).

There are three sei whale stocks in the North Atlantic: Nova Scotia, Iceland-Denmark Strait, and Eastern (Donovan 1991). 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 7 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 (Figure 7). Sei whales could be encountered in the proposed project area during an August survey, but this would be an extremely rare occurrence.

Fin Whale (*Balaenoptera physalus*)

Fin whales are widely distributed in all the world's oceans in coastal, shelf, and oceanic waters, and typically occur in temperate and polar regions (Gambell 1985b; Perry et al. 1999; Gregr and Trites 2001; Jefferson et al. 2015). Fin whales tend to follow steep slope contours, either because they detect them readily or because biological productivity is high along steep contours because of tidal mixing and perhaps current mixing (Sergeant 1977). Fin whales appear to have complex seasonal movements and are seasonal migrants; they mate and calve in temperate waters during the winter and migrate to feed at northern latitudes during the summer (Gambell 1985b). They are known to use the shelf edge as a migration route (Evans 1987).

In the North Atlantic, fin whales are found in summer from Baffin Bay, Spitsbergen, and the Barents Sea, south to North Carolina and the coast of Portugal (Rice 1998). In winter, they have been sighted from Newfoundland to the Gulf of Mexico and the Caribbean, and from the Faroes and Norway south to the Canary Islands (Rice 1998). Based on geographic differences in fin whale calls, Delarue et al. (2014) suggested that there are four distinct stocks in the Northwest Atlantic, including a central North Atlantic stock that and extends south along the Mid-Atlantic Ridge. Similarly, the four stocks in the Northwest Atlantic currently recognized by NAMMCO (2016) are located off West Iceland (in the Central Atlantic), Eastern Greenland, Western Greenland, and Eastern Canada.

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, 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 (Figure 7). Fin whales could be encountered during the proposed August surveys, particularly closer to the shelf edge and near the uppermost continental slope.

Blue Whale (*Balaenoptera musculus*)

The blue whale has a cosmopolitan distribution and tends to be pelagic, only coming nearshore to feed and possibly to breed (Jefferson et al. 2015). It is most often found in cool, productive waters where upwelling occurs (Reilly and Thayer 1990). The distribution of the species, at least during times of the year when feeding is a major activity, occurs in areas that provide large seasonal concentrations of euphausiids (Yochem and Leatherwood 1985). Seamounts and other deep ocean structures may be important habitat for blue whales (Lesage et al. 2016). Generally, blue whales are seasonal migrants between high latitudes in summer, where they feed, and low latitudes in winter, where they mate and give birth (Lockyer and Brown 1981). Their summer range in the North Atlantic extends from Davis Strait, Denmark Strait, and the waters north of Svalbard and the Barents Sea, south to the Gulf of St. Lawrence and the Bay of Biscay (Rice 1998). Although the winter range is mostly unknown, some occur near Cape Verde at that time of year (Rice 1998).

Of the more than 16,000 sightings of blue whale individuals or groups dating back more than 50 years in the OBIS database, only 2 occurred within a rectangular block containing the exemplary proposed USGS seismic survey lines. One of these, comprising a single individual, occurred during July, August, or September and was located ~85 nautical miles offshore New Jersey, on the upper continental slope between the two northernmost exemplary USGS seismic lines to be acquired down the continental slope (dip lines) and may either be an extralimital animal or a misidentification (Figure 7). While it would be a very rare occurrence, it is possible that a blue whale could be encountered in the proposed project area during an August seismic survey.

4. Odontocetes

Sperm Whale (*Physeter macrocephalus*)

The sperm whale is the largest of the toothed whales, with an extensive worldwide distribution (Rice 1989). Sperm whale distribution is linked to social structure: mixed groups of adult females and juvenile animals of both sexes generally occur in tropical and subtropical waters, whereas adult males are commonly found alone or in same-sex aggregations, often occurring in higher latitudes outside the breeding season (Best 1979; Watkins and Moore 1982; Arnbom and Whitehead 1989; Whitehead and Waters 1990). Sperm whales generally are distributed over large areas that have high secondary productivity and steep underwater topography, in waters at least 1000 m deep (Jaquet and Whitehead 1996; Whitehead 2009). They are often found far from shore, but can occur closer to oceanic islands that rise steeply from deep ocean waters (Whitehead 2009).

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 9, 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.

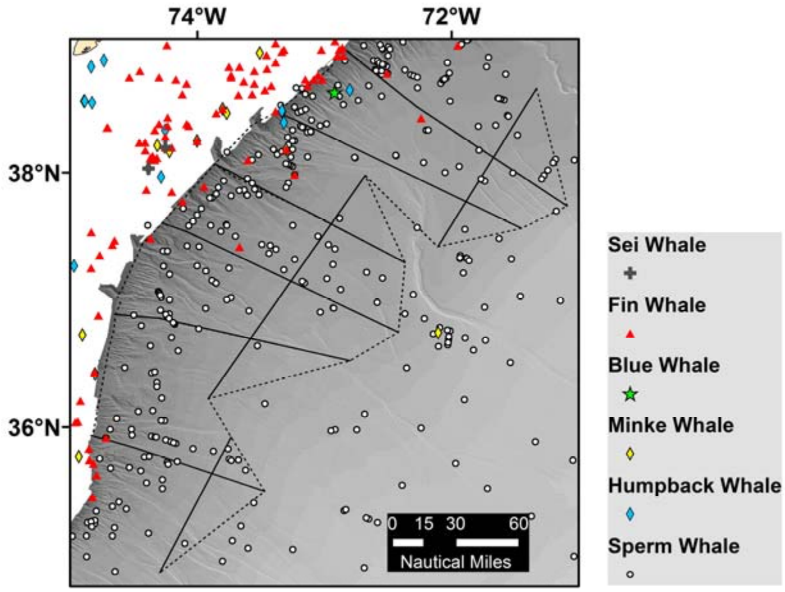

Figure 7. Sightings of endangered cetaceans and all baleen whales simultaneously overlapping the survey area <u>and</u> occurring during the summer (July through September) months as compiled from the iOBIS database by the USGS based on usable records. Note that there are no relevant sightings of North American right whales or Byrde's whales that meet the spatial and temporal criteria.

Pygmy and Dwarf Sperm Whales (*Kogia breviceps and K. sima*)

The pygmy sperm and dwarf sperm whales are high-frequency cetaceans distributed widely throughout tropical and temperate seas, but their precise distributions are unknown as most information on these species comes from strandings (McAlpine 2009). They are difficult to sight at sea, perhaps because of their avoidance reactions to ships and behavior changes in relation to survey aircraft (Würsig et al. 1998). The two species are difficult to distinguish from one another when sighted (McAlpine 2009) and are combined in the Roberts et al. (2015) density modeling under the auspices of the *Kogia* guild.

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 of the pygmy sperm whale sightings in the OBIS database occur 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 (*Ziphius cavirostris*)

Cuvier's beaked whale is probably the most widespread of the beaked whales. Cuvier's beaked whale appears to prefer steep continental slope waters (Jefferson et al. 2015) and is most common in water depths >1000 m (Heyning 1989). 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.

Northern Bottlenose Whale (*Hyperoodon ampullatus*)

The northern bottlenose whale is found only in the North Atlantic, from the subarctic to ~30°N (Jefferson et al. 2015). Northern bottlenose whales are most common in deep waters beyond the continental shelf or over submarine canyons, usually near or beyond the 1000-m isobath (Jefferson et al. 2015). 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.

True's Beaked Whale (*Mesoplodon mirus*)

True's beaked whale is mainly oceanic and occurs in warm temperate waters of the North Atlantic and southern Indian oceans (Pitman 2009). In the western North Atlantic, strandings have been recorded from Nova Scotia (~26°N) to Florida (46°N; MacLeod et al. 2006). Two sightings in the OBIS database occur in the general survey area, but only one of these was during the summer season that overlaps the Proposed Action. True's beaked whale likely would be rare in the proposed project area.

Gervais' Beaked Whale (*Mesoplodon europaeus*)

Gervais' beaked whale is mainly oceanic and occurs in tropical and warmer temperate waters of the Atlantic Ocean (Jefferson et al. 2015). It occurs in the Atlantic from ~54ºN to ~18ºS (MacLeod et al. 2006). Gervais' beaked whale is more common in the western than the eastern part of the Atlantic (Mead 1989). No OBIS sightings of the Gervais' beaked whale have occurred in the survey area. Given the geographic and depth range of the species, though, Gervais' beaked whale could be encountered in the proposed project area.

Sowerby's Beaked Whale (*Mesoplodon bidens*)

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). Sowerby's beaked whale is known primarily from strandings, which are more common in the eastern than the western North Atlantic (MacLeod et al. 2006). It is mainly a pelagic species and is found in deeper waters of the shelf edge and slope (Mead 1989). Eleven OBIS database sightings are in the polygon enclosing the larger area of the proposed surveys, and nine of these were during the summer months. Sowerby's beaked whale could be encountered in the proposed project area.

Blainville's Beaked Whale (*Mesoplodon densirostris*)

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). Like other beaked whales, Blainville's beaked whales are generally found in deep water, 200–1400 m deep (Gannier 2000; Jefferson et al. 2015). In the OBIS database, one sighting occurred in the survey area, and it was during the summer months. Blainville's beaked whale could be encountered in the proposed project area.

Rough-toothed Dolphin (*Steno bredanensis*)

The rough-toothed dolphin occurs in tropical and subtropical waters, rarely ranging farther north than 40°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 (*Tursiops truncatus*)

The bottlenose dolphin is distributed worldwide in coastal and shelf waters of tropical and temperate oceans (Jefferson et al. 2015). There are two distinct bottlenose dolphin types in the Northwest Atlantic: a shallow water type, mainly found in coastal waters, and a deep water type, mainly found in oceanic waters (Duffield et al. 1983; Hoelzel et al. 1998; Walker et al. 1999). 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.

Pantropical Spotted Dolphin (*Stenella attenuata*)

The pantropical spotted dolphin can be found throughout tropical oceans of the world (Jefferson et al. 2015). 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.

Atlantic Spotted Dolphin (*Stenella frontalis*)

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.

Striped Dolphin (*Stenella coeruleoalba*)

The striped dolphin has a cosmopolitan distribution in tropical to warm temperate waters (Perrin et al. 1994); however, it also occurs in temperate waters as far north as 50°N (Jefferson et al. 2015). 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.

Atlantic White-sided Dolphin (*Lagenorhynchus acutus*)

The Atlantic white-sided dolphin occurs in cold temperate and subpolar waters in the North Atlantic; in the western Atlantic, its range is from ~38°N to southern Greenland (Jefferson et al. 2015). It appears to prefer deep waters of the outer shelf and slope, but can also occur in shallow and pelagic waters (Jefferson et al. 2015). In the OBIS database, 28 sightings of the Atlantic white-sided dolphin occur in the general area of the survey, and 9 of these are during the summer months. Atlantic white-sided dolphins could be encountered in the proposed project area.

White-beaked Dolphin (*Lagenorhynchus albirostris*)

The white-beaked dolphin occurs in cold temperate and subpolar regions of the North Atlantic; its range extends from Cape Cod to southern Greenland in the west and Portugal to Svalbard in the east (Kinze 2009; Jefferson et al. 2015). It appears to prefer deep waters along the outer shelf and slope, but can also occur in shallow areas and far offshore (Jefferson et al. 2015). There are four main high-density centers in the North Atlantic, including (1) the Labrador Shelf, (2) Icelandic waters, (3) waters around Scotland, and (4) the shelf along the coast of Norway (Kinze 2009). One sighting in the OBIS database of over 2700 records is of a white-beaked dolphin in the general survey area, and none occurred during the summer. White-beaked dolphins are unlikely to be encountered in the proposed project area.

Short-beaked Common Dolphin (*Delphinus delphis*)

The short-beaked common dolphin is distributed in tropical to cool temperate waters of the Atlantic and the Pacific oceans from 60ºN to ~50ºS (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 ~35ºN (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% 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.

Risso's Dolphin (*Grampus griseus*)

Risso's dolphin is distributed worldwide in temperate and tropical oceans (Baird 2009), although it shows a preference for mid-temperate waters between 30° and 45° (Jefferson et al. 2014). Although it is known to occur in coastal and oceanic habitats (Jefferson et al. 2014), it appears to prefer steep sections of the continental shelf, 400–1000 m deep (Baird 2009), and is known to frequent seamounts and escarpments (Kruse et al. 1999; Baird 2009). 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.

Pygmy Killer Whale (*Feresa attenuata*)

The pygmy killer whale is pantropical, inhabiting waters generally between 40°N and 35°S (Jefferson et al. 2015). 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.

False Killer Whale (*Pseudorca crassidens*)

The false killer whale is found in all tropical and warmer temperate oceans, especially in deep, offshore waters (Jefferson et al. 2015). However, it is also known to occur in nearshore areas (e.g., Stacey and Baird 1991). The pelagic range in the North Atlantic is usually southward of ~30°N but extralimit individuals 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.

Killer Whale (*Orcinus orca*)

The killer whale is globally fairly abundant, and it has been observed in all oceans of the world (Ford 2009). It is very common in temperate waters and also frequents tropical waters, at least seasonally (Heyning and Dahlheim 1988). 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% 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.

Short-finned Pilot Whale (*Globicephala macrorhynchus*)

The short-finned pilot whale is found in tropical, subtropical, and warm temperate waters (Olson 2009); it is seen as far south as ~40ºS and as far north as ~50ºN (Jefferson et al. 2015). 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 (*Globicephala melas*)

The long-finned pilot whale occurs in temperate and sub-polar zones (Jefferson et al. 2015). It can be found in inshore or offshore waters of the North Atlantic (Olson 2009). In the western North Atlantic, high densities of long-finned pilot whales occurred over the continental slope in winter and spring, and they move to the shelf during summer and autumn (Jefferson et al. 2015). 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. (2015), meaning that there are no specific model density grids applicable to short-finned pilot whales.

Melon-headed Whale (*Peponocephala electra*)

The melon-headed whale is a pantropical species usually occurring between 40ºN and 35ºS (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 U.S., 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. (2015) 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 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.

Harbor Porpoise (*Phocoena phocoena*)

The harbor porpoise inhabits temperate, subarctic, and arctic waters. It is typically found in shallow water (<100 m) nearshore, but it is occasionally sighted in deeper offshore water (Jefferson et al. 2015). The subspecies *P.p. phocoena* inhabits the Atlantic Ocean. In the western North Atlantic, it occurs from the southeastern U.S. to Baffin Island; in the eastern North Atlantic (Jefferson et al. 2015). Despite their abundance and the over 49,000 usable sightings of harbor porpoises in the OBIS database, only 7 occurred within the larger rectangular area encompassing the Proposed Action, and only 1 of these was during the summer months. Given their preference for coastal waters, harbor porpoises are expected to be seen during transits across the shelf, but are not expected to be encountered in the survey area during seismic operations.

Fraser's Dolphin (*Lagenodelphis hosei*)

This information is compiled from the NOAA OPR website: http://www.nmfs.noaa.gov/pr/species/mammals/dolphins/frasers-dolphin.html. 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 Western North Atlantic stock of Fraser's dolphins, which is a population division recognized by NOAA, was unknown as of 2007 (http://www.nmfs.noaa.gov/pr/pdfs/sars/ao2007dofr-wn.pdf). The total population size for the Western Atlantic is unknown. The dolphins often occur in large groups (100 or more). The OBIS database has fewer than 200 sightings of Fraser dolphins. Only 3 sightings were within the larger project area, and only 2 of those were during the summer months. Fraser's dolphins could be encountered within the survey area during the Proposed Action.

Spinner Dolphin (*Stenella longirostis*)

The following is taken verbatim from the Final EA for the ENAM project (LGL, 2014): 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 40ºN and 40ºS (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.

Clymene's Dolphin (*Stenella clymene*)

The following is taken verbatim from the Final EA for the ENAM project (LGL, 2014). 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 analysesi, 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.

Table 6. The habitat, abundance, and conservation status of marine mammals that could occur in or near the proposed seismic project area in the Northwest Atlantic Ocean. Elements of this table were adopted directly from the Draft Scripps EA (LGL, 2017) and the ENAM EA (RPS, 2014c), with supplementary information from other sources for the populations. The iOBIS information in the far right columns was compiled by the USGS for this EA using a polygon that roughly enclosed the entire area of the Proposed Action. Usable iOBIS sightings exclude those with dates entered in an incorrect format. Note that some iOBIS sightings lack dates, but were included in the overall count of usable sightings. The algorithm arbitrarily assigned those sightings without dates to January. Abundance values are mostly taken from the Draft Scripps EA (LGL 2017), with some additional values added as footnoted.

Species	Occurrence near survey location	Habitat	Abundance in North Atlantic	ESA[1]	IUCN[2]	CITES[3]	Usable iOBIS sightings compiled by USGS	Subset of sightings within survey area polygon	Subset of sightings in area that occurred July-Sept
Mysticetes									
North Atlantic right whale	Rare	Mainly coastal and shelf	440-736[4]	EN	EN	I	5695	11	0
Humpback whale	Uncommon	Mainly nearshore waters and	11,570[6]	NL[24]	LC	I	41354	79	14
Common minke whale	Uncommon	Coastal, offshore	157,000[7]	NL	LC	I[25]	15843	51	12
Bryde's whale	Uncommon	Coastal,	N.A.	NL	DD	I	914	0	0
Sei whale	Uncommon	Mostly pelagic	10,300[8]	EN	EN	I	11127	7	2
Fin whale	Possible	Slope, mostly pelagic	24,887[9]	EN	EN	I	68029	131	29
Blue whale	Rare	Coastal, shelf, pelagic	855[10]	EN	EN	I	16949	2	1
Odontocetes									
Sperm whale	Likely	Usually deep pelagic, steep topography	13,190[11]	EN	VU	I	53789	686	395
Pygmy sperm whale (Kogia)	Possible	Deep waters off shelf	3785[12,13]	NL	DD	II	432	4	3
Dwarf sperm whale (Kogia)	Possible	Deep waters off shelf		NL	DD	II			
Cuvier's beaked whale	Possible	Slope, pelagic	3532[12]	NL	LC	II	1675	155	76
Northern bottlenose whale	Possible	Pelagic	~40,000[15]	NL	DD	I	2293	1	0
True's beaked whale	Possible	Pelagic	7092[12,14]	NL	DD	II	25	2	1
Gervais beaked whale	Possible	Pelagic	7092[12,14]	NL	DD	II	121	0	0

Sowerby's beaked whale	Possible	Pelagic	7092[12,14]	NL	DD	II	246	11	9
Blainville's beaked whale	Possible	Pelagic	7092[12,14]	NL	DD	II	574	1	1
Rough-toothed dolphin	Possible	Mostly pelagic	N.A.	NL	LC	II	1052	9	7
Table 6 (continued)									
Species	**Occurrence near survey location**	**Habitat**	**Abundance in North Atlantic**	**ESA[1]**	**IUCN[2]**	**CITES[3]**	**Usable iOBIS sightings compiled by USGS**	**Subset of sightings within survey area polygon**	**Subset of sightings in area that occurred July-Sept**
Clymene dolphin	Likely	Deepwater	6068[21]	NL	DD	II	140	23	14
Spinner dolphin	Possible	Coastal	NA [23]	NL	DD	II	2278	0	0
Common bottlenose dolphin	Likely	Coastal, shelf, pelagic	77,532[16]	NL	LC	II	57879	1873	776
Fraser's dolphin	Possible	Deep offshore	492 * (sum of abundance in Roberts et al. 2016 grid)	NL	LC	II	177	3	2
Pantropical spotted dolphin	Possible	Shelf, slope, pelagic	3333[12]	NL	LC	II	4240	48	29
Melon-headed whale	Possible	Seaward of continental	3451 northern	NL	LC	II	327	0	0
Atlantic spotted dolphin	Likely	Shelf, offshore	44,715[12]	NL	DD	II	7655	125	58
Striped dolphin	Likely	Off continental shelf	54,807[12]	NL	LC	II	15620	183	95
Atlantic white-sided dolphin	Possible	Coastal, shelf	48,819[12]	NL	LC	II	7932	28	9
Short-beaked common dolphin	Likely	Shelf, pelagic, high relief	70,184[12]	NL	LC	II	42829	43	3
Risso's dolphin	Likely	Shelf, slope,	18,250[12]	NL	LC	II	7241	471	238
Pygmy killer whale	Uncommon	Pelagic	N.A.	NL	DD	II	204	3	3
False killer whale	Uncommon	Pelagic	442	NL	DD	II	1173	2	1
Killer whale	Uncommon	Coastal, widely distributed	15,014[17]	NL	DD	II	3077	3	0
Long-finned pilot whale	Likely	Mostly pelagic	5636[12] 16,058[20] 780,000[18]	NL	DD	II	9082	51	16
Short-finned pilot whale	Likely	Mostly pelagic, high-relief	21,515[12] 780,000[18]	NL	DD	II	2514	414	105
Harbor porpoise	Uncommon	Coastal and shelf, also pelagic	79,833[19]	NL	LC	II	49502	7	1

White Beaked Dolphin	Uncommon	Cold waters < 200 m	2003[22]	NL	LC	II	2717	1	0

N.A. Not available or not assessed. NL = Not listed.
1 U.S. Endangered Species Act: EN = Endangered.
2 Codes for IUCN classifications: EN = Endangered; VU = Vulnerable; LC = Least Concern; DD = Data Deficient. Classifications are from the IUCN Red List of Threatened Species (IUCN 2017)
3 Convention on International Trade in Endangered Species of Wild Fauna and Flora (UNEP-WCMC 2017); Appendix I = Threatened with extinction; Appendix II = not necessarily now threatened with extinction but may become so unless trade is closely controlled.
4 Based on Pettis et al. (2017), Hayes et al. (2017), and IWC (2017)
5 Doniol-Valcroze (2015)
6 West Indies breeding ground (Stevick et al. 2003)
7 Central (50,000), Northeast Atlantic (90,000), and West Greenland (17,000) populations (IWC 2017)
8 North Atlantic (Cattanach et al. 1993)
9 Central and Northeast Atlantic for 2001 (Víkingsson et al. 2009)
10 Central and Northeast Atlantic for 2001 (Pike et al. 2009)
11 For the northeast Atlantic, Faroes-Iceland, and the U.S. east coast (Whitehead 2002)
12 Western North Atlantic (Hayes et al. 2017)
13 Both *Kogia* species
14 All *Mesoplodon* spp. combined
15 Eastern North Atlantic (NAMMCO 1995)
16 Offshore, Western North Atlantic (Hayes et al. 2017)
17 Northeast Atlantic (Foote et al. *in* NAMMCO 2016)
18 *Globicephala sp*. combined, Central and Eastern North Atlantic (IWC 2017)
19 Gulf of Maine/Bay of Fundy stock (Hayes et al. 2017)
20 Pilot whales in the Gulf of St. Lawrence and on the Scotian Shelf (Lawson and Gosselin 2009, 2011)
21 Waring et al. (2008); Note that the Roberts et al. (2016) abundance grid would correspond to 12526 individuals.
22 From NMFS stock assessment. http://www.nmfs.noaa.gov/pr/pdfs/sars/ao2007dowb-wn.pdf
23 Spinner dolphins have no minimum population assessment. https://www.nefsc.noaa.gov/publications/tm/tm228/190_spinner.pdf

Sea Turtles

Much of this section is taken verbatim from the Draft Scripps EA (2017), with small modifications to adapt it to the USGS Proposed Action.

Five species of sea turtles could occur in or near the proposed project area in the Northwest Atlantic Ocean: the leatherback (*Dermochelys coriacea*), hawksbill (*Eretmochelys imbricata*), Kemp's ridley (*Lepidochelys kempii*), loggerhead (*Caretta caretta*), and green turtle (*Chelonia mydas*). The leatherback and loggerhead turtles are the most likely turtles to be encountered. General information on the taxonomy, ecology, distribution and movements, and acoustic capabilities of sea turtles are given in § 3.4.1 of the NSF-USGS PEIS. The general distribution of sea turtles in the North Atlantic and on the Mid-Atlantic Ridge is discussed in § 3.4.3.1 and § 3.4.3.4 of the NSF-USGS PEIS. The rest of this section deals specifically with their distribution near the proposed project area.

1. Leatherback Turtle

The leatherback is listed as ***endangered*** under the ESA; however, a petition to designate the Northwest Atlantic subpopulation as a DPS and to list the DPS as ***threatened*** under the ESA is currently being considered by NOAA (2017a). Globally, the leatherback turtle is designated as ***vulnerable*** on the IUCN Red List of Threatened Species, but the Northwest Atlantic Ocean subpopulation is considered ***least concern***. TEWG (2007) estimated the North Atlantic population at 34,000–94,000 adults. The leatherback is the largest and most widely distributed sea turtle, ranging far from its tropical and subtropical breeding grounds to feed (Plotkin 2003; Spotila 2004). In the Atlantic, the largest nesting beaches are in Gabon, Africa, and in French Guiana; leatherbacks also nest in the Caribbean and Florida (NOAA 2016a).

Hatchling leatherbacks are pelagic, but virtually nothing is known about their distribution for the first four years (Musick and Limpus 1997). Eckert (2002) determined that juvenile leatherbacks (<100 cm in carapace length) only occur in waters warmer than 26ºC, while slightly larger juveniles (107 cm) are found in waters as cold as 12ºC. Outside of the nesting season, leatherbacks are highly migratory and feed in areas of high productivity, such as convergence zones, and upwelling areas in the open ocean, along continental margins, and in archipelagic waters (Morreale et al. 1994; Eckert 1995). Leatherbacks move over large ranges in the ocean and occur in pelagic regions of the North Atlantic where they forage between April and December on gelatinous zooplankton (Hays et al. 2006; COSEWIC 2012).

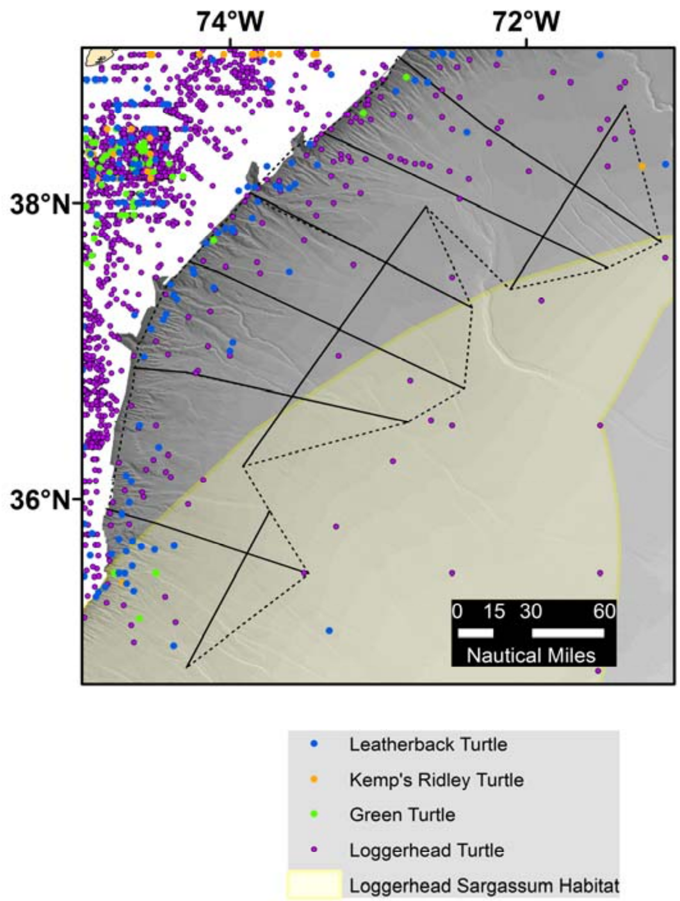

Figure 8. Compilation of the usable turtle sightings in the iOBIS database within a large polygon bounding all of the proposed seismic survey lines during the months of July, August, and September. No sightings of the hawksbill turtle met these criteria, so this species is missing. Also shown is the sargassum habitat for loggerhead turtles, which is described in more detail in §III.4.2.

Leatherback turtles are sometimes taken as bycatch by net and longline fishing in the MAB (Wallace et al., 2013). USGS analysis of the ~13,500 usable global sitings in the OBIS database showed that 316 individuals were identified in the survey area of the Proposed Action during any month and 76 during the July through September period. The locations of these sitings relative to the survey area are shown in Fig. 8. Fig. 9 shows the density map for leatherbacks from DiMatteo et al. (2017). Leatherback turtles are expected to be encountered in the area of the Proposed Action, particularly between the shelf-break and 1500 m water depth.

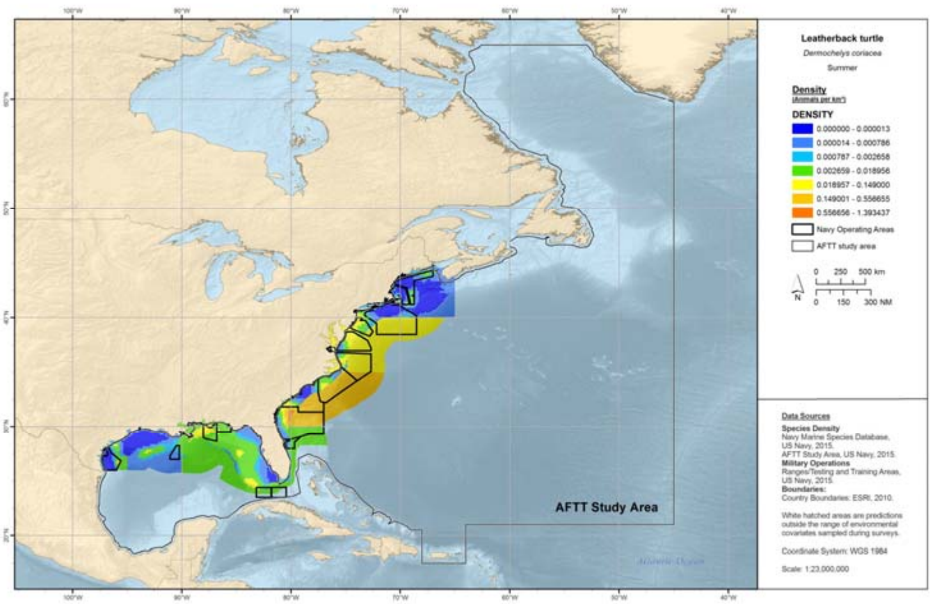

Figure 4-168. Spring NODES density spatial model for the leatherback turtle.

Figure 9. Summer NODES density spatial model for the leatherback turtle from DiMatteo et al. (2017). Note that the diagram's caption is mislabeled in the original, and that this figure should be for summer. It is bound in the original publication by distribution figures for spring and fall.

2. Loggerhead Turtle

Under the ESA, the Northeast Atlantic Ocean DPS (east of 40°W) of the loggerhead turtle is listed as ***endangered***, and the Northwest Atlantic Ocean DPS (west of 40°W) is listed as ***threatened***. Globally, the loggerhead turtle is listed as ***vulnerable*** on the IUCN Red List of Threatened Species, but the North East Atlantic subpopulation is listed as ***endangered***, and the North West Atlantic subpopulation is listed as ***least concern***. The loggerhead distribution is largely constrained by water temperature; it does not generally occur in waters with temperatures below 15°C (O'Boyle 2001; Brazner and McMillan 2008).

The major nesting areas in the North Atlantic occur along the U.S. coast (NOAA 2017b). The loggerhead turtle is the most common sea turtle in North American waters (Spotila 2004; NOAA 2017b). The adult female population in the western North Atlantic is estimated at 38,334 individuals (Richards et al. 2011). Post-hatchlings may reside for months in waters off the nesting beach or be transported by ocean currents within the Gulf of Mexico and North Atlantic (Witherington 2002; COSEWIC 2010). Between 7–12 years of age, juvenile loggerheads migrate from offshore regions to nearshore coastal areas until reaching adulthood (Bjorndal et al. 2000, 2003). Loggerheads migrate considerable distances between near-equatorial nesting areas and temperate foraging areas, and some move with the Gulf Stream into eastern Canadian waters during the summer (Hawkes et al. 2007). Loggerheads may be seen in the open seas during migration and foraging (e.g., Mansfield et al. 2009). According to the analysis by Wallace et al. (2013), loggerheads are the turtle species most frequently encountered as bycatch within the MAB. Bycatch occurs through all fishing methods (nets, longlines, and trawls.

The Sargasso Sea is considered critical habitat for loggerhead turtles. §3.2 describes this area and its importance. Of ~38,200 usable records in the OBIS database, 2859 were within the polygon enclosing the survey area, and 1618 of those were in July through September. These sightings are plotted in Fig. 8, along with the location of the Sargasso Sea critical habitat. Note that by far the highest density of sightings is on the inner and mid-continental shelf. Figure 10 shows the NODES model summer density of loggerhead turtles from DiMatteo et al. (2017). Loggerhead turtles are expected to be encountered during the Proposed Action, even at profound water depths (> 2000 m).

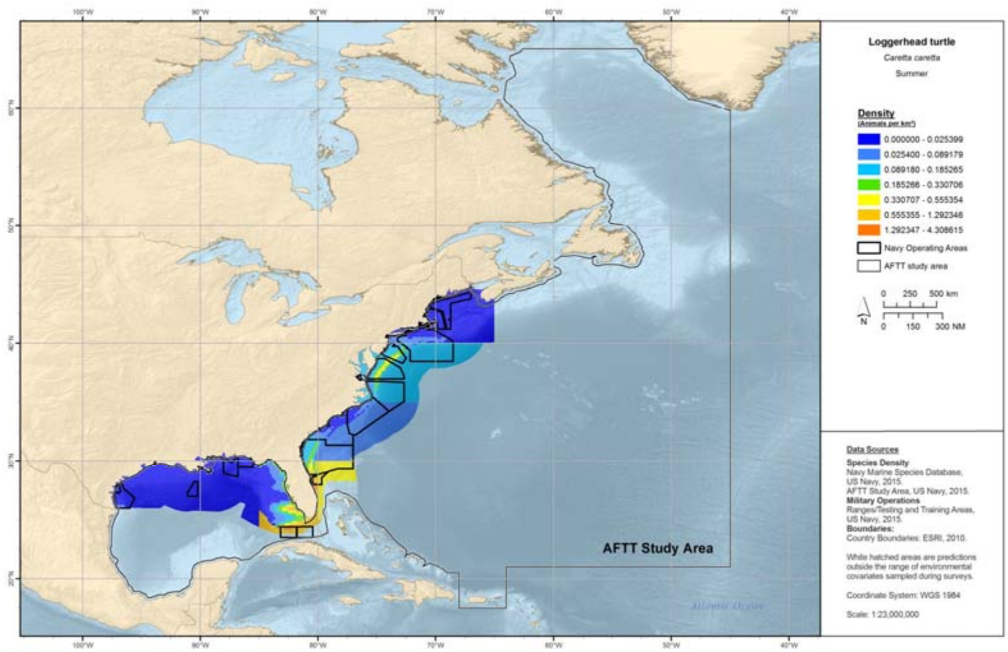

Figure 4-172. Summer NODES density spatial model for the loggerhead turtle.

Figure 10. NODES density for summer distribution of loggerhead turtles from DiMatteo et al. (2017). Note that, despite the far larger number of OBIS sitings in the survey area during the summer months, the density map indicates a lower number of loggerheads than leatherbacks (Figure 9) expected in the Survey Area during the summer.

3. Green Turtle

The North Atlantic DPS of the green turtle is listed as ***threatened*** under the ESA and as ***endangered*** on the IUCN Red List of Threatened Species. The green sea turtle is widely distributed in tropical and subtropical waters near continental coasts and around islands between 30ºN and 30ºS (NOAA 2016b), although it has been recorded 500–800 miles from shore in some regions (Eckert 1993 *in* NMFS 2002). The most important nesting beaches for the North Atlantic DPS are in the Caribbean, Gulf of Mexico, and Florida (Seminoff et al. 2015). The turtle nester abundance for this DPS has been estimated at 167,424 (Seminoff et al. 2015).

Green sea turtles typically migrate along coastal routes from rookeries to feeding grounds, although some populations conduct trans-oceanic migrations (e.g., Ascension Island - Brazil). Hatchlings swim to offshore areas where they are thought to live for several years, feeding near the surface on pelagic plants and animals (NOAA 2016b). Juvenile and sub-adult green sea turtles may travel thousands of kilometers before returning to their breeding and nesting grounds (Carr et al. 1978; NOAA 2016b).

On the U.S. Atlantic margin, green sea turtles are occasionally taken as bycatch by nets and trawls (Wallace et al., 2013). Of the ~4900 usable green turtle records in the OBIS database, 133 are within the polygon bounding the outer edges of the Survey Area, and 56 of these sightings were in the summer.

However, as shown in Figure 8, only 6 of these sightings were deeper than the shelf-break and overlapped the general area of the Proposed Action. The DiMatteo et al. (2017) map for summer hardshell (green plus hawksbill) turtle density shows the highest concentration in the MAB to be on the shelf (Figure 11), where seismic operations will not occur. While green turtles may be encountered during the seismic activities, their occurrence is likely to be rare.

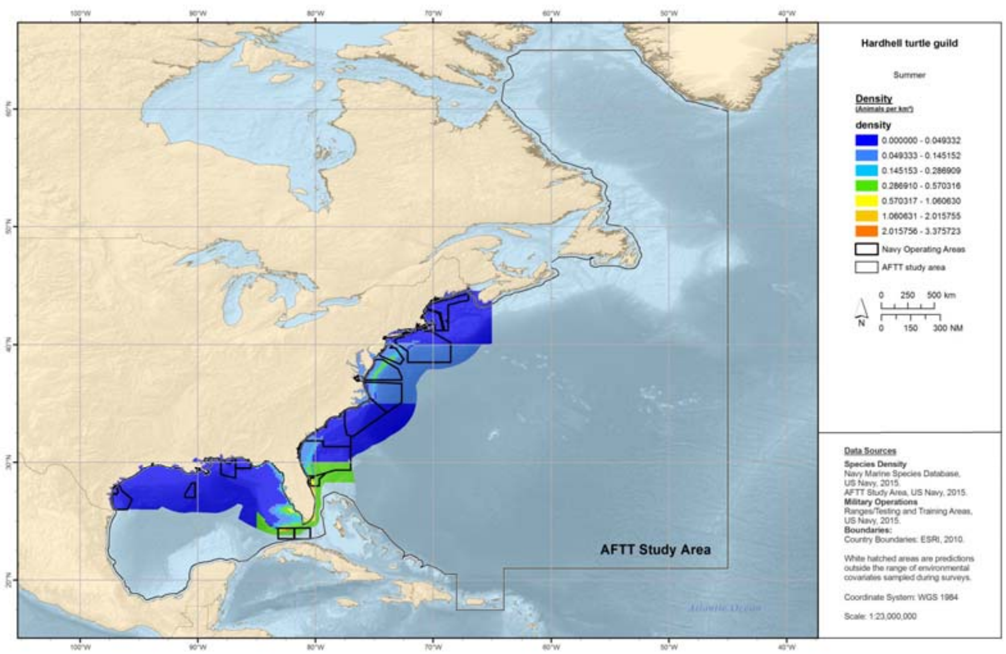

Figure 4-160. Summer NODES density spatial model for hardshell turtles.

Figure 11. NODES model density distribution of hardshell turtles, which combines green and hawksbill turtles, from DiMatteo et al. (2017). These turtle species are combined because definitively identifying them at sea is challenging.

4. Hawksbill Turtle

The hawksbill turtle it is listed as ***endangered*** under the ESA and ***critically endangered*** on the IUCN Red List of Threatened Species. Hawksbill turtles are the most tropical of all sea turtles, generally occurring between 30ºN and 30ºS in the Atlantic, Pacific, and Indian oceans (NOAA 2014a); nesting is confined to areas where water temperature is 25º–35ºC. The most important nesting beaches in the northern-hemisphere Atlantic are along the Yucatan Peninsula, southern Cuba, and a few Caribbean islands. Lutz et al. (2003 *in* NOAA 2014a) estimated that 27,000 adult hawksbills live in the Caribbean. Mature females return to their natal beaches to nest every two to three years between April and November (NOAA 2014a). Hawksbill turtles are typically observed in shallow waters with seagrass or algal meadows and are most common where healthy reef formations are present (NOAA 2014a). In the Atlantic, post-hatchling juveniles are thought to occupy the pelagic environment of the ocean, sheltering in floating algal mats and drift lines of flotsam and jetsam (NOAA 2014a). Hawksbill turtles most commonly perform short-distance movements between nesting beaches and offshore feeding banks, although long-distance movements are also known (e.g., Spotila 2004).

Of the ~8125 usable OBIS records for hawksbill turtles, only 5 (~0.06%) occurred within the large polygon that encloses the entire area. None of these occurrences were in the July through October period, and therefore no sightings are plotted for this species in Figure 8. The density map in Figure 11 includes hawksbill turtles. It would be a rare occurrence for the Proposed Action to encounter a hawksbill turtle during seismic operations.

5. Kemp's Ridley Turtle

The Kemp's ridley turtle it is listed as ***endangered*** under the ESA and ***critically endangered*** on the IUCN Red List of Threatened Species. Kemp's ridley turtles have a more restricted distribution than most other sea turtles. Adult turtles usually only occur in the Gulf of Mexico, but juveniles and immature individuals range between the tropics and temperate coastal areas of the Northwest Atlantic, as far as New England (NOAA 2017c). Occasionally, individuals may be carried by the Gulf Stream as far as northern Europe, although those individuals are considered lost to the breeding population. Adult Kemp's ridley turtles migrate along the coast between nesting beaches and feeding areas, nesting in arribadas on several beaches in Mexico from May to July (NOAA 2017c). Nesting also occurs on a smaller scale in North and South Carolina, Florida, Texas, and other locations in Mexico (NOAA 2017c). After nest emergence, some hatchlings remain within the Gulf of Mexico, while others may be swept out of the Gulf, around Florida and into the Atlantic Ocean (NOAA 2017c). Juveniles have been known to associate with floating Sargassum seaweed for a period of ~2 years; such sub-adults subsequently return to the neritic zones of the Gulf of Mexico or Northwest Atlantic to feed (NOAA 2017c).

Of over 900 usable records in the OBIS database, 32 were within the larger polygon enclosing the Survey Area. Twenty-four of these sightings occurred in July, August, or September (Figure 8), but only two of these occur deeper than the mid-shelf. The NODES density map (Figure 12) also shows a low density of these turtles in the Survey Area. While it is possible that a Kemp's ridley turtle could be encountered in the area of the Proposed Action, it would be considered a rare occurrence.

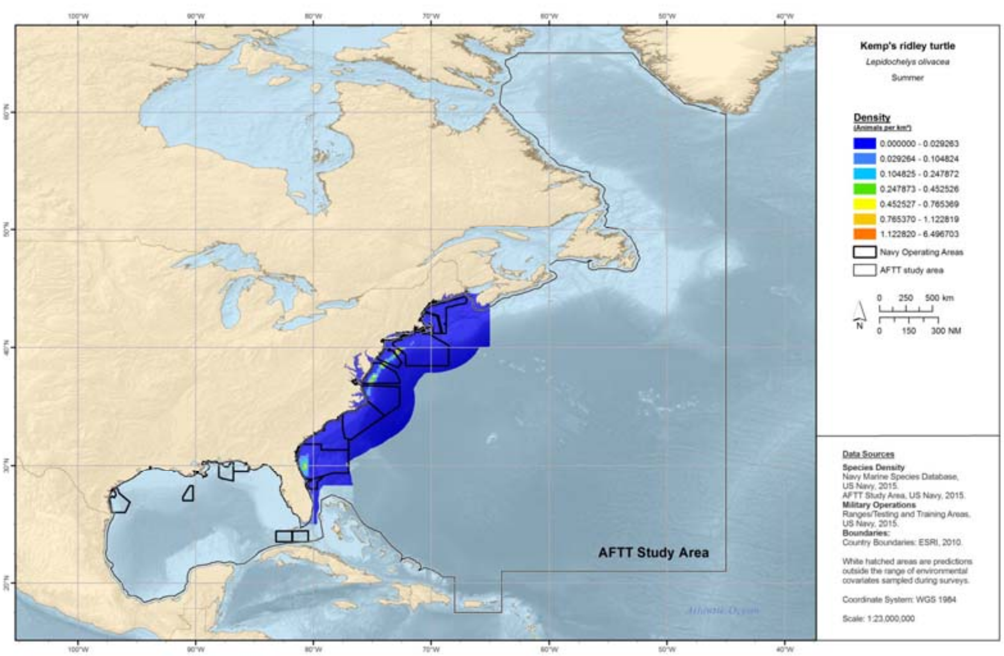

Figure 4-164. Summer NODES density spatial model for the Kemp's ridley turtle.

Figure 12. NODES density model for Kemp's Ridley turtles during summer months from DiMatteo et al. (2017).

Seabirds

Three seabird species that are listed under the ESA or under consideration for listing have ranges that overlap the area of the Proposed Action: the Bermuda petrel (*Pterodroma cahow*), the black capped petrel, and the roseate tern. General information on the taxonomy, ecology, distribution and movements, and acoustic capabilities of seabird families is given in § 3.5.1 of the NSF-USGS PEIS.

1. Bermuda Petrel

The following is adopted verbatim from the Draft Scripps EA (LGL, 2017). The Bermuda petrel is listed as ***endangered*** under the ESA (USFWS 2007) and ***endangered*** on the 2017 IUCN Red List of Threatened Species (IUCN 2017). The Bermuda petrel was exploited for food and was thought to be extinct by the 17^{th} century. It was only rediscovered in 1951, at which time the population consisted of 18 pairs (del Hoyo et al. 1992). The population has been the subject of an ongoing recovery effort, and by 2008 it was up to 85 breeding pairs (Madeiros et al. 2012). This population is now increasing slowly, but remains vulnerable to storm damage, erosion, and predation (BirdLife International 2017a; Madeiros et al. 2012).

Currently, all known breeding occurs on islets in Castle Harbour, Bermuda (Madeiros et al. 2012). Petrels return to the colony in mid-October and remain until June. During the non-breeding season (mid June–mid October), Bermuda petrels are strictly pelagic and likely follow the Gulf Stream. From 2009 to 2012, several birds were fitted with data-loggers to determine their pelagic range. These studies found that many Bermuda petrels spent the non-breeding season in the central North Atlantic, in the vicinity of the Azores, with some travelling as far as Ireland or Spain (Madeiros et al. 2014).

Based on the IUCN (2017) range map accessed by the USGS in March 2018, the entire Proposed Action occurs within the range of the Bermuda petrel. Thus, Bermuda petrels could be encountered in very small numbers during Proposed Action. As noted by the Draft Scripps EA (LGL, 2017), "based on satellite tracked birds, Bermuda petrels would be more likely to occur between 36.5º and 47.5ºN (Madeiros et al. 2014)." This confirms the possibility of encountering these birds within the area of the Proposed Action.

The USGS consulted with the US Fish and Wildlife Service about potential impacts of the Proposed Action on the Bermuda petrel. The USGS received concurrence that the Proposed Action was likely to affect, but not adversely affect, this species.

2. Black Capped Petrel

The black capped petrel (*Pterodroma hasitata*) is listed as ***endangered*** by the IUCN (2017) and is being considered for listing under ESA by the U.S. Fish and Wildlife Service. The following information is compiled from the IUCN (2017): The bird is primarily threatened by habitat loss in breeding areas in the Caribbean and has been entirely eliminated on some Caribbean islands. Currently, it is known to breed only on Hispanola, although it was thought to breed on Guadeloupe and Martinique (prior to 1900) and possibly Cuba in the past. The bird lays eggs and raises its young between mid-January and early July. Young birds depart for the feeding range after that time. Black capped petrels forage in the Gulf Stream and the Florida Current and their range as delineated by IUCN (2017) spatial data extends offshore North Carolina and far out to sea in the Mid-Atlantic region. The birds feed in flocks and mostly at dusk and nocturnally, targeting squid, fish, crustaceans, and Sargassum. Curtice et al. (2016) show very small abundance of these birds in the study area (Figure 13). Based on the range of these birds, it is possible that they could be encountered during the Proposed Action while acquiring data along the southernmost exemplary lines. If the Gulf Stream were to shift west during the Proposed Action, black capped petrels might also follow the current westward, thereby intersecting other parts of the survey area. The USGS consulted with the US Fish and Wildlife

Service about potential impacts of the Proposed Action on the black capped petrel. Because the species is not yet listed, no further action is necessary.

3. Roseate Tern

The U.S. Fish and Wildlife Service lists the Roseate tern (*Sterna dougalli*) is listed as ***endangered*** under the ESA on the Atlantic Coast from Massachusetts to North Carolina and threatened throughout the rest of the Western Hemisphere. The roseate tern is designated ***Least Concern*** on the 2017 IUCN Red List of Threatened Species (IUCN 2017). According to the IUCN, roseate terns on the U.S. Atlantic coast breed in the coastal areas and on offshore islands. No critical habitat has been established for the roseate tern. The area shown in Figure 13 marks the foraging area as obtained from IUCN (2017).

According to the information compiled by the IUCN (2017), the roseate tern is a plunge diving bird that feeds alone or in small groups. The primary prey is small pelagic fish and sometimes crustaceans. Birds generally forage within a few tens of kilometers of their coastal nesting sites, meaning that they are unlikely to be encountered in the survey area during the Proposed Action. The abundance map compiled by Curtice et al. (2016) shows effectively zero of these birds overlapping the survey area during the summer season.

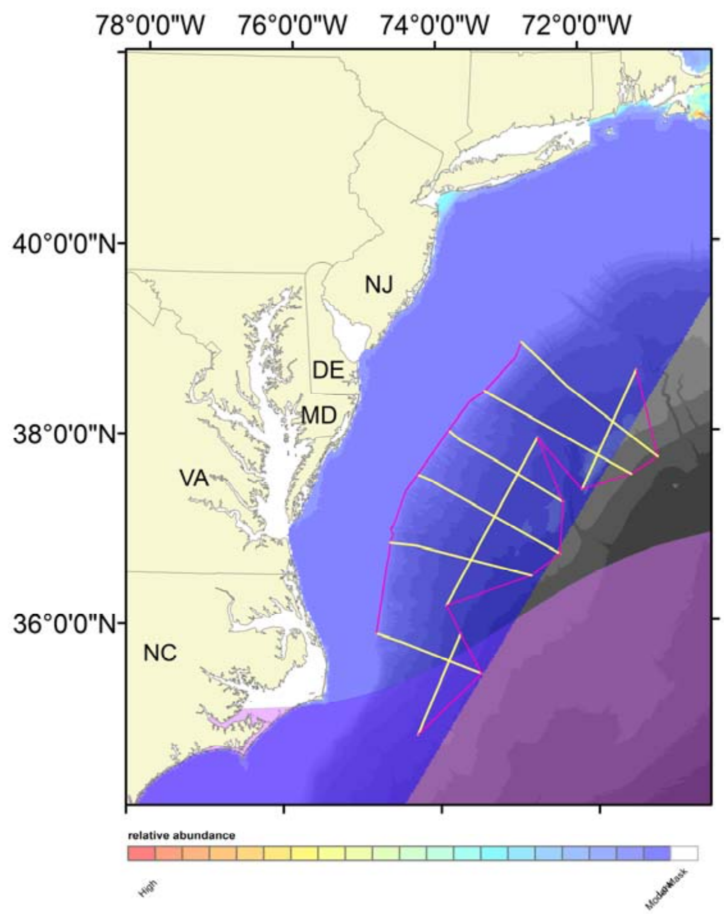

Figure 13. Compilation of information related to the black-capped petrel and the roseate tern. The yellow lines are the exemplary transects for the Proposed Action, with the pink lines nominal linking transits (interseismic lines). The purple area marks the foraging range of the roseate tern from the IUCN (2017). No critical habitat has yet been designated under ESA. The blue shows the area occupied by resident black-capped petrels as taken from the abundance maps of Curtice et al. (2016). Note that

the abundance corresponding to this shading is $1.8x10^{-7}$ individuals. The range of the Bermuda petrel encompasses the entire area of the Proposed Action and is not depicted on the map.

The USGS consulted with the US Fish and Wildlife Service about potential impacts of the Proposed Action on the roseate tern and was told that the Proposed Action is unlikely to affect this species.

Fish

The area of the Proposed Action overlaps Essential Fish Habitat for numerous species listed in Table 4. These include species within the Mid-Atlantic and the northern part of the Southeast fisheries areas, as well as Atlantic highly-mobile species. This section describes in detail the ESA-listed species, essential fish habitat and habitats of particular concern, and commercial and recreational fisheries. Parts of the following sections are adopted verbatim from the Draft Scripps EA (LGL, 2017), with minor modifications to fit the circumstances of the Proposed Action.

1. ESA-listed Species

The term "species" under the ESA includes species, subspecies, and, for vertebrates only, Distinct Population Segments (DPSs) or "evolutionarily significant units (ESUs)". ESA-listed species designated as ***endangered*** (NOAA 2017e) that could occur in the proposed project area include the Carolina, Chesapeake Bay, New York Bight DPSs of Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) and the shortnose sturgeon (*Acipenser brevirostrum*). (The Gulf of Maine DPS of Atlantic sturgeon is an ESA-listed species designated as ***threatened*** and is not considered relevant to the Proposed Action). Species proposed for listing under the ESA as ***threatened*** and that may occur within the proposed project area include the giant manta ray (*Manta birostris*) and oceanic whitetip shark (*Carcharhinus longimanus*) (NOAA 2017f).

Atlantic Sturgeon

The Atlantic sturgeon is an anadromous, estuarine fish species that inhabits freshwater and brackish waters, as well as marine coastal waters. It is not believed to take extensive migrations beyond the coastal zone to the open ocean (NOAA 2017g). Sturgeon generally occur solitary or in small groups and are long-lived and late maturing (St. Pierre and Parauka 2006). This species is separated into four separate "Endangered" DPSs: New York Bight, Chesapeake Bay, Carolina, and South Atlantic; as well as one "Threatened" DPS in the Gulf of Maine (NOAA 2017g). All DPSs have designated several river systems that sturgeon are known to inhabit as critical habitat. The Atlantic sturgeon is not expected to occur in the offshore proposed project area.

Shortnose Sturgeon

The shortnose sturgeon is the smallest sturgeon species that is found in North America. Similar to the Atlantic sturgeon, it is both an anadromous and estuarine species that undertakes migrations in coastal waters throughout its adult life and is not known to make long offshore migrations (NOAA 2015b). The shortnose sturgeon occurs in many riverine systems along the east coast of North America, from the St. John River, New Brunswick to Florida (NOAA 2015b). It is not expected to occur in the area of the Proposed Action.

Giant Manta Ray

Giant manta rays are migratory and cold-water tolerant, with highly fragmented populations sparsely distributed in the tropical, subtropical, and temperate waters of the world (NOAA 2017h). Giant manta rays are the largest living ray in the world (NOAA 2017h) and tend to be solitary (DoW 2015a). This species filter-feeds virtually exclusively on plankton (DoW 2015a). Regional population sizes are small and have generally declined in known areas except where specifically protected (NOAA 2017h). It could occur within or near the proposed project area.

Oceanic Whitetip Shark

The oceanic white tip shark is an offshore pelagic species inhabiting surficial waters in the open ocean, occurring worldwide typically between 20ºN and 20ºS but also at higher latitudes during the summer months (NOAA 2016e). Oceanic whitetip sharks are aggressive and persistent, and prey on bony fishes such as tunas, barracuda, white marlin, dolphinfish, lancetfish, oarfish, threadfish and swordfish), along with threadfins, stingrays, sea turtles, seabirds, gastropods, squid, crustaceans, mammalian carrion and garbage (NOAA 2016e). Oceanic whitetip shark populations have shown severe declines in the Atlantic Ocean (DoW 2015b). It could occur within or near the proposed project area.

2. Fish Habitats

Maps provided by the Marine-Life Data and Analysis Team (MDAT) at Duke University (Curtice et al., 2016) based on data from the Northeast Fisheries Science Center give compilations of biomass, diversity, and species richness based primarily on tow data acquired on the continental shelf. The maps do not extend beyond the shelf-break and thus do not overlap the area of the Proposed Action.

Essential Fish Habitat (EFH)

The following is taken verbatim or with slight modifications from the Final Environmental Assessment for the 2014 ENAM Project (RPS, 2014c). Two fishery management councils, created by the 1976 Magnuson Fisheries Conservation and Management Act (renamed Magnuson Stevens Fisheries Conservation and Management Act in 1996) are responsible for the management of fishery resources, including designation of EFH, in federal waters of the survey area: the Mid-Atlantic Fishery Management Council (MAFMC) covers nearly the entire survey area and the South Atlantic Fishery Management Council (SAFMC) has jurisdiction over the very southernmost parts of the surveys. The Highly Migratory Division of the National Marine Fisheries Service in Silver Spring, MD, manages highly migratory species (sharks, swordfish, billfish, and tunas).

Using ArcGIS, the exemplary seismic transects and tie-lines for the Proposed Action were intersected with the the polygons provided by NMFS for the Mid-Atlantic, South Atlantic, and Highly Mobile Species EFH. The result is a list of species EFH and species' life stages that overlap with the USGS seismic surveys. Table 7 summarizes the results for the 41 species and the life stage that overlaps with the general area of the Proposed Action.

Several EFH areas in or near the proposed survey area have prohibitions in place for various gear types and/or possession of specific species/species groups: (1) Restricted areas designated to minimize impacts on juvenile and adult tilefish EFH from bottom trawling activity (see further under next section); (2) Prohibitions on the use of several gear types to fish for and retain snapper-grouper species from state waters to the limit of the EEZ, including roller rig trawls, bottom longlines, and fish traps; and on the harvesting of Sargassum (an abundant brown algae that occurs on the surface in the warm waters of the western North Atlantic), soft corals, and gorgonians (SAFMC 2013), and (3) Prohibitions on the possession of coral species and the use of bottom-damaging gear (including bottom longline, bottom and mid-water trawl, dredge, pot/trap, and anchor/anchor and chain/grapple and chain) by all fishing vessels.

Habitats of Particular Concern

As taken from the Final EA for the ENAM project (LGL, 2014), Habitat Areas of Particular Concern (HAPC) are subsets of EFH that provide important ecological functions and/or are especially vulnerable to degradation and that are designated by Fishery Management Councils. The exemplary survey lines for the

Proposed Action do not directly intersect any HAPC in the Mid-Atlantic or South Atlantic region, nor HAPC or Atlantic highly mobile species.

One of the tie-lines (interseismic, linking lines) between primary exemplary survey lines may approach the seaward side of HAPC for juvenile and adult tilefish near the head of Norfolk Canyon. Tilefish inhabit burrows in clay outcrops and in the walls of submarine canyons at water depths of 100-300 m (MAFMC and NMFS 2008) in this area. In addition, the southernmost exemplary dip-line for the Proposed Action lies ~3 nautical miles north of HAPC for snapper-grouper on a hardground called the Point, straddling the shelf-break offshore Cape Hatteras. This area is important for spawning.

TABLE 7. Marine species with Essential Fish Habitat (EFH) overlapping the proposed survey area. Table 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[4]	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

3. Commercial Fisheries

Table 8 summarizes the catch data for commercial fisheries in the coastal states landward of the Proposed Survey area: New Jersey, Delaware, Maryland, Virginia, and North Carolina. Although the Proposed Action would not occur offshore New York or Pennsylvania, these states are also included. In 2015 and 2016, the value of commercial fishing in these states was over $1.25 billion for more than 1.37 billion pounds of fish landed. As noted in Table 8, most of the revenue was generated by estuarine and inner shelf species whose depth ranges do not overlap with that of the Proposed Action, which would only take place at greater than 100 m water depth. These high-value estuarine/inner shelf species include blue crab, various shellfish (oysters, clams, sea scallops), and menhaden. The following paragraphs touch only on the species that contribute the most to the overall revenue in the coastal states and that live at water depths beyond those characteristic of estuaries, the coastal zone, and the inner shelf.

Summer flounder, which is currently under fishing restrictions in the mid-Atlantic states for 2018 (with no landings permitted in Delaware), does occur on the uppermost continental slope (to 160 m water depth) according to the IUCN (accessed March 2018), which lists the species as “least threatened.” The Proposed Action occurs entirely within the Summer Flounder Management Area and occupies most of the Scup and Black Sea Bass Management areas (all extend eastward to the EEZ boundary) as defined by NOAA in 2014. The Proposed Action also overlaps the area where summer flounder trawl fisherman must use a turtle excluder device (TED).

Longfin squid occur at greater water depths (up to 400 m) from November through February than during the period of the Proposed Action (August), when they are expected only to ~180 m on the uppermost slope (NEFSC, 2005). The endangered golden tilefish, which occurs to 540 m water depth according to the IUCN (2018), was a high-value commercial species only in New York. The Norfolk Canyon HAPC for this species is discussed above.

On a per pound basis, the most economically-valuable fish for landings in the coastal states in 2015 and 2016 were nearly all estuarine/coastal shellfish. The major exceptions were bluefin and bigeye tuna, swordfish, golden tilefish (2016), and some sharks. None of these species constituted a large component of the commercial landings in the associated states.

Table 8. Compilation of commercial fish landings in the Mid-Atlantic Bight in 2015 and 2016.

State	2015/2016 Catch Value ($, millions)	2015/2016 Catch (lbs. landed, millions)	Common name of primary species landed (% total value)	Depth range of primary species landed	Proposed Action (exclusively > 100 m water depth) closest approach
New York	99.3	56.3	Northern quahog, longfin squid, sea scallop (2016), golden tilefish, scup, summer flounder (56%)	Golden tilefish 80 to 540 m^; summer flounder to 160 m^; longfin squid adults up to 180 m March to October*; scup 10 to 200 m^; other species shelfal/estuarine	No lines offshore NY; >100 nm (~185 km) to closest line
New Jersey	359.2	272.0	Scallops, clams, menhaden, blue crab, longfin squid, summer flounder (91%)	Summer flounder to 160 m^; Menhaden to 50 m^; longfin squid to 180 m March to October; other species shelfal/estuarine	~70 nm (~130 km)
Pennsylvania	0.24	0.14	Carp, minnows (77%)		N/A

Delaware	16.9	8.5	Blue crab (73%)	Estuarine/coastal	~65 nm (120 km)
Maryland	183.6	110.6	Blue crab (61%)	Estuarine/coastal	50 nm (~93 km)
Virginia	405.4	801.0	Sea scallop, blue crab, menhaden, northern quahog, eastern oyster, summer flounder (87%)	Summer flounder up to 160 m^; menhaden to 50 m^; other species shefal/estuarine	55 nm (102 km)
North Carolina	188.8	125.9	Blue crab, white & brown shrimp, summer flounder (60%)	Summer flounder up to 160 m^; other species on shelf/estuarine	38 nm (70 km)

* https://www.nefsc.noaa.gov/publications/tm/tm193/tm193.pdf ^ IUCN red list

4. Recreational Fisheries

The Mid-Atlantic area hosts several recreational fisheries that are managed by NOAA Fisheries. NOAA Fisheries collaborates with the Mid-Atlantic Regional Fishery Council, the coastal states, and the Atlantic States Marine Fisheries Commission to manage recreational fisheries in state and federal waters. As of March 2018, recreational fishing vessels operating in federal waters within the Greater Atlantic Regional fishing area must report on harvesting of Atlantic mackeral, squid, butterfish, summer flounder, scup, black sea bass, bluefish, and tilefish. In addition, these recreational activities come under the same management plan as that applied to commercial fisheries for summer flounder and black sea bass. Recreational fishers must already report bluefin tuna landings to NOAA. Maryland and North Carolina additionally require reporting on white and blue marlin, roundscale spearfish, and sailfish.

Some of the information in this section is taken from the MRIP/MRFSS catch estimates maintained by NOAA. About 9,000 individual saltwater fishing permits were held by recreational anglers in the coastal states landward of the Proposed Action in 2014 (NOAA, 2016f). All activities associated with recreational saltwater fishing in these states added value of approximately $3.1 billion to the economy. Highly migratory species (big game fish) are among those species whose habitats overlap with the Proposed Action, which occurs in deepwater areas. Pursuit of highly migratory species such as tuna, billfish, and sharks generated $17.7 million of added value to the economies the coastal states of Maine through North Carolina during a study period in 2011 (NOAA, 2014b). Maryland, Virginia, and North Carolina dominated the billfish recreational fishery, while New York and New Jersey constitute over 50% of the May through December 2011 trips focused on shark fishing. In the coastal states landward of the Proposed Action area, New Jersey recreational anglers conducted 45% of the tuna fishing trips during the reporting period.

IV. Environmental Consequences

Proposed Action

1. Direct Effects on Marine Mammals and Sea Turtles and Their Significance

The material in this section includes a brief summary of the anticipated potential effects (or lack thereof) of airgun sounds on marine mammals and sea turtles as provided in the NSF-USGS PEIS. It also includes updates from recent literature that has become available since the NSF-USGS PEIS was released in 2011. A more comprehensive review of the relevant background information appears in § 3.4.4.3, § 3.6.4.3, § 3.7.4.3, and § 3.8.4.3, and Appendix E of the NSF-USGS PEIS. Relevant background information on the hearing abilities of marine mammals and sea turtles can also be found in the NSF-USGS PEIS.

This section also includes estimates of the numbers of marine mammals that could be affected by the proposed seismic surveys scheduled to occur during August 2018, along with a description of the rationale for USGS's estimates of the numbers of individuals exposed to received sound levels ≥160 dB re 1 μPa_{rms}. Acoustic modeling for the proposed action was conducted by L-DEO, consistent with past EAs submitted for USGS and NSF seismic surveys and as previously determined to be acceptable by NMFS for use in the calculation of estimated Level B takes under the MMPA. Take calculations were carried out by the USGS using methodology described below and in a teleconference/webinar with NMFS personnel on 8 March, 2018.

(a) Summary of Potential Effects of Airgun Sounds

The Draft Scripps EA (LGL, 2017) is hereby incorporated by reference. The section is taken verbatim from that document. Therefore, all material has simply been reproduced in Appendix D for convenience.

(b) Possible Effects of Other Acoustic Sources

The Simrad fisheries EK60/80 transceiver with a single (38 kHz) split-beam transducer would be operated from the source vessel at water depths less than ~1800 m. Such equipment was not commonly used when the NSF-USGS PEIS was completed, but is now installed and run routinely on many global class research ships (e.g., Okeanos Explorer) and NOAA fisheries vessels. The EK80 is the newer, broadband transceiver that is starting to replace the widely used EK60 transceiver on some federal fleet vessels.

The following is copied nearly verbatim from the NOAA Northeast Fisheries Science Center application for a Letter of Authorization (NEFSC, 2014) for small takes associated with their research operations. Minor modifications have been made to focus the text on the type of EK60/80 system the USGS will use during the Proposed Action. NMFS granted NEFSC a 5-year LOA in 2015.

"Category 2 active acoustic sources (as defined by NEFSC) have moderate to very high output frequencies (10 to 180 kHz), generally short ping durations, and are typically focused (highly directional) to serve their intended purpose of mapping specific objects, depths, or environmental features. A number of these sources, particularly those with relatively lower sound frequencies coupled with higher output levels can be operated in different output modes (e.g., energy can be distributed among multiple output beams) that may lessen the likelihood of perception by and potential impact on marine life." The USGS Proposed Action would use only the 38 kHz transducer.

"Category 2 active acoustic sources are likely to be audible to some marine mammal species. Among the marine mammals, most of these sources are unlikely to be audible to whales and most pinnipeds, whereas they may be detected by odontocete cetaceans (and particularly high frequency specialists such as harbor porpoise). There is relatively little direct information about behavioral responses of marine mammals, including the odontocete cetaceans, but the responses that have been measured in a variety of species to audible sounds (see Nowacek et al. 2007; Southall et al. 2007 for reviews) suggest that the most likely behavioral responses (if any) would be short-term avoidance behavior of the active acoustic sources.

The potential for direct physical injury from these types of active sources is low, but there is a low probability of temporary changes in hearing (masking and even temporary threshold shift) from some of the more intense sources in this category. Recent measurements by Finneran and Schlundt (2010) of TTS in mid-frequency cetaceans from high frequency sound stimuli indicate a higher probability of TTS in marine mammals for sounds within their region of best sensitivity; the TTS onset values estimated by Southall et al. (2007) were calculated with values available at that time and were from lower frequency sources. Thus, there is a potential for TTS from some of the Category 2 active sources, particularly for mid- and high-frequency cetaceans. However, even given the more recent data, animals would have to be either very close (few hundreds of meters) and remain near sources for many repeated pings to receive overall exposures sufficient to cause TTS onset (Lucke et al. 2009; Finneran and Schlundt 2010). If behavioral responses typically include the temporary avoidance that might be expected (see above), the potential for auditory effects considered physiological damage (injury) is considered extremely low so as to be negligible in relation to realistic operations of these devices." It should be noted that in 2015 the USGS experienced at least once instance of a large group of unidentified odontocetes (greater than 20) approaching the vessel and engaging with the vessel's wake while the EK60 was running in active mode using the 38 kHz transducer in relatively low power mode at < 200 m water depth.

Additional information added by the USGS in formulating this EA: A recent study by Cholewiak et al. (2017) describes beaked whale detections and sightings on the shelf and upper slope while operating the EK60 in passive (listening for sounds) and active (transmitting a pulse from the transducer) mode off New England. The reduced number of sightings and vocalizations during EK60 surveys led the authors to conclude that beaked whales exhibit a behavioral response to EK60 surveys and that the whales may detect the signals at some distance. Cholewiak et al. (2017) also cite unpublished data showing that bottom recorders 1.3 km from the *R/V Henry Bigelow* could detect her EK60 transmissions at depths of 800 m. The results of a 2016 farfield sound source verification experiment conducted at ~100 m water depth with the USGS 38 kHz EK60 transducer are not yet available.

Clear data about the impact of EK60/80 fisheries sonars are still lacking. There is a possibility of a behavioral response to the EK60 transmissions from some odontocetes, despite the fact that the modeled radii to the 160 dB isopleths is small.

(c) Other Possible Effects of Seismic Surveys

The possible effects of seismic surveys are incorporated by reference to the Draft Scripps EA (2017). For convenience, this section is reproduced in Appendix E. Additional text related to the specifics of the Proposed Action is provided below.

Vessel noise from *R/V Hugh R. Sharp* could affect marine animals in the proposed project area. It should be noted that the ship was Navy-designed as a "quiet vessel" and produces underwater radiated noise at levels below the International Council on Exploration of the Seas (ICES) noise curve at 8 knots (cruising speed).

Note that the USGS Proposed Surveys will be carried out at ~4 knots, which requires the use of only one generator on the *R/V Hugh R. Sharp*. According to the ship's radiated noise measurement report

(2009), this mode of operation produces two primary signals at less than 200 kHz: 83 kHz with SEL of 146 dB re 1 μPa at 1 yard and 163 kHz with SEL of 151 dB re 1 μPa at 1 yard.

2. Mitigation Measures

This section copies verbatim from the Draft Scripps EA (LGL, 2017), with modifications keyed to the USGS Proposed Action.

Several mitigation measures are built into the proposed seismic surveys as an integral part of the planned activities. These measures include the following: power ramp ups of the airgun array during a 30 minute period, adding one gun at a time until the full array strength is reached; a minimum of one dedicated observer maintaining a visual watch during all daytime airgun operations, with two observers for 30 min before and during ramp ups during the day; and shut downs when mammals or turtles are detected in or about to enter the designated EZ. The acoustic source would also be shut down in the event an ESA-listed seabird were observed diving or foraging within the designated exclusion zone. Observers would also watch for any impacts the acoustic sources may have on fish.

These mitigation measures, as well as adaptive mitigation to comply with current best practices, are mostly described in § 2.4.4.1 of the NSF-USGS PEIS and summarized earlier in this document, in § II(3). The fact that the GI airgun arrays, as a result of their design, direct the majority of the energy downward, and less energy laterally, is also an inherent mitigation measure.

Previous and subsequent analysis of the potential impacts takes account of these planned mitigation measures. It would not be meaningful to analyze the effects of the planned activities without mitigation, as the mitigation (and associated monitoring) measures are a basic part of the activities, and would be implemented under the Proposed Action or Alternative Action.

3. Potential Numbers of Marine Mammals Exposed to Various Received Sound Levels

All takes would be anticipated to be Level B "takes by harassment." As described in § I, such takes involve temporary changes in behavior.

In the sections below, we describe methods to estimate the number of potential exposures to Level A and Level B sound levels and present estimates of the numbers of marine mammals that could be affected during the proposed seismic surveys. The estimates are based on consideration of the number of marine mammals that could be disturbed appreciably by the USGS Proposed Action.

(a) Basis for Estimating Exposure

Parts of this section are taken verbatim from the Draft Scripps EA (LGL, 2017), while other components originate entirely with the USGS based on the circumstances of the Proposed Action.

The Level B estimates are based on a consideration of the number of marine mammals that could be within the area around the operating airgun array where received levels of sound ≥160 dB re 1 μPa_{rms} are predicted to occur (see Table 1). The estimated numbers are based on abundances (numbers) of marine mammals expected to occur in the area of the Proposed Action in the absence of a seismic survey. To the extent that marine mammals tend to move away from seismic sources before the sound level reaches the criterion level and tend not to approach an operating airgun array, these estimates likely overestimate the numbers actually exposed to the specified level of sound. The overestimation is expected to be particularly large when dealing with the higher sound level criteria, i.e., the PTS thresholds (Level A), as animals are more likely to move away when received levels are higher. Likewise, animals are less likely to approach within the PTS threshold radii than they are to approach within the considerably larger ≥160 dB (Level B) radius.

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) and for the beaked whale guild (Blainville's, Cuvier's, Gervais', Sowerby's, and True's beaked whales). There are no data for the pygmy killer whale, and results for the false killer whale were adopted.

Due to the heterogeneous species' densities in the Survey Area and the USGS's direct use of quantitative species density grids from Roberts et al. (2016) in estimating the impact of the surveys on cetaceans, it would be inappropriate to report the type of generic species density values commonly given in some Environmental Assessments produced for research seismic surveys. Instead, Table 9 gives calculated species density and standard deviation in the area containing the entire Proposed Action as calculated from the Roberts et al. (2016) density grid and summarizes group size, as taken primarily from the Draft Scripps EA (LGL, 2017).

To determine takes, the USGS combined the Duke density grids with buffer zones arrayed on either side of each exemplary seismic line and linking/interseismic line, with the buffer zone sizes determined based on the Level A EZ and Level B mitigation zones calculated from the acoustic modeling. The Level A and Level B takes for each species in each 10 km x 10 km block of the IMG density grids are calculated based on the fractional area of each block intersected by the buffer zones (EZ and MZ) for LF, MF, and HF cetaceans. Summing takes along all of the lines yields the total take for each species for the Proposed Action for the Base and Optimal (§ 1) 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.

The estimated numbers of individuals potentially exposed are based on the 160-dB re 1 μPa_{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 10 shows the estimates of the number of cetaceans that potentially could be exposed to ≥160 dB re 1 μPa_{rms} during the Proposed Action for the Base Survey and the Optimal Survey if no animals moved away from the survey vessel. The *Requested Take Authorization* is given in the far right column of Table 10 and represents 25% more than the number of takes calculated using the ArcGIS-based quantitative method devised by the USGS. The requested takes are sometimes increased to account for the size of animal groups (Table 9), to capture the possibility that a rare species could be encountered and taken during the surveys, or to account for the fact that the species is particularly abundant and take up to 1% of population size should be considered.

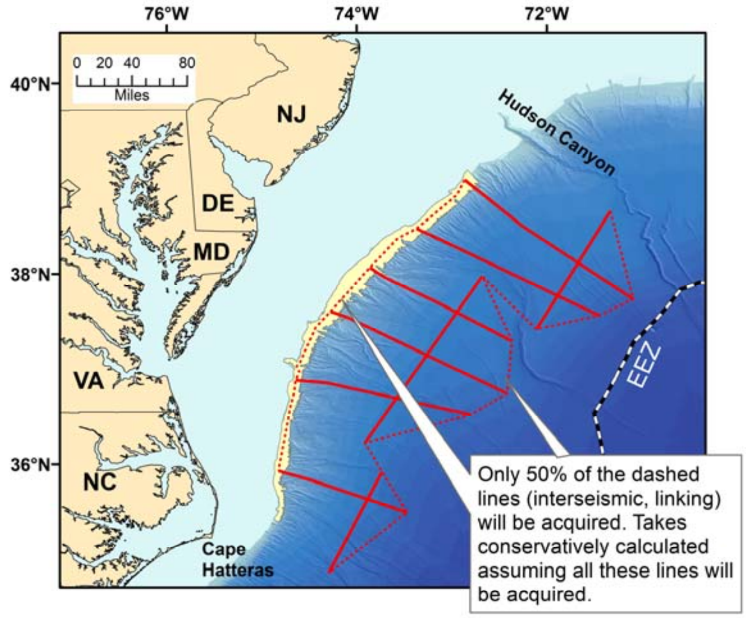

Figure 14. The Base Survey would acquire data along the exemplary lines (solid) and 50% of the interseismic linking lines using the base configuration of the GI guns (4 guns at 105 in^3 each). The Optimal Survey would acquire data on the exemplary lines using the GG gun configuration (4 guns at 210 in^3 each for the portions of these lines at greater than 1000 m water depth). For the Optimal Survey, the portion of the exemplary lines between 100 and 1000 m (yellow shading; bathymetry from Andrews et al., 2016) plus 50% of the linking interseismic lines with the base configuration. Takes are calculated for the entire survey pattern shown here even though only 50% of the linking, interseismic lines would be acquired.

The calculated takes in Table 10 also assume that the proposed surveys would be completed. In fact, it is unlikely that the entire survey pattern (exemplary lines plus 50% of the interseismic, linking lines) would be completed given the limitations on ship time, likely logistical challenges (compressor and GI gun repairs), time spent on transits and refueling, and the historical problems with weather during August in the Northwest Atlantic. In fact, USGS calculated timelines indicate that 25 days, including contingency, could be required to complete the full survey pattern. In fact, 22 days or fewer would be scheduled for this survey with the ship operator. The lines that are actually acquired would be dependent on weather, strength of the Gulf Stream (affects ability to tow the streamer in the appropriate geometry), and other considerations. Thus, fewer takes would be expected than have been calculated or requested. Nonetheless, as is common practice, the requested takes ***have been increased by 25%*** (see below). Thus, the estimates estimates of the numbers of marine mammals potentially exposed to Level B sounds≥160 dB re 1 μPa_{rms} are precautionary (conservative) and probably overestimate the actual numbers of marine mammals that could be involved.

In addition, it is possible that delphinids are less responsive to airgun sounds than are mysticetes, as referenced in both the NSF-USGS PEIS and in this document. The 160-dB (rms) criterion currently applied by NMFS, on which the Level B estimates are based, was developed primarily using data from gray and bowhead whales. The estimates of "takes by harassment" of delphinids are thus considered precautionary. Available data suggest that the current use of a 160-dB criterion could be improved upon, as behavioral response might not occur for some percentage of marine mammals exposed to received levels >160 dB, whereas other individuals or groups might respond in a manner considered as "taken" to sound levels <160 dB (NMFS 2013). It has become evident that the context of an exposure of a marine mammal to sound can affect the animal's initial response to the sound (NMFS 2013).

Table 9. Mean density and standard deviation of species' population in a polygon enclosing the entire survey based on ArcGIS analysis of the Roberts et al. (2016) grids. Month 8 (August) is used when available. Otherwise, the generalized annual grid is used. Where there is a disparity in group sizes between this table and the IHA, those in the IHA take precedence.

	Mean Density Per 100 km^2 in Polygon Enclosing Total Survey	Std Deviation on Mean Density Per 100 km^2	Group Size	Source[1]
Mysticetes				
Low-Frequency Cetaceans				
North Atlantic Right Whale (*Eubalaena glacialis*)	0.00002	0.00013	1	J
Humpback Whale (*Megaptera novaeangliae*)	0.002	0.007	2	W
Minke Whale (*Balaenoptera acutorostrata*)	0.002	0.004	1	W
Bryde's Whale (*Balaenoptera edeni/brydei*)	<0.001	NA	1	W
Sei Whale (*Balaenoptera borealis*)	0.005	0.02	1.42	W
Fin Whale (*Balaenoptera physalus*)	0.041	0.077	1.71	W
Blue Whale (*Balaenoptera musculus*)	<0.001	NA	1	W
Odontocetes				
Mid-Frequency Cetaceans				
Sperm Whale (*Physeter macrocephalus*)	2.18	0.909	1.6	W
Cuvier's Beaked Whale (*Ziphius cavirostris* True's Beaked Whale (*Mesoplodon mirus*) Gervais' Beaked Whale (*Mesoplodon europaeus*) Sowerby's Beaked Whale (*Mesoplodon bidens*) Blainville's Beaked Whale (*Mesoplodon densirostris*)	2.42	2.51	3	W
Northern Bottlenose Whale (*Hyperoodon ampullatus*)	0.035	0.014	4-10	NOAA[5]
Rough-toothed Dolphin (*Steno bredanensis*)	0.068	0.006	10	J
Common Bottlenose Dolphin (*Tursiops truncatus*)	8.446	7.143	19	P
Pantropical Spotted Dolphin (*Stenella attenuata*)	0.607	0.055	26.3	P
Atlantic Spotted Dolphin (*Stenella frontalis*)	20.17	14.514	26.3	P
Striped Dolphin (*Stenella coeruleoalba*)	18.72	12.47	9.69	W
Atlantic White-sided Dolphin (*Lagenorhynchus acutus*)	0.064	0.083	14.71	W
White-beaked Dolphin (*Lagenorhynchus albirostris*)	<0.001	0.003	3	W
Short-beaked Common Dolphin (*Delphinus delphis*)	20.17	45.57	9.15	W
Risso's Dolphin (*Grampus griseus*)	2.683	5.01	11.5	P
Pygmy Killer Whale (*Feresa attenuata*)	No data	No data	12	J
False Killer Whale (*Pseudorca crassidens*)	0.008	NA	1	W
Killer Whale (*Orcinus orca*)	<0.001	NA	5	W
Short-finned Pilot Whale (*Globicephala macrorhynchus*) Long-finned Pilot Whale (*Globicephala melas*)	4.153	2.738	25.76	W
Clymene's dolphin (*Stenella clymene*)	1.365	1.262	60-80	NOAA[2]
Spinner dolphin (*Stenella longirostis*)	0.04	0.004	---	---
Fraser's dolphin (*Lagenodelphis hosei*)	0.042	0.051	10-100	NOAA[3]
Melon-headed whale (*Peponocephala electra*)	0.109	0.12	>100	NOAA[4]
High Frequency Cetaceans				
Harbor Porpoise (*Phocoena phocoena*)	0.009	0.019	3.6	P
Pygmy Sperm Whales (*Kogia breviceps*) Dwarf Sperm Whales (*Kogia sima*)	0.093	0.008	1.8	P

[1] Group sizes compiled primarily from the Draft Scripps EA (LGL, 2017); J = Jefferson et al., 2015; P = Palka, 2006; W=Waring et al., 2008. False killer whale group size based on that of unidentified small whales; Palka used data from the Northeast Navy Operating Area Offshore Stratum.[2]http://www.nmfs.noaa.gov/pr/species/mammals/dolphins/clymene-dolphin.html

[3]https://www.fisheries.noaa.gov/species/frasers-dolphin; [4] http://www.nmfs.noaa.gov/pr/species/mammals/whales/melon-headed-whale.html; [5]http://www.nmfs.noaa.gov/pr/species/mammals/whales/northern-bottlenose-whale.html

TABLE 10. Estimates of the possible numbers of individual marine mammals that could be exposed to Level B and Level A thresholds for various hearing groups during the proposed seismic surveys in the Northwest Atlantic Ocean in August 2018. As detailed in §1, the **base survey** corresponds to 4 GI guns producing a total of 420 in^3 of air. The **optimal survey** acquires the exemplary seismic lines with 4 GI guns operated in GG mode (840 in^3 of air) and interseismic linking lines collected with 4 GI guns operated at 105 in^3 each. Species in italics are listed under the ESA as *endangered*. Requested takes in **bold** have been increased over the calculations to reflect group size or other issues, as explained in the text. If there is a disparity between this table and the authorization in the IHA, the IHA takes precedence and will be used to guide actual operations.

Species	Base Survey[2]		Optimal Survey[2]		Max Level A Take	Max Level B Take for Optimal or Base Surveys +25%	Popula-tion used from Table 6	Level A + (Level B+25 %) as % of Pop.[5]	Requested Take Authorization (all Level B)[6]
	Level A[3]	Level B[4]	Level A[3]	Level B[4]					
LOW FREQUENCY CETACEANS									
North Atlantic right whale	0	*0*	0	*0*	0	*0*	*440*	*0*	*0*
Humpback whale	0	0	0	0	0	0	11,570	<0.1	1[7]
Minke whale	0	0	0	0	0	0	157,000	<0.1	0
Bryde's whale	0	0	0	0	0	0	N.A.	N.A.	0
Sei whale	0	*1*	*0*	*1*	0	*1*	*10,300*	*<0.01*	*1*
Fin whale	0	*4*	*0*	*4*	0	*5*	*24,887*	*0.02*	*5*
Blue whale	0	*0*	*0*	*0*	0	*0*	*855*	*<0.1*	*0*
MID-FREQUENCY CETACEANS									
Sperm whale	*0*	*119*	*0*	*128*	0	*161*	*13,190*	*1.2*	*161*
Cuvier's beaked whale True's beaked whale Gervais beaked whale Sowerby's beaked whale Blainville's beaked whale	0	94[11]	0	103[11]	0	128	3,532 7092[9] (non-Cuvier)	1.2, As proportion of total beaked whale population	128 (sum of all beaked whale takes)
Northern bottlenose whale	0	2	0	2	0	2	40,000	0.01	**4**
Rough-toothed dolphin	0	4	0	5	0	8	NA	N.A.	**10**
Common bottlenose dolphin	0	572	0	606	0	757	77,532	0.98	757
Pantropical spotted dolphin	0	38	0	40	0	50	3,333	1.5	50
Atlantic spotted dolphin	0	1191	0	1278	0	1598	44,715	3.6	1598
Striped dolphin	0	1086	0	1167	0	1459	54,807	2.7	1459
Atlantic white-sided dolphin	0	5	0	5	0	6	48,819	<0.1	**15**
White-beaked dolphin	0	0	0	0	0	0	2003	0	0
Short-beaked common dolphin	0	1253	0	1296	0	1620	70,184	2.3	1620
Risso's dolphin	0	181	0	189	0	237	18,250	1.5	237
Pygmy killer whale	0	1	0	1	0	1	NA	N.A.	**6**
False killer whale	0	1	0	1	0	1	442	0.18	**28**
Killer whale	0	3	0	3	0	4	15,014	0.03	**7**
Long-finned pilot whale	0	215	0	231	0	288	5,636-16,058[8]	1.7-4.9[10]	288 (sum of pilot whales)
Short-finned pilot whale					0		21,515	1.3[10]	
Clymene's dolphin	0	91	0	97	0	122	6,068	2	122
Spinner dolphin	0	3	0	3	0	3	ND	ND	**91**
Fraser's dolphin	0	3	0	3	0	4	ND	NA	**204**
Melon-headed whale	0	8	0	8	0	10	3451	1.5	**50**
HIGH-FREQUENCY CETACEANS									
Pygmy/dwarf sperm whale	0	6	0	7	0	9	3,785	0.2	9

Harbor porpoise	0	0	0	0	0	0	79,833	<0.01	0

[1] See text for density sources. N.A. = population size not available (see Table 6).
[2] Take calculated using method described in text and discussed with NMFS on USGS-managed webinar on March 8, 2018.
[3] Level A takes if there were no mitigation measures. Ensonified areas are based on PTS thresholds.
[4] Level B takes, based on the 160-dB criterion, excluding exposures to sound levels equivalent to PTS thresholds.
[5] Level A and B takes (used by NMFS as proxy for number of individuals exposed), expressed as % of population.
[6] Requested takes (Level A+Level B); increased to mean group size in some instances (see Table 9 for sources).
[7] Very small take requested because these species are very abundant, but the calculated take is zero based on the Duke density maps, which cannot capture all of the complexity in species distribution. In fact, the map of summer season sitings compiled from the OBIS database (Figure 6) by the applicant shows that humpback whales have been seen in the northern part of the Proposed Action area during this period.
[8] Low end estimate from https://www.nefsc.noaa.gov/publications/tm/tm241/86_F2016_longfinnedpilotwhale.pdf. High end estimate from TNASS (Western North Atlantic) surveys that counted pilot whales in habitat where the whales present are interpreted to be solely long-finned pilot whales, as described in the NMFS FR notice, 82 FR 26244.
[9] The combined number for *Mesoplodon sp*. Is the only one provided by NOAA in: https://www.nefsc.noaa.gov/publications/tm/tm228/91_blainvilles.pdf
[10] Calculated assuming that all takes were attributed to each of the two types of pilot whales, even though the take calculated for pilot whales represents the sum of the takes for the two types. Thus, the calculation shown here yields a maximum possible percentage of the population.
11 The species density maps treat beaked whales as an entire guild. Furthermore, NEFSC states that the population breakdown among the four species of beaked whales other than Cuvier's is unknown (https://www.nefsc.noaa.gov/publications/tm/tm228/91_blainvilles.pdf). The calculated take mathematically represents the sum of all beaked whale takes. The sum cannot be broken into individual species because the underlying data were for the guild and the fractional representation of each species among the total is unknown.
[12] Some of these takes were increased by 1 during consultation due to a disagreement in how numbers were rounded. The NMFS values are used here although the USGS spreadsheets indicate 1 fewer take in some instances based on mathematical considerations. This difference is considered negligible and affects only species with fairly elevated take numbers.

(b) Potential Number of Marine Mammals Exposed *to ≥160 dB*

As noted above, the number of cetaceans that could be exposed to airgun sounds with received levels ≥160 dB re 1 μPa_{rms} (Level B) for marine mammals on one or more occasions has been estimated by combining the gridded animal abundances available from the Duke University cetacean density website (http://seamap.env.duke.edu/models/Duke-EC-GOM-2015/) with the exemplary track lines/linking lines and Level B PTS threshold buffers calculated by LDEO. The method intersects the ensonified area along each track line for the appropriate Level B threshold buffer with the gridded animal abundances. For each block of the underlying abundance grid intersected by the trackline and associated ensonified area, the take is calculated as the percentage of that block that is ensonified multipled by the abundance of animals in the block. The takes are summed along each trackline and linking line and added to determine the total take for the surveys. The approach assumes that no marine mammals would move away or toward the trackline in response to increasing sound levels before the levels reach the specific thresholds as R/V *Sharp* approaches. The amount of overlap of the ensonified area is minimal and confined to areas of turns at the ends of exemplary survey lines or where linking lines join exemplary lines. The small amount of overlap reflects in part the fact that most exemplary dip lines are spaced at more than 20 km.

Total estimated takes for the entire survey are reported in Table 10 for the Optimal and Base surveys. The table also reports the maximum take of each species for the two survey configurations (see below) with 25% added as a buffer and the requested take authorization. The Optimal Survey includes most dip lines and one strike line acquired with the GG configuration (840 in^3 of air), with the remaining lines and linking lines acquired using the base (4x105 in^3 or 420 in^3 of air) configuration (Figure 14). Note that this is an overestimate since it assumes that **all** of the interseismic linking lines would have data acquisition, even though at most only half of the lines will be acquired. Some of the linking lines would not even be surveyed with seismic methods since transit between exemplary lines is faster with no streamer in the water, and such transits provide an opportunity to fix gear, refuel compressors, and address other issues. The take calculations for the Base Survey assume all of the exemplary lines and linking lines are acquired with the base (420 in^3 of air) configuration and, again, that all of the interseismic linking lines are acquired.

The *maximum* estimate of the number of cetaceans that could be exposed to seismic sounds with received levels ≥160 dB re 1 μPa_{rms} in the survey area is 5178 for the Optimal Survey (Table 10). This number was calculated assuming that seismic data would be acquired along all the shelf-break and deepwater interseismic connecting lines shown in the red dashed pattern in Figure 1 and assuming the maximum source levels are used for the major exemplary seismic lines (Optimal Survey). At most, only about half of the interseismic connecting lines will be acquired at either the shelf-break or deepwater. The maximum Level B take estimate of 5178 cetaceans includes ~133 cetacean individuals listed under the ESA: 1 sei whale, 4 fin whales, 128 sperm whales, and no blue or North Atlantic right whales. Adding the nominal 25% extra take to these values, the sperm whale figure represents 1.2% of the estimated population, fin whale take is ~0.02%, and sei whale take is 0.01%. The largest potential takes would be for species that are plentiful and widespread, such as Atlantic spotted dolphin, striped dolphin, short-beaked common dolphin, and common bottlenose dolphin.

The take authorizations requested in the last column of Table 10 are precautionary and assume that certain extralimital mysticetes could be encountered during the Proposed Survey. For example, although no humpback whales have historically been observed within the study area during the summer months, these species are very abundant in the North Atlantic, and a single Level B take has been requested. Note also that the basis of the Take Authorization Request is the maximum A (all zero) + B takes +25% (6474 animals total) for the Base and Optimal surveys, so the requested takes are very conservative. Were an equipment failure to force the Proposed Action to be carried out with the Base Configuration, takes would be far smaller based on the much smaller MZ given in Appendix A.

All of the <u>calculated</u> takes fall well within the typical definition of “small takes” as implemented under the MMPA. Some of the requested takes (bold in Table 10), but not all, have been increased to account for the average group size (Table 9).

(c) Level A Takes

Per NMFS requirement, estimates of the numbers of cetaceans that could be exposed to seismic sounds with received levels equal to Level A thresholds for various hearing groups, if there were no mitigation measures (shut downs when PSOs observed animals approaching or inside the EZs), are also given in Table 10. Level A takes were determined to be less than 0.5 individuals (and thus recorded as 0, the nearest whole number) for all species and for both survey configurations, even after the calculated takes were increased by 25%, as is common practice. Even those small calculated take numbers likely overestimate actual Level A takes because the predicted Level A EZs are very small and mitigation measures would further reduce the chances of, if not eliminate, any such takes. Level A takes are considered highly unlikely and are not requested.

4. Potential Number of Turtles Exposed to > 175 dB

The USGS does not have access to the Navy database that supports the NODES grids for turtle distributions (DiMatteo et al., 2017). Therefore, the USGS was not able to independently calculate potential takes of turtles during the MATRIX survey. NMFS as the quantitative data supporting NODES and communicated the following takes to the USGS during consultation: Leatherback turtles—28; Loggerhead turtles associated with the northwest Atlantic DPS—174; Kemp’s Ridley—9; and hardshell turtles—137. NMFS will also make a distinction between animals less than and greater than 30 cm in its Biological Opinion. The USGS will observe the precepts of the Biological Opinion and the ITS with respect to turtles and the impact of the MATRIX survey.

5. Conclusions for Marine Mammals and Sea Turtles

The Proposed Action would involve towing an array of two to four GI airguns that introduce pulsed sounds into the ocean. Routine vessel operations, other than the proposed seismic operations, are conventionally assumed not to affect marine mammals sufficiently to constitute "taking".

(a) Cetaceans

This section incorporates by reference and adopts nearly verbatim the Draft Scripps EA (2017), with minor changes to reflect the particular circumstances applicable to the Proposed Action.

In § 3.6.2, 3.7.2, and 3.8.2, the NSF-USGS PEIS concluded that airgun operations with implementation of the proposed monitoring and mitigation measures could result in a small number of Level B behavioral effects in some cetaceans in the Northwest Atlantic DAA, that Level A effects were highly unlikely, and that operations were unlikely to adversely affect ESA-listed species. No Level A takes are requested for the Proposed Action. For five past NSF-funded seismic surveys and the 2014/15 USGS ECS survey (RPS, 2014a), NMFS issued small numbers of Level A take for some marine mammal species for the remote possibility of low-level physiological effects; however, NMFS expected neither mortality nor serious injury of marine mammals to result from the surveys (NMFS 2015b, 2016b,c, NMFS 2017a,b).

In this EA, estimates of the numbers of marine mammals that could be exposed to airgun sounds during the proposed program have been presented, together with the requested "take authorization". The estimated numbers of animals potentially exposed to sound levels sufficient to cause appreciable disturbance are very low percentages of the regional population sizes (Table 10).

The take calculations are likely to yield significant overestimates of the actual number of animals that would be exposed to and would react to the seismic sounds, particularly because most mammals, except some delphinids, tend to move away from sound sources. The relatively short-term exposures are unlikely to result in any long-term negative consequences for the individuals or their populations. Therefore, no significant impacts on marine mammals would be anticipated from the proposed activities.

In decades of seismic surveys carried out by the U.S. academic research fleet, PSOs and other crew members have not observed any seismic sound-related marine mammal injuries or mortality. Also, actual numbers of animals potentially exposed to sound levels sufficient to cause disturbance (i.e., to be considered takes) have almost always been much lower than predicted and authorized takes. For example, during an NSF-funded, ~5000-km, 2-D seismic survey conducted by the *Langseth* off the coast of North Carolina in September–October 2014, only 296 cetaceans were observed within the predicted 160-dB zone and potentially taken, representing <2% of the 15,498 takes authorized by NMFS (RPS 2015). During an USGS-funded, ~2700 km, 2-D seismic survey conducted by the *Langseth* along the U.S. east coast in August–September 2014, only 3 unidentified dolphins were observed within the predicted 160-dB zone and potentially taken, representing <0.03% of the 11,367 authorized takes (RPS 2014b). Furthermore, as defined, all animals exposed to sound levels >160 dB are Level B 'takes' whether or not a behavioral response occurred. The 160-dB zone, which is based on predicted sound levels, is thought to be conservative given the type of acoustic modeling used to calculate the distance from the source to this isopleth; thus, not all animals detected within this zone would be expected to have been exposed to actual sound levels >160 dB.

(b) Sea Turtles

In § 3.4.7, the NSF-USGS PEIS concluded that with implementation of the proposed monitoring and mitigation measures, no significant impacts of airgun operations are likely to sea turtle populations in any of the analysis areas, and that any effects are likely to be limited to short-term behavioral disturbance and short-term localized avoidance of an area of unknown size near the active airguns. Only foraging or migrating individuals are likely to occur in the area of the Proposed Action. Given the proposed activities, no significant impacts on sea turtles would be anticipated. In decades of seismic surveys carried out by the U.S. academic research fleet, PSOs and other crew members have not observed any seismic sound-related turtle injuries or mortality.

6. Direct Effects on Marine Invertebrates, Fish, Fisheries, and Their Significance

§ IV.4 of the Draft Scripps EA (2017) is hereby incorporated by reference. This information is provided nearly verbatim, with small changes to reflect the particular Proposed Action, in Appendix F, as part of an effort to comply with streamlining directives for NEPA documentation.

(a) Effects of Sound on Marine Invertebrates

(b) Effects of Sound on Fish

(c) Effects of Sound on Fisheries

(d) Conclusions for Invertebrates, Fish, and Fisheries

This section is mostly verbatim from the Draft Scripps EA (LGL, 2017), with changes to reflect the specifics of the USGS's Proposed Action.

The newly available information does not affect the outcome of the effects assessment as presented in the NSF-USGS PEIS. The NSF-USGS PEIS concluded that there could be changes in behavior and other non-lethal, short-term, temporary impacts, and injurious or mortal impacts on a small number of individuals within a few meters of a high-energy acoustic source, but that there would be no significant impacts of NSF-funded marine seismic research on populations. The NSF-USGS PEIS also concluded that seismic surveys could cause temporary, localized reduced fish catch to some species, but that effects on commercial and recreation fisheries would not be significant.

Interactions between the proposed survey and fishing operations in the proposed project area are expected to be limited. Two possible conflicts in general are streamer entangling with fishing gear and the temporary displacement of fishers from the proposed project area. Fishing activities could occur within the proposed project area; however, a safe distance would need to be kept from R/V *Sharp* and the towed seismic equipment. During the survey, the towed seismic streamer is relatively short, so this distance would be relatively small. Conflicts would be avoided through communication with the fishing community during the surveys. In particular, USGS experience on the *R/V Sharp* in 2015, 2016, and 2017 (including during times that partially overlap the month of the Proposed Action for 2018) indicates that the vessel's crew has good relationships with fishers and a good understanding of how they arrange their gear, where fishing is most likely, and how to negotiate in real-time to ensure that both the scientific and fishing operations can continue. Based on past experience by the USGS investigators participating in six cruises in the Survey Area since 2014, the most likely overlap between fishing activities and the Proposed Action would be on the uppermost continental slope, between the shallowest extent of the surveys (100 m water depth) and ~500 m water depth, particularly near canyons. Particular diligence will be exercised to communicate with fishers in these areas 6 to 12 hours before commencing acquisition of data on these parts of the exemplary survey lines.

Given the proposed activity, no significant impacts on marine invertebrates, marine fish, and their fisheries would be expected. In decades of seismic surveys carried out by vessels in the U.S. academic research fleet, PSOs and other crew members have not observed any seismic sound-related fish or invertebrate injuries or mortality.

7. Direct Effects on Seabirds and Their Significance

§ IV.5 of the Draft Scripps EA (2017) is hereby incorporated by reference. The section is reproduced in Appendix G for the sake of convenience.

8. Indirect Effects on Marine Mammals, Sea Turtles, Seabirds, Fish, and Their Significance

§ IV.6 of the Draft Scripps EA (LGL, 2017) is hereby incorporated by reference. The section is reproduced in Appendix G for the sake of convenience.

9. Cumulative Effects

Taking text verbatim from the Draft Scripps EA (LGL, 2017) and making small changes to reflect the particulars of the Proposed USGS Action for this leading paragraph: The results of the cumulative impacts analysis in the NSF-USGS PEIS indicated that there would not be any significant cumulative effects to marine resources from the proposed USGS marine seismic research. However, the NSF-USGS PEIS also stated that, "A more detailed, cruise-specific cumulative effects analysis would be conducted at the time of the preparation of the cruise-specific EAs, allowing for the identification of other potential activities in the area of the proposed seismic surveys that may result in cumulative impacts to environmental resources. Here we focus on activities that could impact animals specifically in the proposed project area (academic and industry research activities, vessel traffic, and fisheries)."

(a) Past and future research activities in the 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 15), 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. Several IHAA 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.

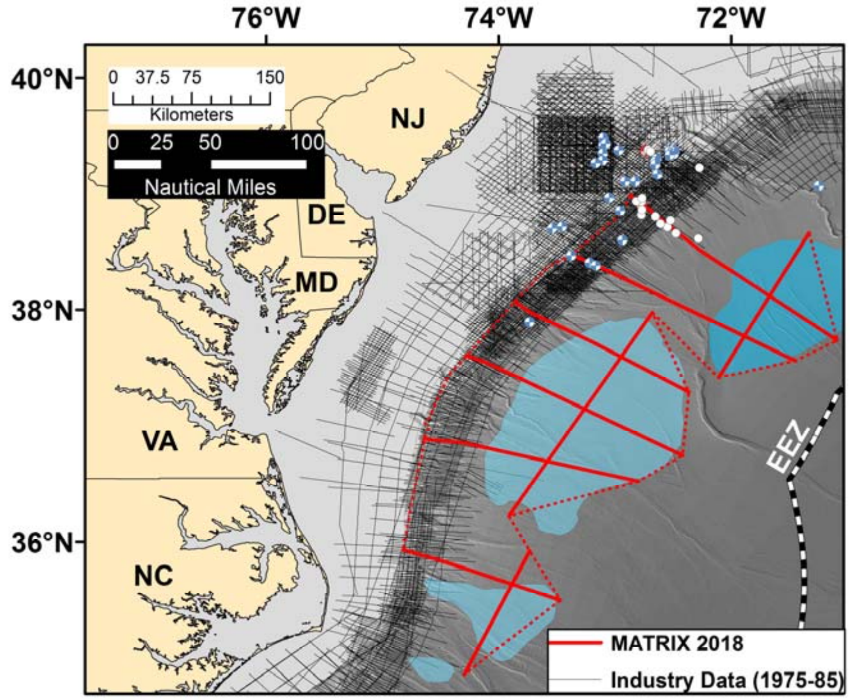

Figure 15. Industry seismic lines acquired primarily from 1975 to 1982 (some as late as 1985) are shown in black relative to the MATRIX seismic survey (Proposed Action). The industry data were released by BOEM through the USGS NAMSS portal over the past few years. The blue polygons were identified by 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 16). 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 16), 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 16), 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 (LGL, 2014) 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) would 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.

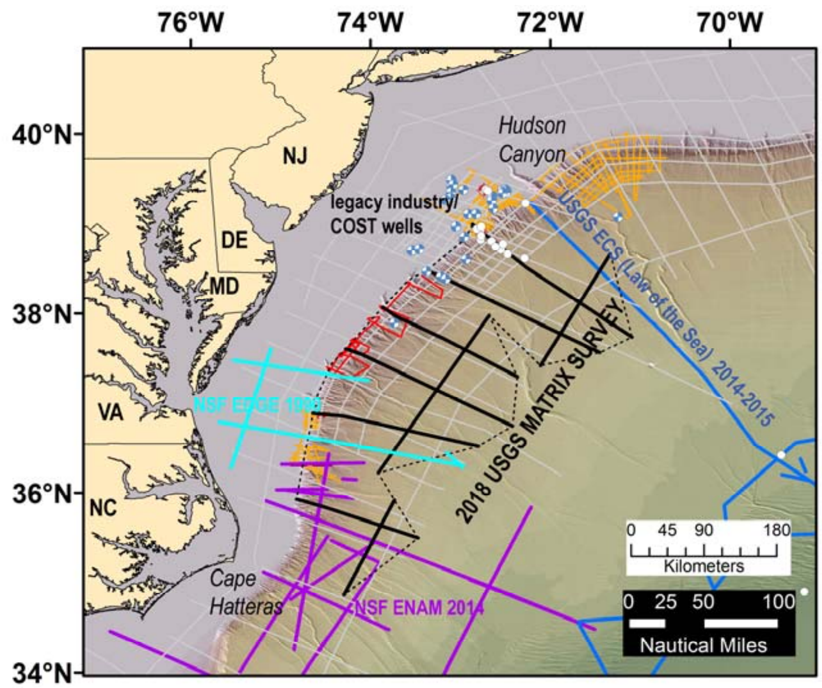

Figure 16. Past airgun seismic surveys conducted by the research community on the northern part of the U.S. Atlantic margin, along with some high-resolution (non-airgun) surveys. The gray lines show legacy USGS data, mostly from the late 1970s. Purple lines are the 2014 NSF ENAM cruise (RPS, 2014c), 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.

(b) 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 Sharp* 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 6 shiptracks 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.

(c) Fisheries

This section is partially excerpted from the Draft Scripps EA (LGL, 2017). The commercial fisheries in the general area of the proposed survey are described in § III. The primary contributions of fishing to potential cumulative impacts on marine mammals and sea turtles 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 operations in the Proposed Action are of limited duration (< 1 month), with only 1-2 days operating on a specific line. The combination of the USGS 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 *R/V Sharp* would avoid fishing vessels when towing seismic equipment. Operation of R/V *Sharp*, therefore, would not be expected to significantly impact commercial fishing operations in the area.

(d) Summary of Cumulative Impacts to Marine Mammals, Sea Turtles, Seabirds, and Fish

This section is taken verbatim from the Draft Scripps EA (LGL, 2017), with changes to reflect the specifics of USGS activities. The impacts of the USGS's proposed seismic surveys are expected to be no more than a minor (and short-term) increment when viewed in light of other human activities within the proposed project area. Unlike some other ongoing and routine activities in the area (e.g., commercial fishing), the USGS activities are not expected to result in injuries or deaths of sea turtles or marine mammals. Although the airgun sounds from the seismic surveys will have higher source levels than do the sounds from most other human activities in the area, airgun operations during the surveys would last only 1-3 days at each location, in contrast to those from many other sources that have lower peak pressures but occur continuously over extended periods. Thus, the combination of the USGS operations with the existing shipping and fishing activities would be expected to produce only a negligible increase in overall disturbance effects on marine mammals and turtles.

10. Unavoidable Impacts

This section is taken verbatim from the Draft Scripps EA (LGL, 2017). Unavoidable impacts to the species of marine mammals and turtles occurring in the proposed project area would be limited to short-term, localized changes in behavior of individuals. For cetaceans, some of the changes in behavior may be sufficient to fall within the MMPA definition of "Level B Harassment" (behavioral disturbance; no serious injury or mortality). TTS, if it occurs, would be limited to a few individuals, is a temporary phenomenon that does not involve injury, and is unlikely to have long term consequences for the few individuals involved. No long-term or significant impacts would be expected on any of these individual marine mammals or turtles, or on the populations to which they belong. Effects on recruitment or survival would be expected to be (at most) negligible.

11. Coordination with Other Agencies and Processes

This EA incorporates by reference large components of the Scripps EA (2017), recently prepared by LGL on behalf of SIO, NSF, OSU, and Rutgers. Potential impacts to endangered species and critical habitat have also been assessed in the document; it will be used to support the ESA Section 7 consultation process with NMFS and USFWS. This document will also be used as supporting documentation for an IHA application submitted to NMFS, under the U.S. MMPA, for "taking by harassment" (disturbance) of small numbers of marine mammals, for this proposed seismic project. The USGS will comply with any additional applicable federal regulations and will continue to coordinate with federal regulatory agencies and their requirements.

Alternative Action: Another Time

Adopting the language of the Draft Scripps EA (LGL, 2017) for usage here: An alternative to issuing the IHA for the period requested, and to conducting the Project then, is to issue the IHA for another time, and to conduct the project at that alternative time. The proposed dates for the cruise (August 2018) are the dates when the personnel and equipment essential to meet the overall project objectives are available.

Marine mammals and sea turtles are expected to be found throughout the proposed project area and throughout the time period during which the project would occur. Except for some baleen whales, most marine mammal species probably occur in the project area year-round, so altering the timing of the proposed project likely would result in no net benefits for most species (see § III, above).

No Action Alternative

This section is taken verbatim from the Draft Scripps EA (LGL, 2017): "An alternative to conducting the proposed activities is the "No Action" alternative, i.e., do not issue an IHA and do not conduct the operations. If the research were not conducted, the "No Action" alternative would result in no disturbance to marine mammals or sea turtles attributable to the proposed activities; however, valuable data about the marine environment would be lost." Data collection to provide information about the distribution of marine gas hydrates and shallow methane offshore the US and within its EEZ would not be acquired. The No Action Alternative would not meet the purpose and need for the proposed activities.

DISCLAIMER: ***Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.***

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APPENDICES

In accordance with deliberations underway at the Council on Environmental Quality and the order of the Secretary of the Interior dated August 31, 2017 (Secretary's Order 3355) on "Streamlining National Environmental Policy Reviews and Implementation of Executive Order 13807, "Establishing Discipline and Accountability in the Environmental Review and Permitting Process for Infrastructure Projects," this EA has incorporated by reference and taken verbatim from existing Draft EAs (particularly the Draft Scripps EA (LGL, 2017)) whenever possible. In addition, material not necessary in the core of this EA document has been shifted to the appendices. In some cases, these appendices provide material nearly verbatim from the Draft Scripps EA (LGL, 2017). This text is provided here for the convenience of reviewers, even though it is considered fully incorporated by reference within this EA.

Appendix A: Backup Configuration Information and Calculations

In the case of compressor failure or other equipment problems, the airguns could be operated in the backup, 2 GI gun, configuration. The exclusion/mitigation zones for this configuration are significantly smaller than those for the configurations (Base and GG) targeted for the Optimal and Base Surveys. Thus, takes calculated for the other configurations are larger and therefore more conservative than applicable to the Backup Configuration. For the sake of completeness, information about the backup configuration is provided here and calculations of the sound source levels are given in Appendix C.

Backup Configuration (Configuration 3) is 2 GI guns producing 210 in^3 total volume, as shown in Figure 4. If a compressor were offline, this lowest-energy configuration would be used to sustain data acquisition. Guns 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.

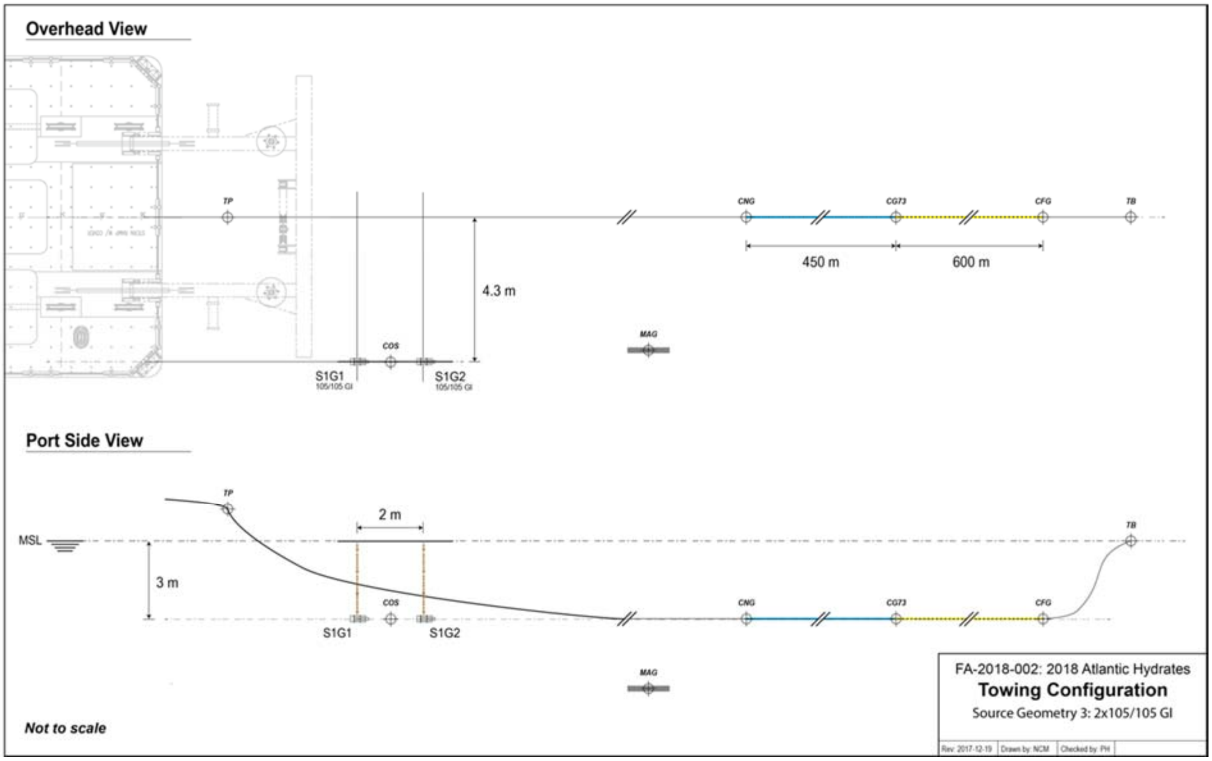

Figure A1. **Backup configuration** (Source configuration 3): 210 in^3 total volume consisting of 2x105/105in^3 GI guns firing in standard GI mode. Guns are labelled as S#G*, where # is the side and * is the gun number.

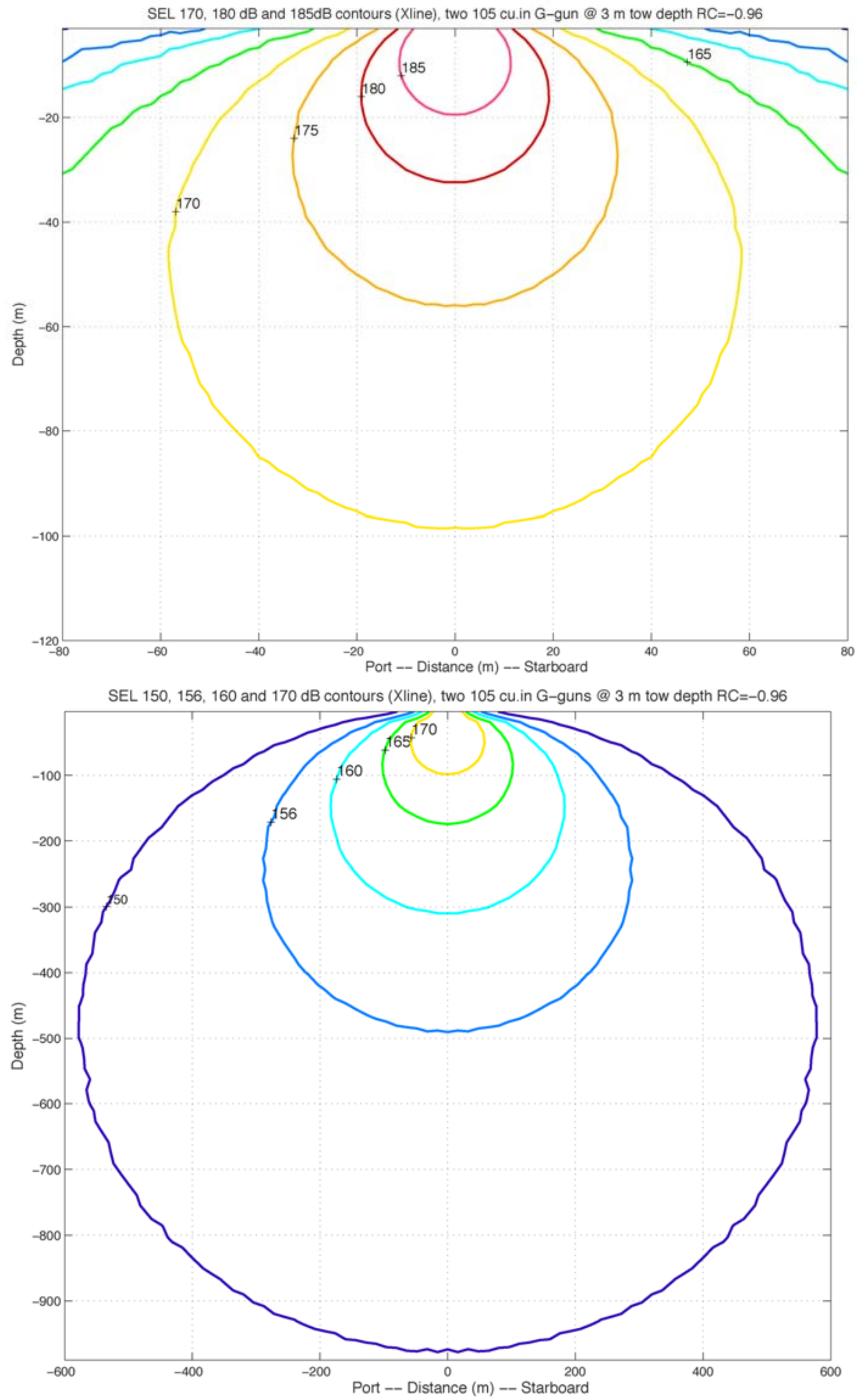

FIGURE 8. Modeled deep-water received sound exposure levels (SELs) from the backup configuration (Configuration 3; two 105 in^3 GI-guns) at a 3-m tow depth. Received rms levels (SPLs) are expected to be ~10 dB higher. The plot at the top provides the radius to the 170-dB SEL isopleth as a proxy for the 180-dB rms isopleth, and the plot at the bottom provides the radius to the 150 and 165-dB SEL isopleths as a proxy for the 160 and 175-dB rms isopleths, respectively. The upper plot is a blow-up of the lower plot.

Appendix B: Sound Exposure Levels (SEL): Scaling Analyses and All Results

SEL (dB) associated with airgun arrays tested in the Gulf of Mexico as part of Tolstoy et al. (2009). These values are used to scale calculations conducted by L-DEO for the Proposed Action.

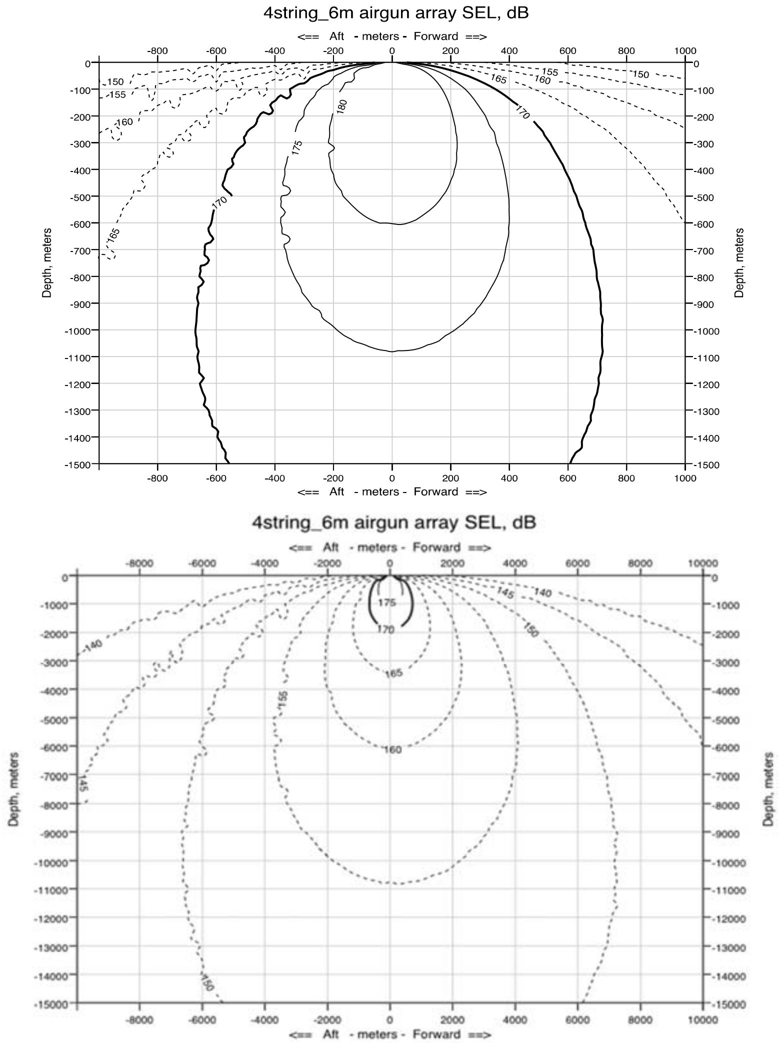

FIGURE B1. Modeled deep-water received sound exposure levels (SELs) from the 36-airgun array at a 6-m tow depth used during the GoM calibration survey. These values are used along with a scaling factor to determine SELs for shallow-water deployments with the three proposed configurations. Received rms levels (SPLs) are expected to be ~10 dB higher. The plot at the top provides the radius to the 170 dB SEL isopleth as a proxy for the 180-dB rms isopleth, and the plot at the bottom provides the radius to the 150-dB SEL isopleth as a proxy for the 160-dB rms isopleth.

For the **Base Configuration** (Configuration 1):

- the 150-decibel (dB) Sound Exposure Level (SEL)[3] corresponds to deep-water maximum radii of 1090.6 m for the four 105 in^3 airguns at 3 m tow depth (Fig. 5), and 7,244 m for the 6600 in^3 at 6-m tow depth, yielding scaling factors of 0.151 to be applied to the shallow-water 6-m tow depth results.

- the 165-decibel (dB) Sound Exposure Level (SEL) corresponds to deep-water maximum radii of 193.94 m for the four 105 in^3 airguns at 3 m tow depth, and 1,284 m for a 6-m tow depth, yielding a scaling factor of 0.151 to be applied to the shallow-water 6-m tow depth results.

- Similarly, the 170 dB SEL corresponds to deep-water maximum radii of 109.72 for the four 105 in^3 airguns at 3 m tow depth (Fig. 2) and 719 m for the 6600 in^3 at 6-m tow depth (Fig. 4), yielding the same 0.152 scaling factor.

- the 185-decibel (dB) Sound Exposure Level (SEL) corresponds to deep-water maximum radii of 19.89 m for the four 105 in^3 at 3-m tow depth, and 126.3 m for a 6-m tow depth, yielding a scaling factor of 0.157 to be applied to the shallow-water 6-m tow depth results.

Measured 160-, 175-, 180-, 190- and 195-dB re 1µPa_{rms} distances in shallow water for the 36-airgun *R/V Langseth* array towed at 6 m depth were 17.5 km, 2.84 km, 1.6 km, 458 m and 240 m, respectively, based on a 95th percentile fit (Tolstoy et al. 2009). Multiplying by the scaling factors to account for the tow depth and discharge volume differences between the 6600 cu.in airgun array at 6 m tow depth and the USGS Proposed Action Base Configuration, the 420 cu.in airgun array at 3 m tow depth yields distances of 2.642 km, 429 m, 243 m, 71 m and 38 m, respectively.

For the **GG Configuration** (Configuration 2):

- the 150-decibel (dB) Sound Exposure Level (SEL) corresponds to deep-water maximum radii of 1,244 m for the four 210 in^3 airguns at 3 m tow depth (Fig. 6), and 7,244 m for the L-DEO 6600 in^3 at 6-m tow depth (Fig. 8), yielding scaling factors of 0.172 to be applied to the shallow-water 6-m tow depth results.

- the 165-decibel (dB) Sound Exposure Level (SEL) corresponds to deep-water maximum radii of 219.54 m for the four 210 in^3 airguns at 3 m tow depth, and 1,284 m for a 6-m tow depth, yielding a scaling factor of 0.171 to be applied to the shallow-water 6-m tow depth results.

- Similarly, the 170 dB SEL corresponds to deep-water maximum radii of 124.72 for the four 210 in^3 airguns at 3 m tow depth (Fig. 2) and 719 m for the 6600 in^3 at 6-m tow depth (Fig. 4), yielding the same 0.173 scaling factor.

- the 185-decibel (dB) Sound Exposure Level (SEL) corresponds to deep-water maximum radii of 22.69 m for the four 210 in^3 at 3-m tow depth, and 126.3 m for a 6-m tow depth, yielding a scaling factor of 0.179 to be applied to the shallow-water 6-m tow depth results.

Measured 160-, 175-, 180-, 190- and 195-dB re 1µPa_{rms} distances in shallow water for the 36-airgun *R/V Langseth* array towed at 6 m depth were 17.5 km, 2.84 km, 1.6 km, 458 m and 240 m, respectively, based on a 95th percentile fit (Tolstoy et al. 2009). Multiplying by the scaling factors to account for the tow depth and discharge volume differences between the 6600 cu.in airgun array at 6 m tow depth and the 840 cu.in airgun array at 3 m tow depth yields distances of 3.01 km, 485 m, 277 m, 80 m and 43 m, respectively.

For the **Backup Configuration** (Configuration 3):

---

[3] SEL (measured in dB re 1 µPa^2 · s) is a measure of the received energy in the pulse and represents the SPL that would be measured if the pulse energy were spread evenly across a 1-s period. Because actual seismic pulses are less than 1 s in duration in most situations, this means that the SEL value for a given pulse is usually lower than the SPL calculated for the actual duration of the pulse. In this EA, we assume that rms pressure levels of received seismic pulses would be 10 dB higher than the SEL values predicted by L-DEO's model.

- the 150-decibel (dB) Sound Exposure Level (SEL) corresponds to deep-water maximum radii of 578.152 m for the two 105 in^3 airguns at 3 m tow depth (Fig. 7), and 7,244 m for the 6600 in^3 at 6-m tow depth (Fig. 8), yielding scaling factors of 0.080 to be applied to the shallow-water 6-m tow depth results.

- the 165-decibel (dB) Sound Exposure Level (SEL) corresponds to deep-water maximum radii of 102.37 m for the two 105 in^3 airguns at 3 m tow depth, and 1,284 m for a 6-m tow depth, yielding a scaling factor of 0.080 to be applied to the shallow-water 6-m tow depth results.

- Similarly, the 170 dB SEL corresponds to deep-water maximum radii of 58.395 for the two 105 in^3 airguns at 3 m tow depth (Fig. 2) and 719 m for the 6600 in^3 at 6-m tow depth (Fig. 4), yielding the same 0.081 scaling factor.

- the 185-decibel (dB) Sound Exposure Level (SEL) corresponds to deep-water maximum radii of 11.343 m for the two 105 in^3 at 3-m tow depth, and 126.3 m for a 6-m tow depth, yielding a scaling factor of 0.089 to be applied to the shallow-water 6-m tow depth results.

Measured 160-, 175-, 180-, 190- and 195-dB re 1µPa_{rms} distances in shallow water for the 36-airgun *R/V Langseth* array towed at 6 m depth were 17.5 km, 2.84 km, 1.6 km, 458 m and 240 m, respectively, based on a 95th percentile fit (Tolstoy et al. 2009). Multiplying by the scaling factors to account for the tow depth and discharge volume differences between the 6600 cu.in airgun array at 6 m tow depth and the 110 cu.in airgun array at 3 m tow depth yields distances of 1.4 km, 227 m, 130 m, 38 m and 21 m, respectively.

Table B1. Predicted distances to which sound levels ≥ 195, 190-, 180-, 175-, and 160-dB re 1 μPa$_{rms}$ are expected to be received during the proposed surveys in the Northwest Atlantic Ocean. The Proposed Action will not involve ensonifying the seafloor at water depths shallower than 100 m.

Source and Volume	Tow Depth (m)	Water Depth (m)	Predicted rms Radii (m)				
			195 dB	190dB	180 dB	175 dB	160 dB
Base Configuration (Configuration 1) Four 105 in^3 G-guns	3	>1000 m	100[4]	100[4]	110[4]	194[1]	1091[1]
		100–1000 m	100[4]	100[4]	165[4]	291[2]	1637[2]
GG Configuration (Configuration 2) Four 210 in^3 G-guns	3	>1000 m	100[4]	100[4]	125[1]	220[1]	1244[1]
		100–1000 m	100[4]	100[4]	188[2]	330[2]	1866[2]
Backup Configuration (Configuration 3) Two 105 in^3 G-guns	3	>1000 m	100[4]	100[4]	100[4]	102[1]	578[1]
		100–1000 m	100[4]	100[4]	100[4]	153[2]	867[2]

[1] Distance is based on L-DEO model results.
[2] Distance is based on L-DEO model results with a 1.5 x correction factor between deep and intermediate water depths.
[3] Distance is based on empirically derived measurements in the GoM with scaling applied to account for differences in tow depth.
[4] Modeled distances based on empirically derived measurements in the GoM are smaller than 100 m. Therefore, we use 100 m for these mitigation zone according to accepted practice.

Appendix C. Supporting Documentation for Level A Acoustic Modeling

The following information was provided by Dr. Anne Bécel at Lamont-Doherty Earth Observatory based on modeling methodology previously applied in EAs for NSF-funded programs. The documentation is provided verbatim, with modifications only to eliminate redundancies, to clarify how the different components relate to the Proposed Action, and to ensure consistency in terminology across this EA.

BASE CONFIGURATION:

4 x 105 cu.in – 2 m separation aft-fore direction and 8.6 m separation in the port-starboard direction @ a 3 m tow depth

SELcum methodology (spreadsheet – Sivle et al., 2014)

Source Velocity (meters/second)	2.05778*
1/Repetition rate^ (seconds)	12.149**

† Methodology assumes propagation of 20 log R; Activity duration (time) independent
^ Time between onset of successive pulses.
* 4 kts

Table C1: Table showing the results for one single SEL SL modeling without and with applying weighting function to the 5 hearing groups. The modified farfield signature is estimated using the distance from the source array geometrical center to where the SELcum threshold is the largest. A propagation is of 20 $\log_{10}$ (Radial distance) is used to estimate the modified farfield SEL.

SEL_{cum} Threshold	183 dB	185 dB	155 dB	185 dB	203 dB
Distance(m) (no weighting function)	34.3541	28.0537	907.6353	28.0537	N/A (<1m)
Modified Farfield SEL*	213.7196	213.9598	214.1582	213.9598	203
Distance (m) (with weighting function)	15.6980	N/A	N/A	N/A	N/A
Adjustment (dB)	-6.80	N/A	N/A	N/A	N/A

* Propagation of 20 log R

For the Low Frequency Cetaceans, we estimated a new adjustment value by computing the distance from the geometrical center of the source to where the 183dB SEL cum isopleth is the largest. We first run the modeling for one single shot without applying any weighting function. The maximum 183dB SEL cum isopleth is located at 34.35 m from the source. We then run the modeling for one single shot with the low frequency Cetaceans weighting function applied to the full spectrum. The maximum 183 dB SEL cum isopleth is located at 15.69 m from the source. Difference between 34.35 m and 15.69 m gives an adjustment factor of -6.80 dB assuming a propagation of 20log10(R).

TABLE C2. Results for single shot SEL source level modeling for the four 105 in^3 airguns with weighting function calculations for SEL_{cum} criteria.

F: MOBILE SOURCE: Impulsive, Intermittent (SAFE DISTANCE METHODOLOGY)

VERSION 1.1: Aug-16

KEY

(green)	Action Proponent Provided Information
(pink)	NMFS Provided Information (Acoustic Guidance)
(blue)	Resultant Isopleth

STEP 1: GENERAL PROJECT INFORMATION

PROJECT TITLE	Carolyn Ruppel -
PROJECT/SOURCE INFORMATION Please include any assumptions	source : SIO portable system = 4 x 105 cu.in GI-gun at a 3m towed depth - (2 m separation in the fore-aft direction, 8.6 m in the port- starboard direction)
PROJECT CONTACT	

STEP 2: WEIGHTING FACTOR ADJUSTMENT

Specify if relying on source-specific WFA, alternative weighting/dB adjustment, or if using default value

Weighting Factor Adjustment (kHz)[¥]	User defined	Override WFA: Using LDEO modeling

[¥] Broadband: 95% frequency contour percentile (kHz) OR Narrowband: frequency (kHz); For appropriate default WFA: See INTRODUCTION tab

† If a user relies on alternative weighting/dB adjustment rather than relying upon the WFA (source-specific or default), they may override the Adjustment (dB) (row 62), and enter the new value directly. However, they must provide additional support and documentation supporting this modification.

* BROADBAND Sources: Cannot use WFA higher than maximum applicable frequency (See GRAY tab for more information on WFA applicable frequencies)

STEP 3: SOURCE-SPECIFIC INFORMATION

NOTE: Choose either F1 OR F2 method to calculate isopleths (not required to fill in sage boxes for both)

NOTE: LDEO modeling relies on Method F2

F2: ALTERNATIVE METHOD† TO CALCULATE PK and SEL_{cum} (SINGLE STRIKE/SHOT/PULSE EQUIVALENT)

SEL_{cum}

Source Velocity (meters/second)	2.05778
1/Repetition rate^ (seconds)	12.149

†Methodology assumes propagation of 20 log R; Activity duration (time) independent

^Time between onset of successive pulses.

Modified farfield SEL	213.7196	213.9598	214.1582	213.9598	203
Source Factor	1.93829E+20	2.04852E+20	2.14427E+20	2.04852E+20	1.64233E+19

RESULTANT ISOPLETHS*

*Impulsive sounds have dual metric thresholds (SELcum & PK). Metric producing largest isopleth should be used.

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
SEL_{cum} Threshold	183	185	155	185	203
PTS SEL_{cum} Isopleth to threshold (meters)	31.0	0.0	0.0	0.4	0.0

WEIGHTING FUNCTION CALCULATIONS

Weighting Function Parameters	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds	
a	1	1.6	1.8	1	2	
b	2	2	2	2	2	
f_1	0.2	8.8	12	1.9	0.94	
f_2	19	110	140	30	25	
C	0.13	1.2	1.36	0.75	0.64	
Adjustment (dB)†	-6.80	-54.02	-63.18	-23.74	-29.86	OVERIDE Using LDEO Modeling

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
SEL_{cum} Threshold	183	185	155	185	203
PTS SEL_{cum} Isopleth to threshold (meters)	31.0	0.0	0.0	0.4	0.0

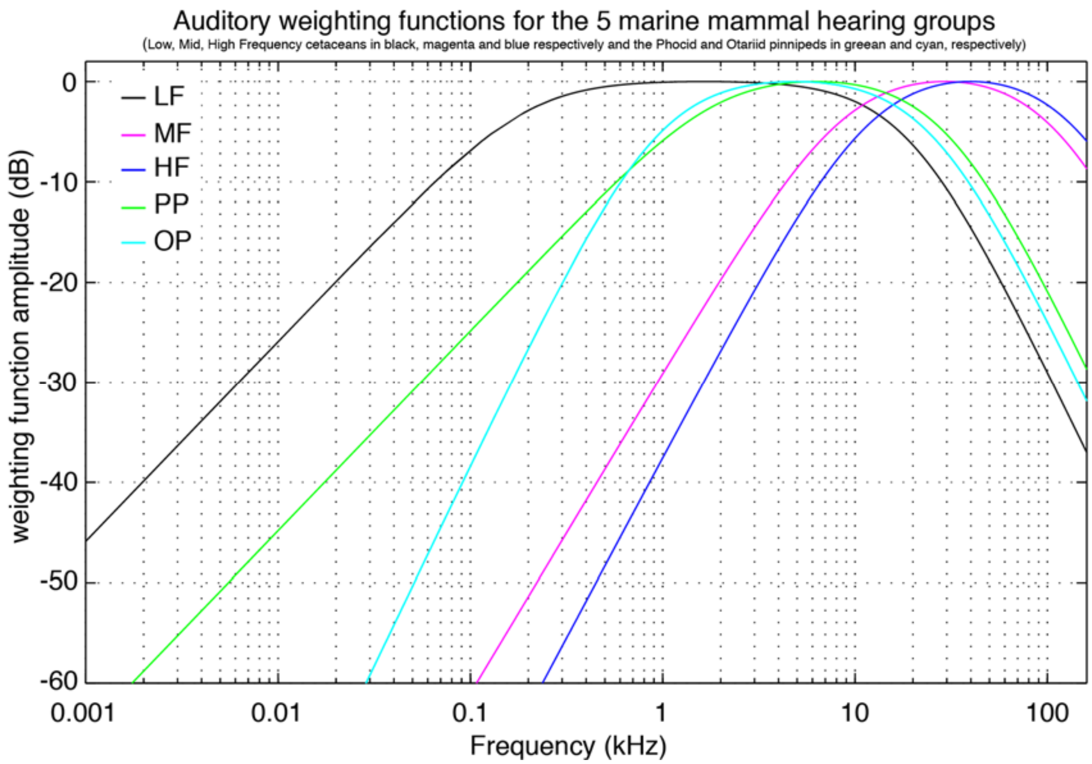

FIGURE C1: Auditory weighting functions for the 5 marine mammal hearing groups defined by NOAA's Acoustic Guidelines.

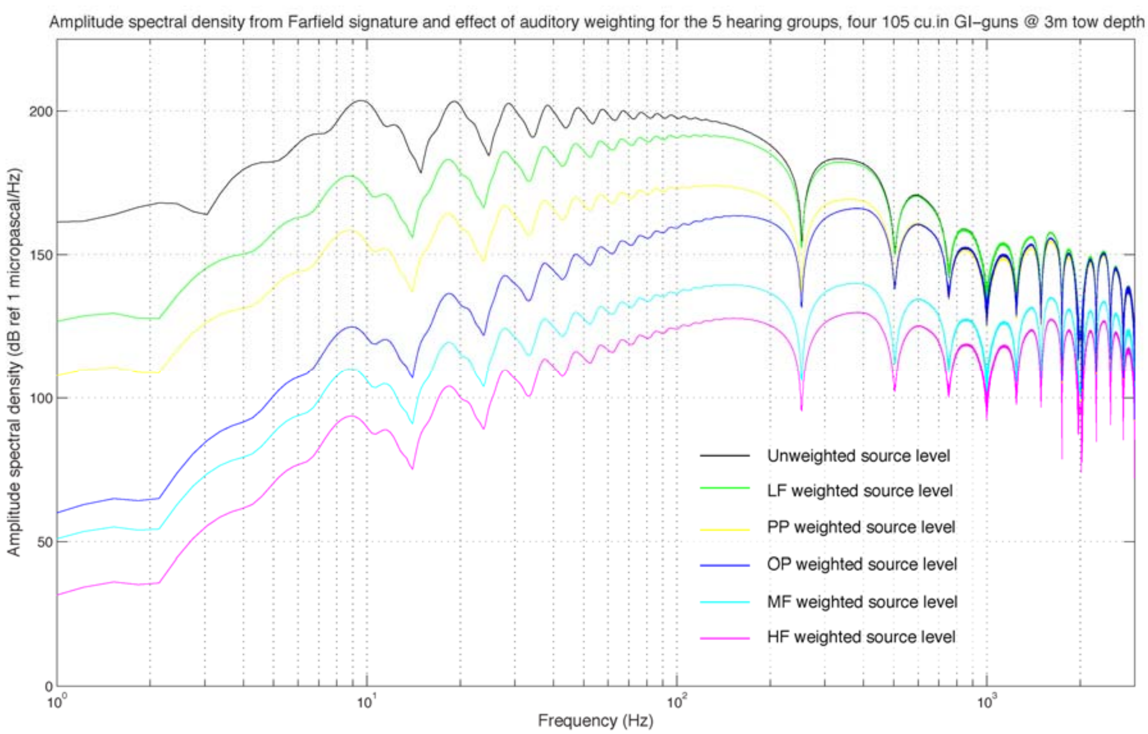

FIGURE C2: Modeled amplitude spectral density of the four 105 cu.in airgun farfield signature. Amplitude spectral density before (black) and after (green, yellow, blue, cyan, magenta) applying the auditory weighting function for the Low Frequency Cetaceans, Phocid Pinnipeds, Otariid Pinnipeds, Mid Frequency Cetaceans, High Frequency Cetaceans, respectively. Modeled spectral levels in micropascals are used to calculate the difference between the un-weighted and weighted source level at each frequency and to derive the adjustment factors for the Phocid Pinnipeds, Otariid Pinnipeds, Mid Frequency Cetaceans, and High Frequency Cetaceans as inputs into the NMFS user spreadhseet.

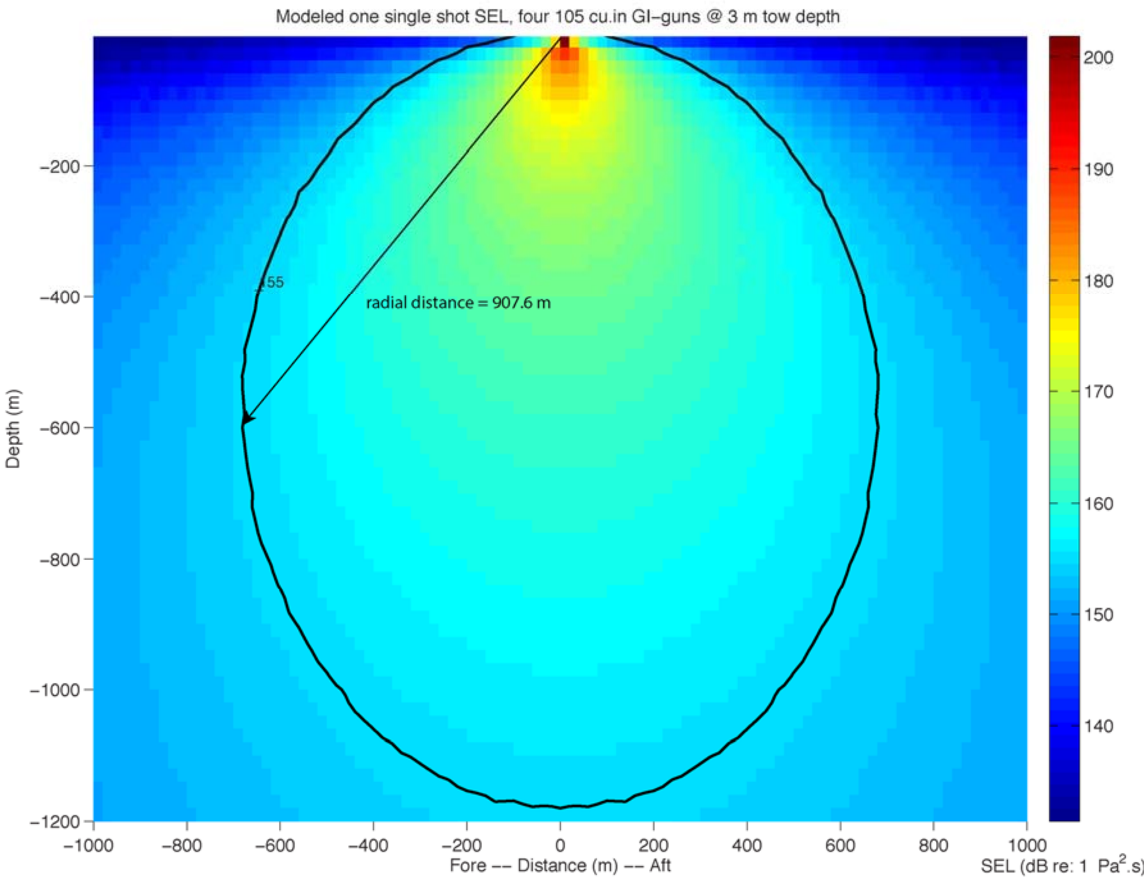

FIGURE C3: Modeled received sound levels (SELs) in deep water from the four 105 cu.in GI-guns at a 3-m tow depth. The plot provides the distance from the geometrical center of the source array to the 155-dB SEL isopleth (907.6 m).

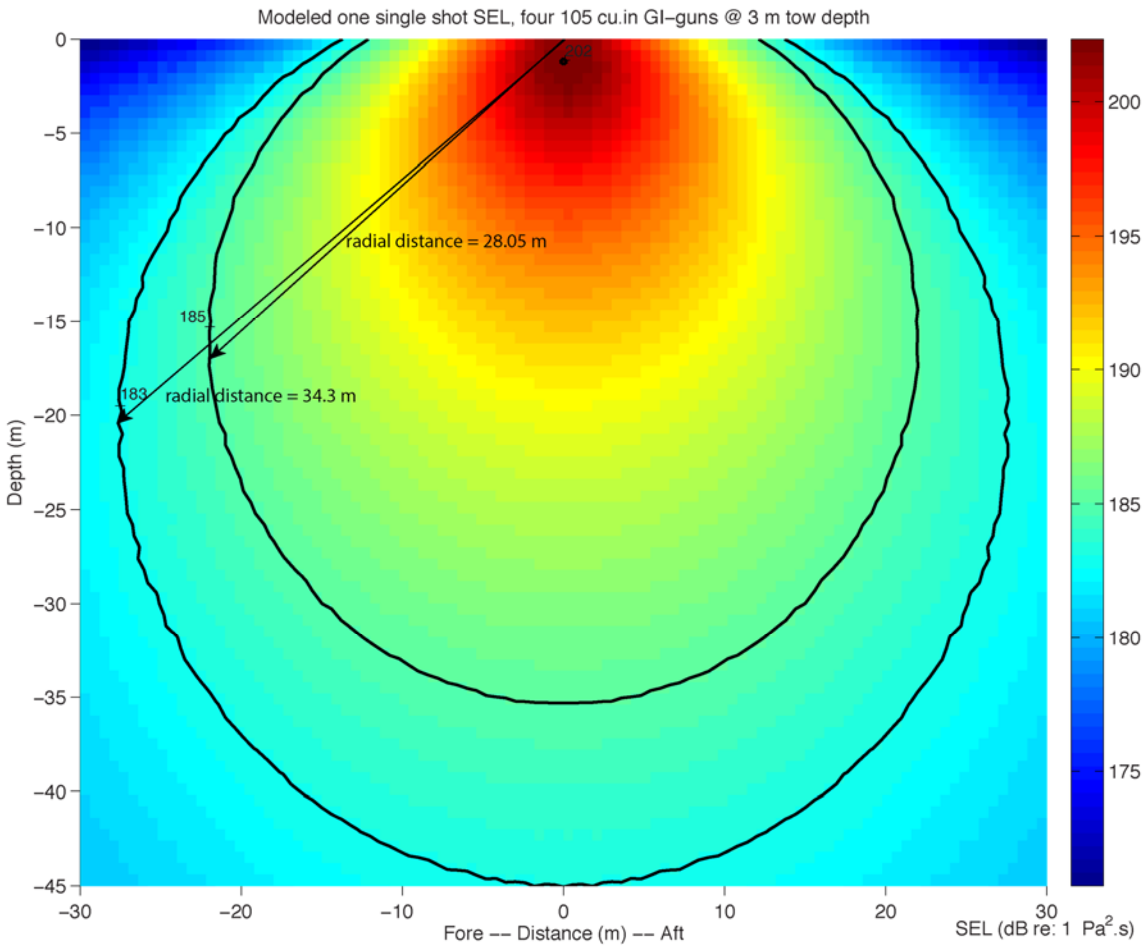

FIGURE C4 : Modeled received sound levels (SELs) in deep water from the four 105 cu.in GI-guns at a 3-m tow depth. The plot provides the distance from the geometrical center of the source array to the 183 and 185 dB SEL isopleths

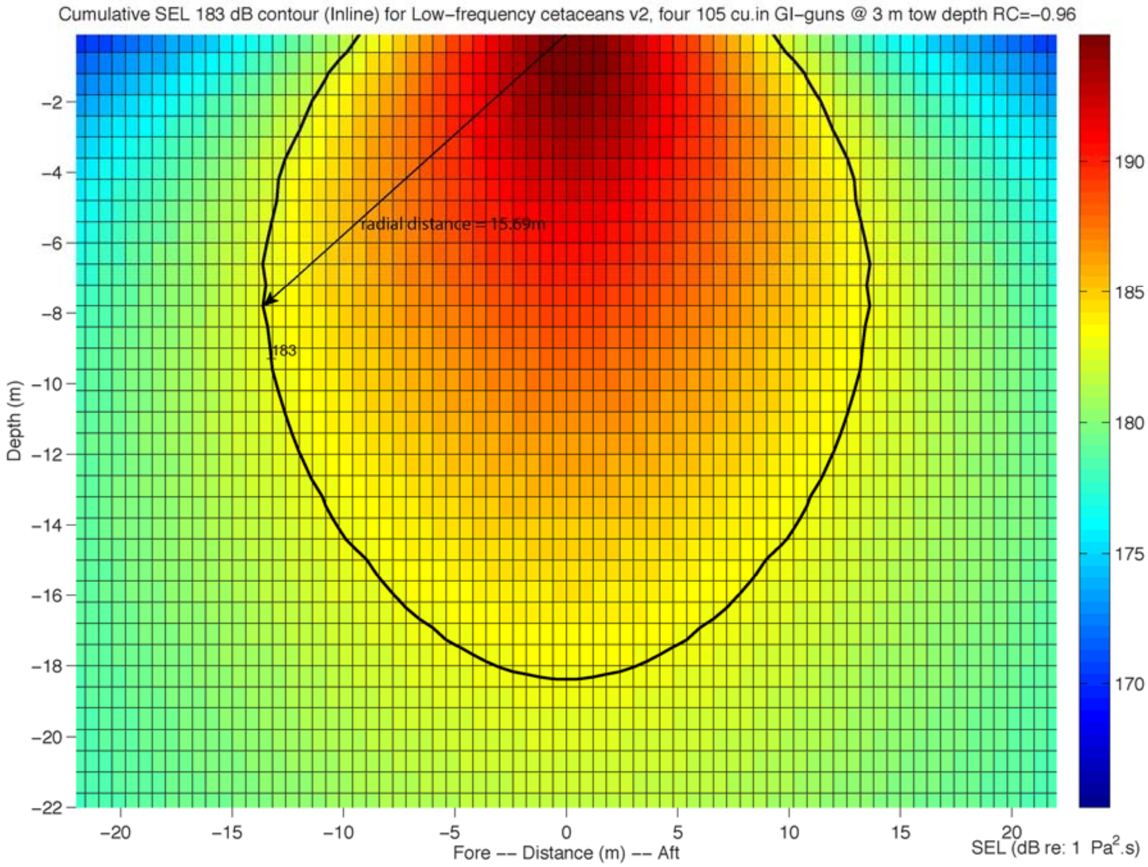

FIGURE C5: Modeled received sound exposure levels (SELs) from the four 105 cu.in GI-guns at a 3-m tow depth, after applying the auditory weighting function for the Low Frequency Cetaceans hearing group following to the new technical guidance. The plot provides the radial distance to the 183-dB SELcum isopleth for one shot. The difference in radial distances between Fig. 4 (34.35 m) and this figure (15.69 m) allows us to estimate the adjustment in dB.

Peak Sound Pressure Level :

TABLE C3. LEVEL A. NMFS Level A acoustic thresholds (Peak SPL_{flat}) for impulsive sources for marine mammals and predicted radial distances to Level A thresholds for various marine mammal hearing groups that could be received from the four 105 cu.in airguns at a 3 m tow depth during the proposed seismic survey in the north western Atlantic Ocean.

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
PK Threshold	219	230	202	218	232
Radius to threshold (meters)	10.03	N/A (0)	70.426	11.35	N/A (0)

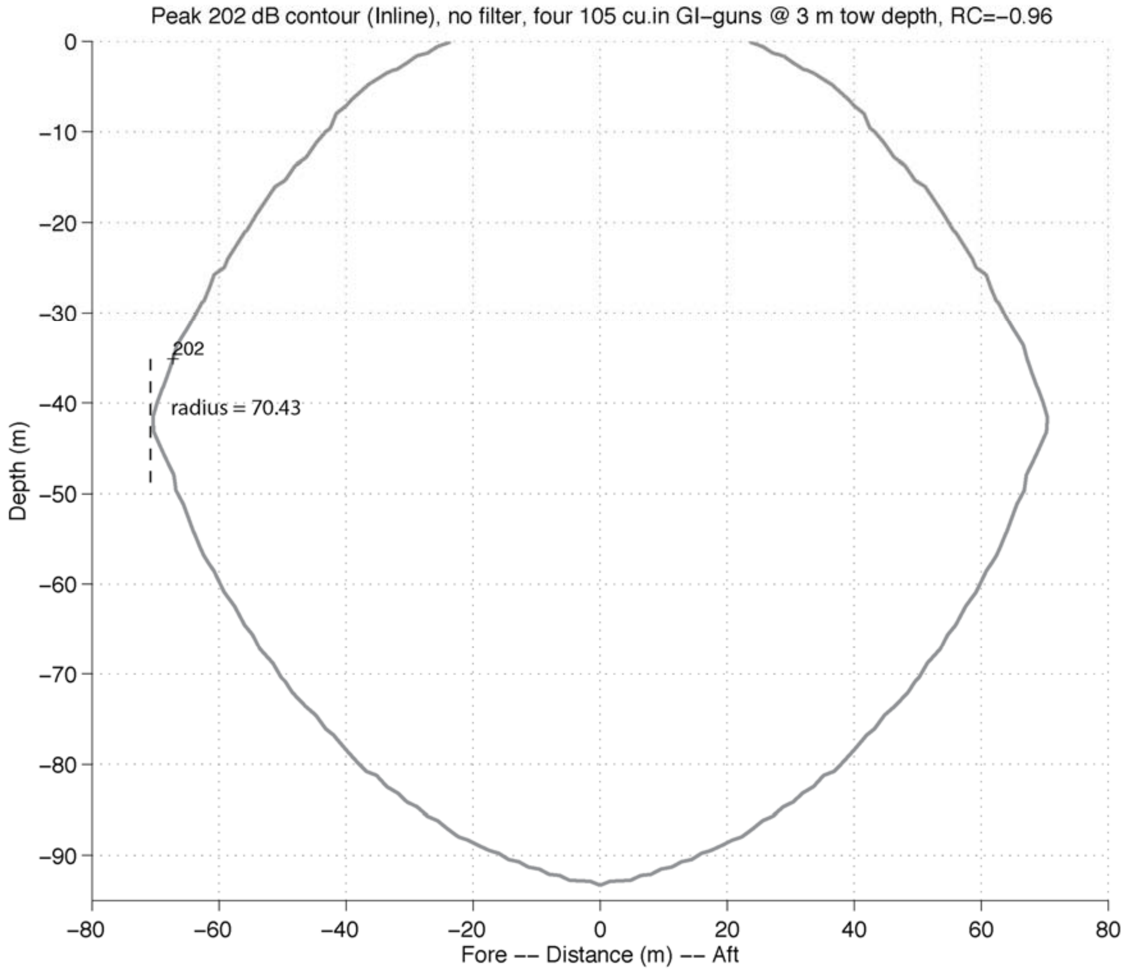

FIGURE C6: Modeled deep-water received Peak SPL from the four 105 cu.in GI-guns at a 3-m tow depth. The plot provides the radius of the 202-dB peak isopleth (70.43 m).

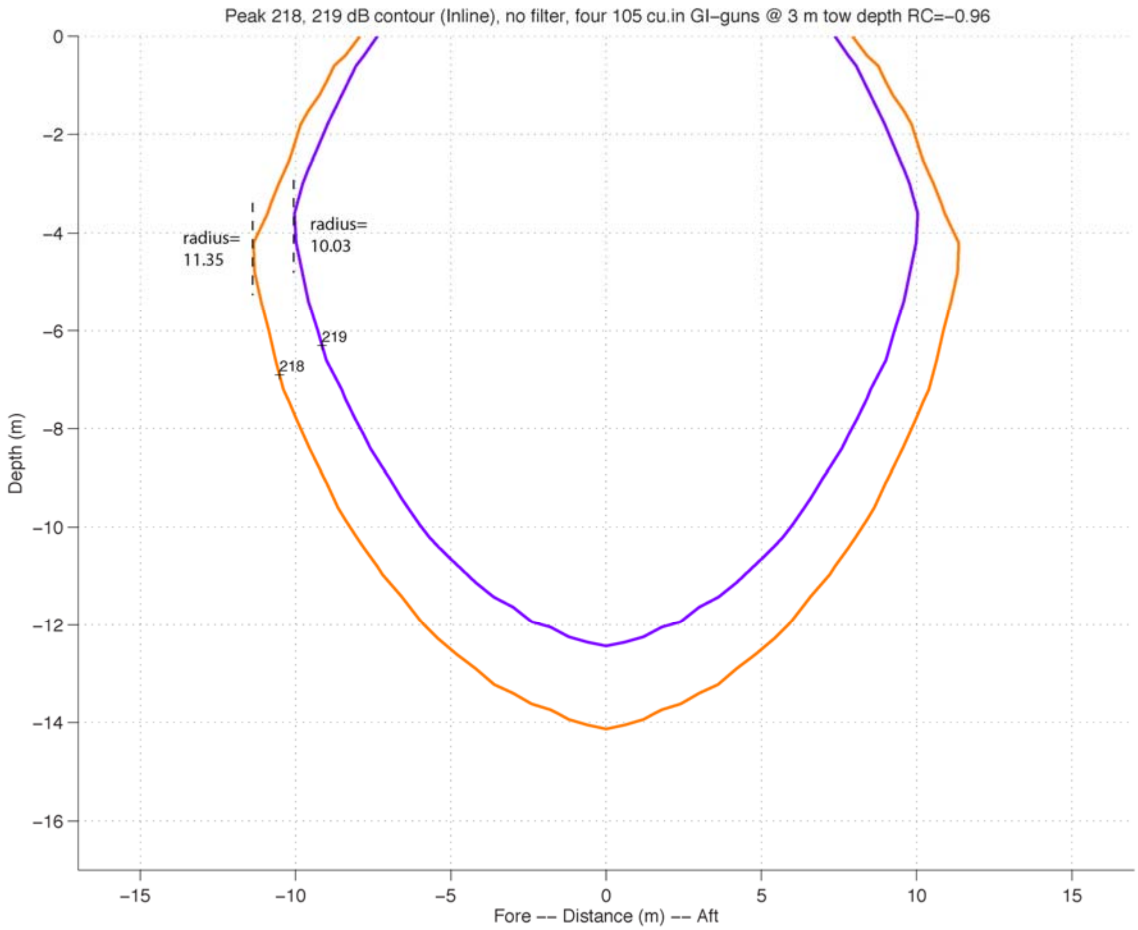

FIGURE C7: Modeled deep-water received Peak SPL from four 105 cu.in GI-guns at a 3-m tow depth. The plot provides the radius of the 218 and 219 dB peak isopleths.

GG CONFIGURATION

4 x 210 cu.in – 2 m separation aft-fore direction and 8.6 m separation in the port-starboard direction @ a 3 m tow depth

Table C4: Table showing the results for one single SEL SL modeling without and with applying weighting function to the 5 hearing groups. The modified farfield signature is estimated using the distance from the source array geometrical center to where the SELcum threshold is the largest. A propagation is of 20 $\log_{10}$ (Radial distance) is used to estimate the modified farfield SEL.

SEL_{cum} Threshold	183	185	155	185	203
Distance(m) (no weighting function)	39.4216	30.8975	1029.1	30.8975	1.8439
Modified Farfield SEL*	214.9147	214.7985	215.2492	214.7985	208.3147
Distance (m) (with weighting function)	17.7149	N/A	N/A	N/A	N/A
Adjustment (dB)	-6.9479	N/A	N/A	N/A	N/A

* Propagation of 20 log R

For the Low Frequency Cetaceans, we estimated a new adjustment value by computing the distance from the geometrical center of the source to where the 183dB SEL cum isopleth is the largest. We first run the modeling for one single shot without applying any weighting function. The maximum 183dB SEL cum isopleth is located at 39.42 m from the source. We then run the modeling for one single shot with the low frequency Cetaceans weighting function applied to the full spectrum. The maximum 183 dB SEL cum isopleth is located at 17.71 m from the source. Difference between 17.71 m and 39.42 m gives an adjustment factor of -6.95 dB assuming a propagation of 20log10(R).

TABLE C5. Results for single shot SEL source level modeling for the four 210 in^3 airguns with weighting function calculations for SEL_{cum} criteria.

F: MOBILE SOURCE: Impulsive, Intermittent (SAFE DISTANCE METHODOLOGY)

VERSION 1.1: Aug-16

KEY

(green)	**Action Proponent Provided Information**
(pink)	**NMFS Provided Information (Acoustic Guidance)**
(blue)	**Resultant Isopleth**

STEP 1: GENERAL PROJECT INFORMATION

PROJECT TITLE	Carolyn Ruppel -
PROJECT/SOURCE INFORMATION	source : SIO portable system = 4 x 210 cu.in GI-gun at a 3m towed depth - (2 m separation in the fore-aft direction, 8.6 m separation in the port-starboard direction)
Please include any assumptions	
PROJECT CONTACT	

STEP 2: WEIGHTING FACTOR ADJUSTMENT

Specify if relying on source-specific WFA, alternative weighting/dB adjustment, or if using default value

Weighting Factor Adjustment (kHz)[¥]	User defined	Override WFA: Using LDEO modeling

[¥] Broadband: 95% frequency contour percentile (kHz) OR Narrowband: frequency (kHz); For appropriate default WFA: See INTRODUCTION tab

† If a user relies on alternative weighting/dB adjustment rather than relying upon the WFA (source-specific or default), they may override the Adjustment (dB) (row 62), and enter the new value directly. However, they must provide additional support and documentation supporting this modification.

*** BROADBAND Sources: Cannot use WFA higher than maximum applicable frequency (See GRAY tab for more information on WFA applicable frequencies)**

STEP 3: SOURCE-SPECIFIC INFORMATION

NOTE: Choose either F1 OR F2 method to calculate isopleths (not required to fill in sage boxes for both)

NOTE: LDEO modeling relies on Method F2

F2: ALTERNATIVE METHOD† TO CALCULATE PK and SEL_{cum} (SINGLE STRIKE/SHOT/PULSE EQUIVALENT)

SEL_{cum}

Source Velocity (meters/second)	2.05778
1/Repetition rate^ (seconds)	12.149

†Methodology assumes propagation of 20 log R; Activity duration (time) independent

^Time between onset of successive pulses.

Modified farfield SEL	214.9147	214.7985	215.2492	214.7985	208.3147
Source Factor	2.55229E+20	2.4849E+20	2.75664E+20	2.4849E+20	5.5838E+19

RESULTANT ISOPLETHS*

*Impulsive sounds have dual metric thresholds (SELcum & PK). Metric producing largest isopleth should be used.

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
SEL_{cum} Threshold	183	185	155	185	203
PTS SEL_{cum} Isopleth to threshold (meters)	39.5	0.0	0.1	0.5	0.0

WEIGHTING FUNCTION CALCULATIONS

Weighting Function Parameters	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds	
a	1	1.6	1.8	1	2	
b	2	2	2	2	2	
f_1	0.2	8.8	12	1.9	0.94	
f_2	19	110	140	30	25	
C	0.13	1.2	1.36	0.75	0.64	
Adjustment (dB)†	-6.94	-54.84	-64.11	-24.04	-30.75	OVERIDE Using LDEO Modeling

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
SEL_{cum} Threshold	183	185	155	185	203
PTS SEL_{cum} Isopleth to threshold (meters)	39.5	0.0	0.1	0.5	0.0

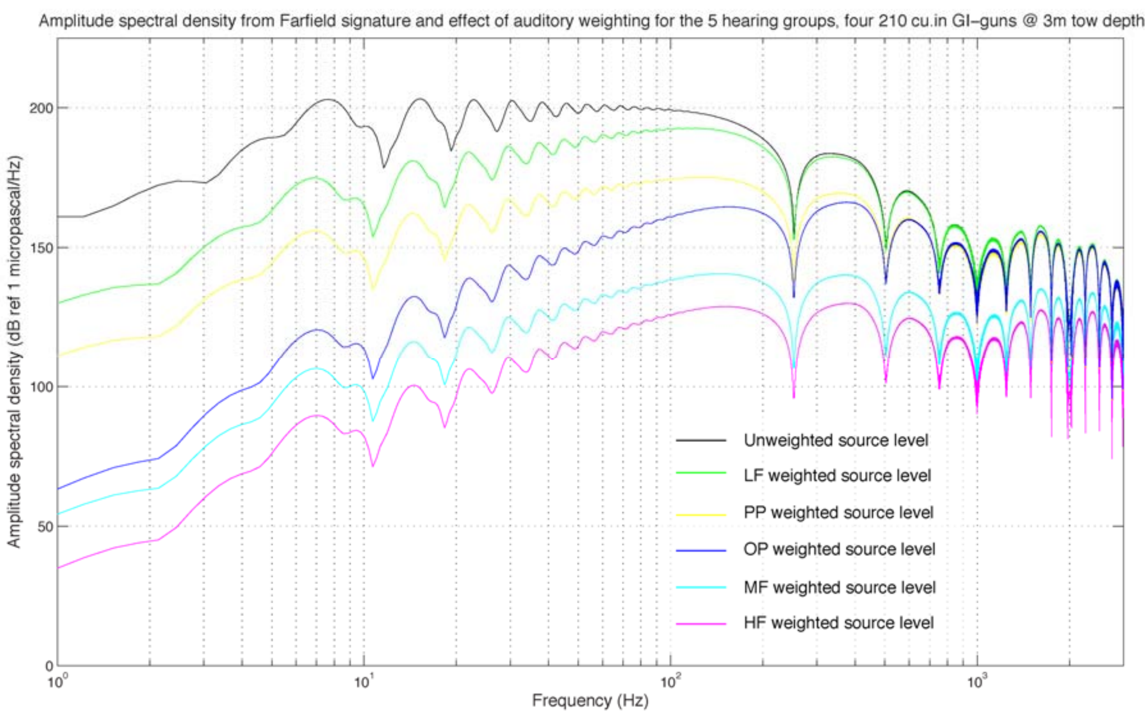

FIGURE C8: Modeled amplitude spectral density of the four 210 cu.in airgun farfield signature. Amplitude spectral density before (black) and after (green, yellow, blue, cyan, magenta) applying the auditory weighting function for the Low Frequency Cetaceans, Phocid Pinnipeds, Otariid Pinnipeds, Mid Frequency Cetaceans, High Frequency Cetaceans, respectively. Modeled spectral levels in micropascals are used to calculate the difference between the un-weighted and weighted source level at each frequency and to derive the adjustment factors for the Phocid Pinnipeds, Otariid Pinnipeds, Mid Frequency Cetaceans, and High Frequency Cetaceans as inputs into the NMFS user spreadhseet.

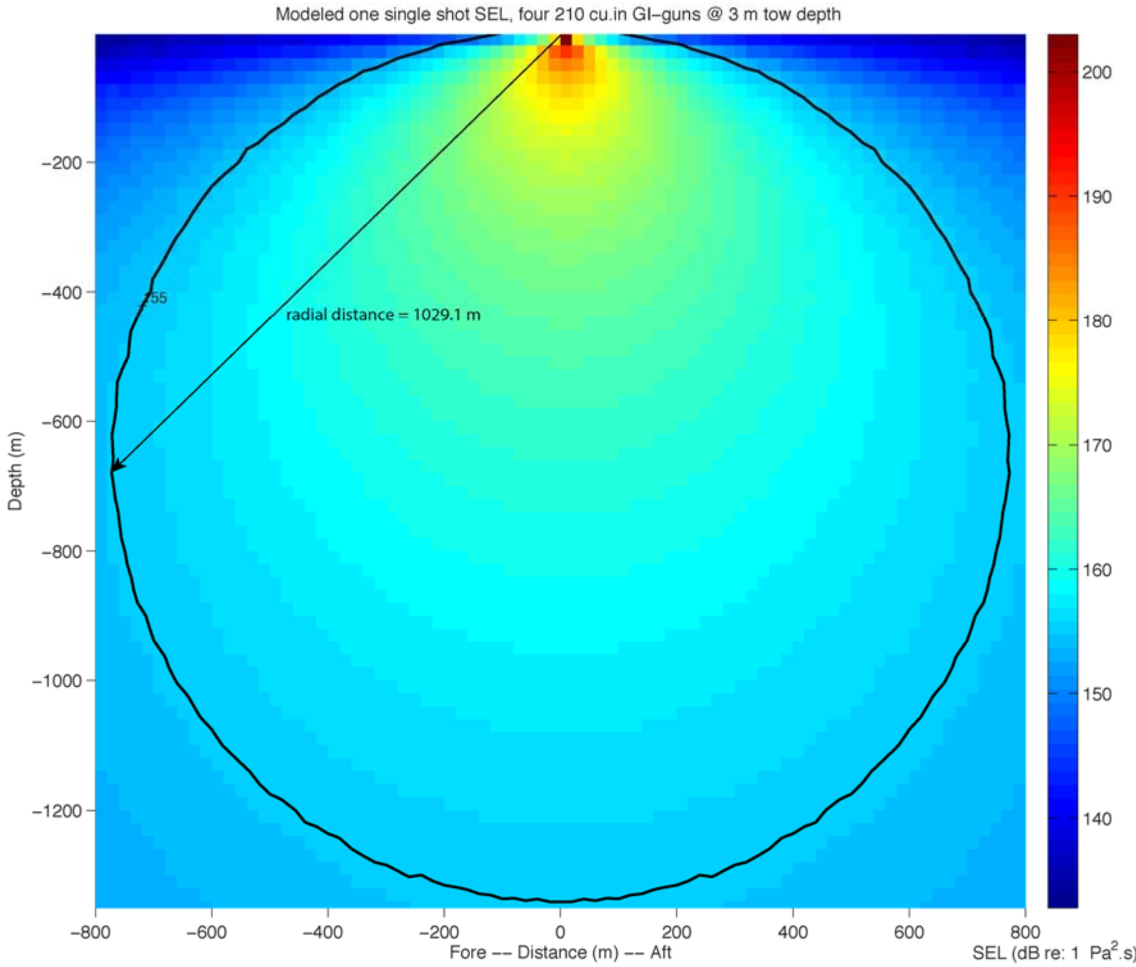

FIGURE C9: Modeled received sound levels (SELs) in deep water from the four 210 cu.in GI-guns at a 3-m tow depth. The plot provides the distance from the geometrical center of the source array to the 155-dB SEL isopleth (1029.1 m).

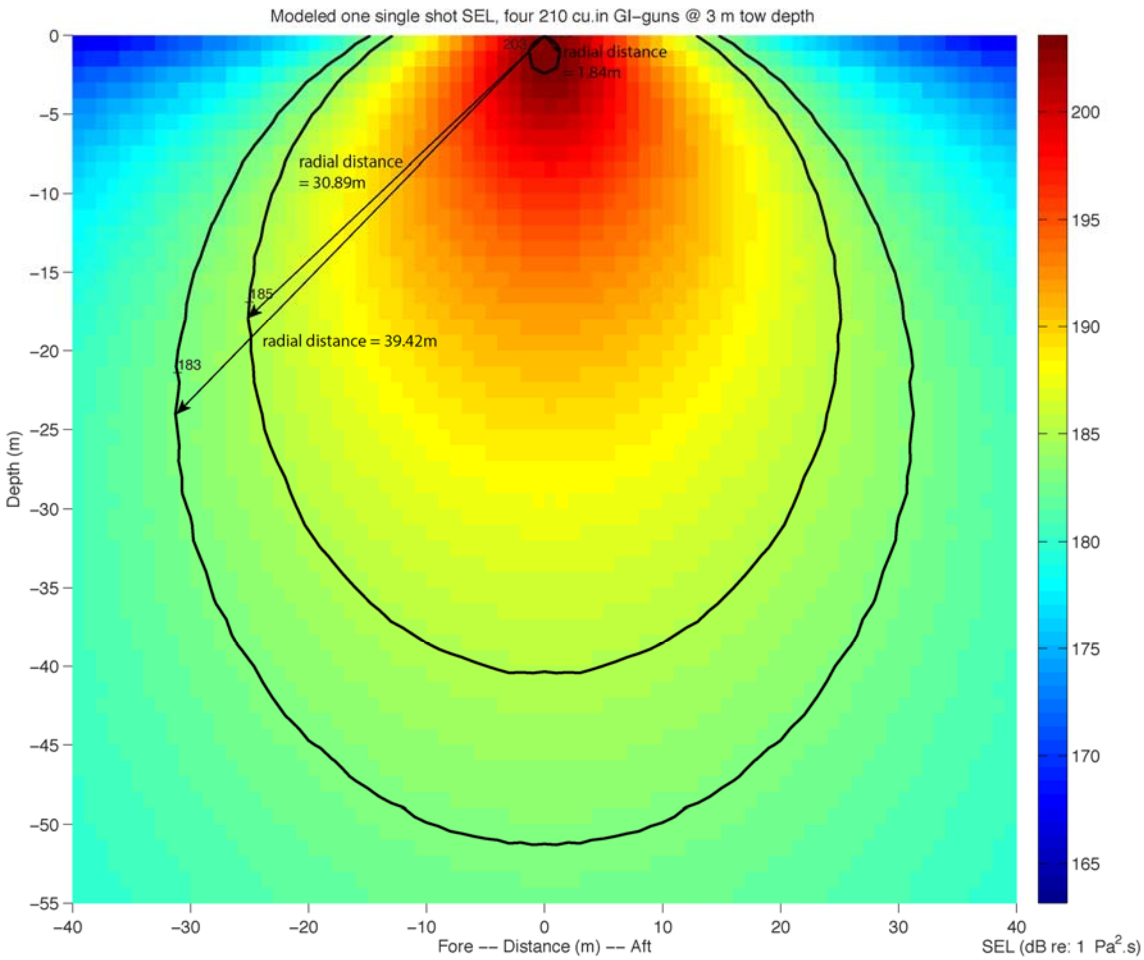

FIGURE C10 : Modeled received sound levels (SELs) in deep water from the four 210 cu.in GI-guns at a 3-m tow depth. The plot provides the distance from the geometrical center of the source array to the 183, 185 and 203 dB SEL isopleths

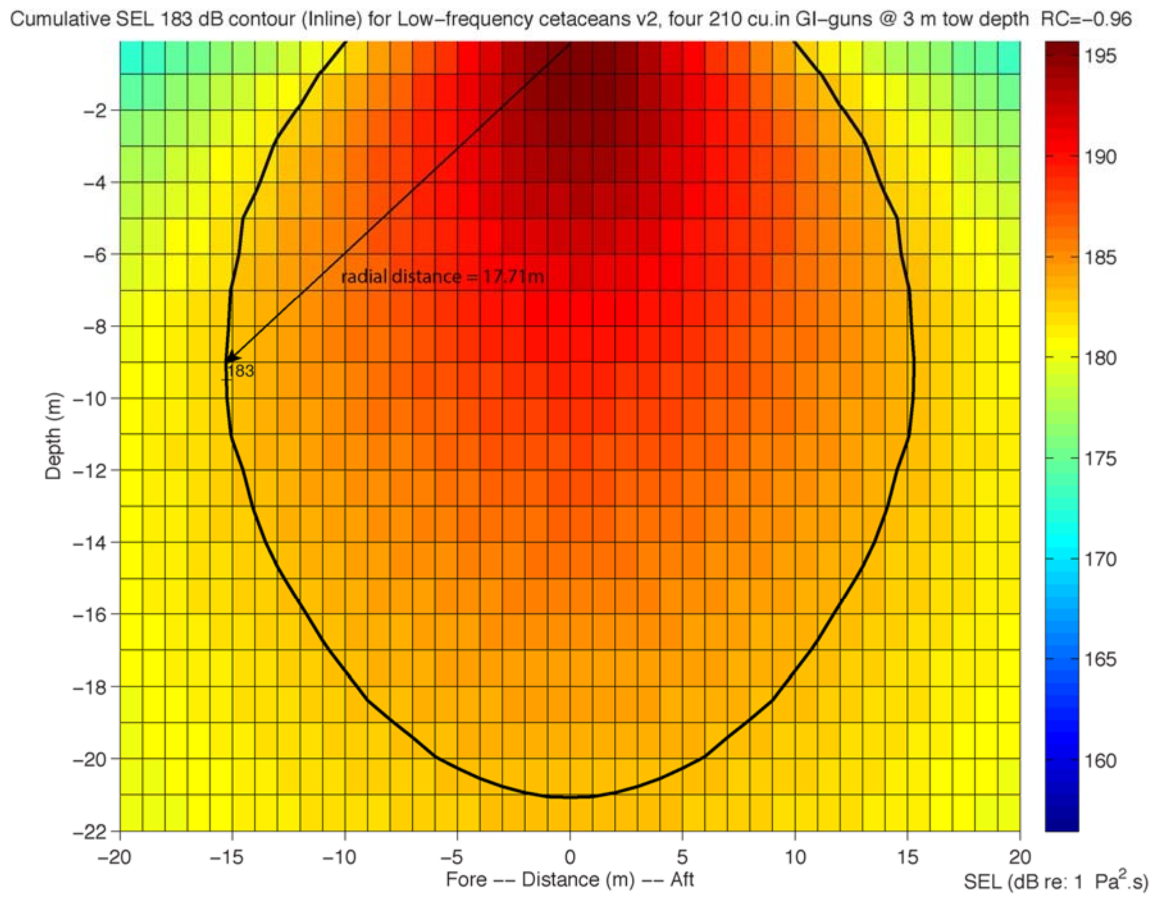

FIGURE C11: Modeled received sound exposure levels (SELs) from the four 210 cu.in GI-guns at a 3-m tow depth, after applying the auditory weighting function for the Low Frequency Cetaceans hearing group following to the new technical guidance. The plot provides the radial distance to the 183-dB SELcum isopleth for one shot. The difference in radial distances between Fig. 4 (39.42 m) and this figure (17.71 m) allows us to estimate the adjustment in dB.

Peak Sound Pressure Level :

TABLE C6. LEVEL A. NMFS Level A acoustic thresholds (Peak SPL_{flat}) for impulsive sources for marine mammals and predicted radial distances to Level A thresholds for various marine mammal hearing groups that could be received from the four 210 cu.in airguns at a 3 m tow depth during the proposed seismic survey in the north western Atlantic Ocean.

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
PK Threshold	219	230	202	218	232
Radius to threshold (meters)	11.56	N/A (0)	80.50	13.04	N/A (0)

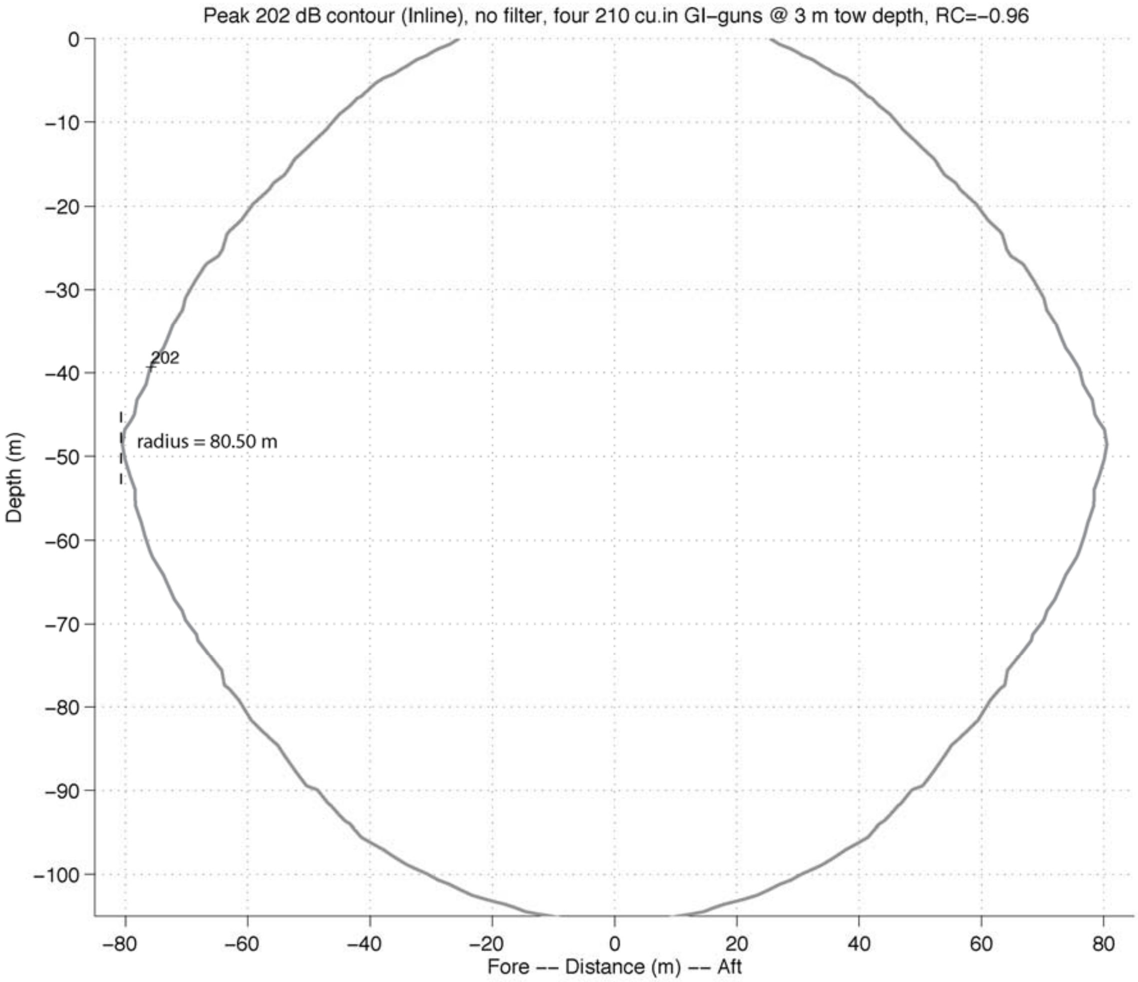

FIGURE C12: Modeled deep-water received Peak SPL from four 210 cu.in airguns at a 3-m tow depth. The plot provides the radius of the 202-dB peak isopleth (80.50 m).

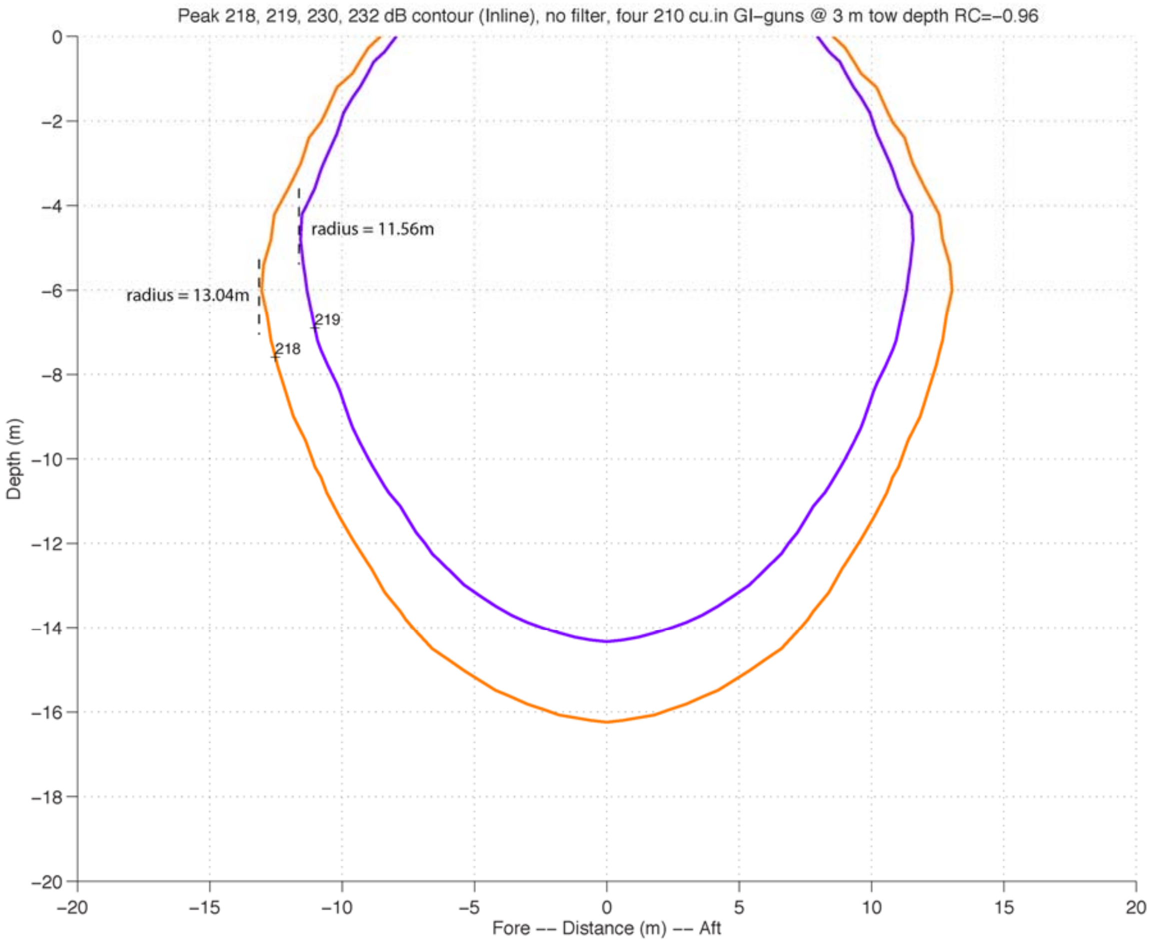

FIGURE C13: Modeled deep-water received Peak SPL from two 210 cu.in airguns at a 3-m tow depth. The plot provides the radius of the 218 and 219 dB peak isopleths.

BACKUP CONFIGURATION

2 x 105 cu.in – 2 m separation aft-fore direction @ 3 m depth

SELcum methodology (spreadsheet – Sivle et al., 2014)

Table C7: Table showing the results for one single SEL SL modeling without and with applying weighting function to the 5 hearing groups. The modified farfield signature is estimated using the distance from the source array geometrical center to where the SELcum threshold is the largest. A propagation of 20 $\log_{10}$ (Radial distance) is used to estimate the modified farfield SEL.

SEL_{cum} Threshold	183	185	155	185	203
Distance(m) (no weighting function)	17.9821	14.5253	459.5354	14.5352	2.2227
Modified Farfield SEL*	208.0968	208.2425	208.2464	208.2425	209.9376
Distance (m) (with weighting function)	9.1754	N/A	N/A	N/A	N/A
Adjustment (dB)	- 5.84	N/A	N/A	N/A	N/A

* Propagation of 20 log R

For the Low Frequency Cetaceans, we estimated a new adjustment value by computing the distance from the geometrical center of the source to where the 183dB SEL cum isopleth is the largest. We first run the modeling for one single shot without applying any weighting function. The maximum 183dB SEL cum isopleth is located at 17.98 m from the source. We then run the modeling for one single shot with the low frequency Cetaceans weighting function applied to the full spectrum. The maximum 183 dB SEL cum isopleth is located at 9.17 m from the source. Difference between 17.98 m and 9.17 m gives an adjustment factor of -5.84 dB assuming a propagation of 20log10(R).

TABLE C8. Results for single shot SEL source level modeling for the two 105 in^3 airguns with weighting function calculations for SEL_{cum} criteria.

F: MOBILE SOURCE: Impulsive, Intermittent (SAFE DISTANCE METHODOLOGY)

VERSION 1.1: Aug-16

KEY	
(green)	Action Proponent Provided Information
(pink)	NMFS Provided Information (Acoustic Guidance)
(blue)	Resultant Isopleth

STEP 1: GENERAL PROJECT INFORMATION

PROJECT TITLE	Carolyn Ruppel -
PROJECT/SOURCE INFORMATION Please include any assumptions	source : SIO portable system = 2 x 105 cu.in GI-gun at a 3m towed depth - (2 m separation in the fore-aft direction)
PROJECT CONTACT	

STEP 2: WEIGHTING FACTOR ADJUSTMENT

Specify if relying on source-specific WFA, alternative weighting/dB adjustment, or if using default value

Weighting Factor Adjustment (kHz)[¥]	User defined	Default used

[¥] Broadband: 95% frequency contour percentile (kHz) OR Narrowband: frequency (kHz); For appropriate default WFA: See INTRODUCTION tab

† If a user relies on alternative weighting/dB adjustment rather than relying upon the WFA (source-specific or default), they may override the Adjustment (dB) (row 62), and enter the new value directly. However, they must provide additional support and documentation supporting this modification.

*** BROADBAND Sources: Cannot use WFA higher than maximum applicable frequency (See GRAY tab for more information on WFA applicable frequencies)**

STEP 3: SOURCE-SPECIFIC INFORMATION

NOTE: Choose either F1 OR F2 method to calculate isopleths (not required to fill in sage boxes for both)

NOTE: LDEO modeling relies on Method F2

F2: ALTERNATIVE METHOD† TO CALCULATE PK and SEL_{cum} (SINGLE STRIKE/SHOT/PULSE EQUIVALENT)

SEL_{cum}

Source Velocity (meters/second)	2.05778
1/Repetition rate^ (seconds)	12.149

†Methodology assumes propagation of 20 log R; Activity duration (time) independent

^Time between onset of successive pulses.

Modified farfield SEL	**208.0968**	**208.2425**	**208.2464**	**208.2425**	**209.9376**
Source Factor	**5.31055E+19**	**5.49173E+19**	**5.49667E+19**	**5.49173E+19**	**8.11371E+19**

RESULTANT ISOPLETHS*

*Impulsive sounds have dual metric thresholds (SELcum & PK). Metric producing largest isopleth should be used.

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
SEL_{cum} Threshold	183	185	155	185	203
PTS SEL_{cum} Isopleth to threshold (meters)	**10.6**	**0.0**	**0.0**	**0.1**	**0.0**

WEIGHTING FUNCTION CALCULATIONS

Weighting Function Parameters	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
a	1	1.6	1.8	1	2
b	2	2	2	2	2
f_1	0.2	8.8	12	1.9	0.94
f_2	19	110	140	30	25
C	0.13	1.2	1.36	0.75	0.64
Adjustment (dB)†	-5.84	-53.99	-63.14	-23.74	-29.82

OVERIDE Using LDEO Modeling

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
SEL_{cum} Threshold	183	185	155	185	203
PTS SEL_{cum} Isopleth to threshold (meters)	10.6	0.0	0.0	0.1	0.0

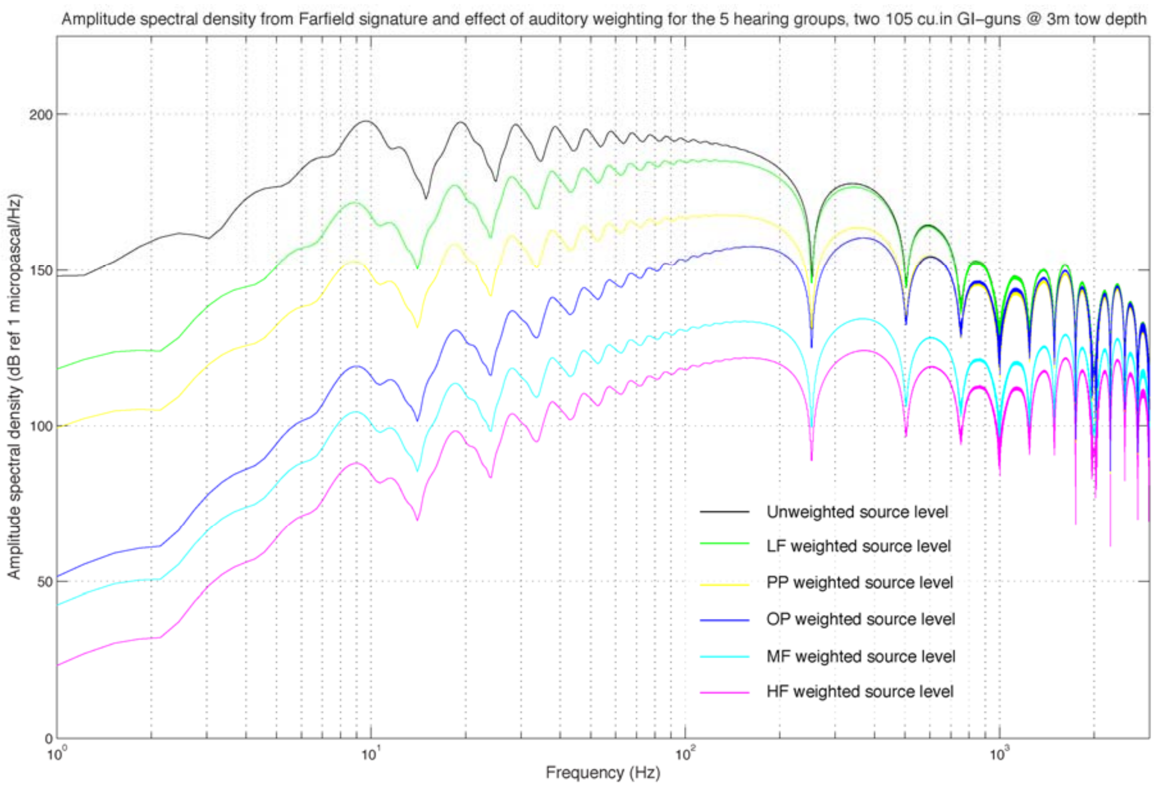

FIGURE C14: Modeled amplitude spectral density of the two 105 cu.in airgun farfield signature. Amplitude spectral density before (black) and after (green, yellow, blue, cyan, magenta) applying the auditory weighting function for the Low Frequency Cetaceans, Phocid Pinnipeds, Otariid Pinnipeds, Mid Frequency Cetaceans, High Frequency Cetaceans, respectively. Modeled spectral levels in micropascals are used to calculate the difference between the un-weighted and weighted source level at each frequency and to derive the adjustment factors for the Phocid Pinnipeds, Otariid Pinnipeds, Mid Frequency Cetaceans, and High Frequency Cetaceans as inputs into the NMFS user spreadhseet.

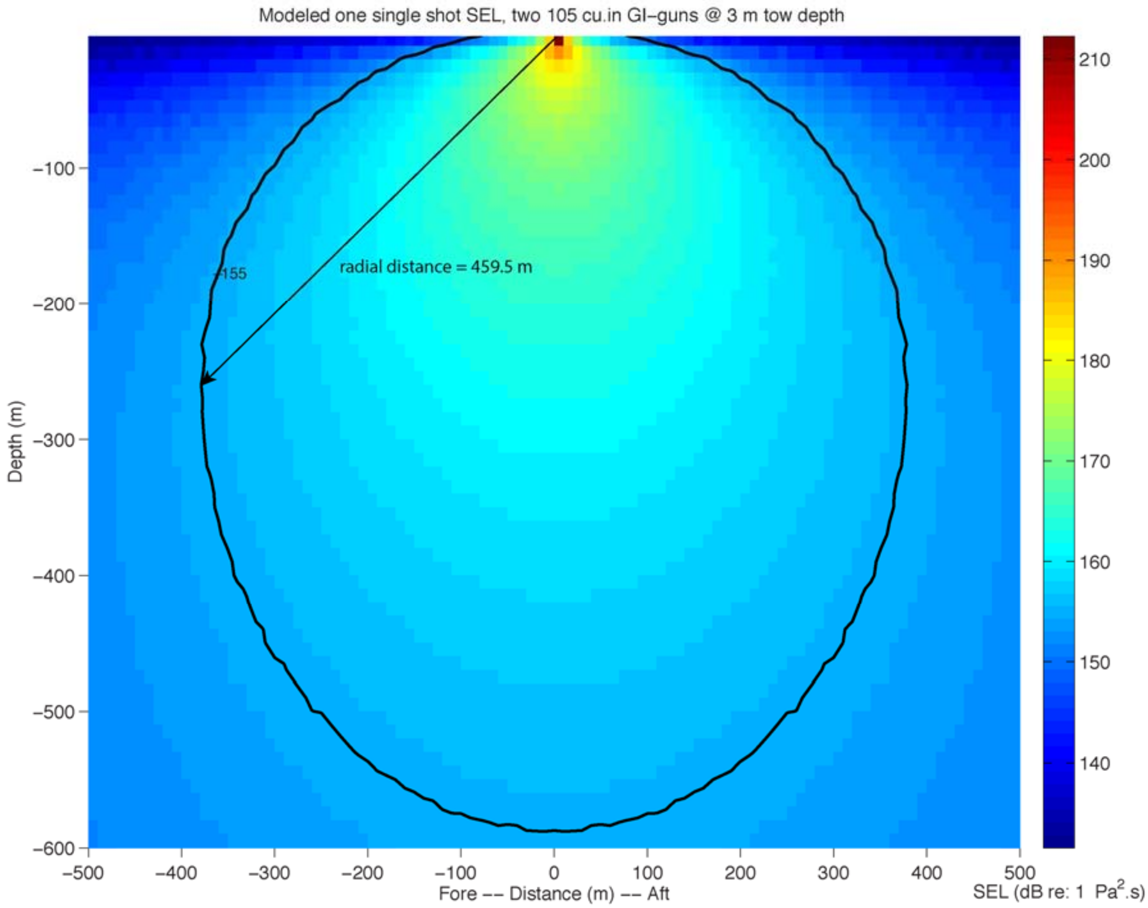

FIGURE C15: Modeled received sound levels (SELs) in deep water from the two 105 cu.in GI-guns at a 3-m tow depth. The plot provides the distance from the geometrical center of the source array to the 155-dB SEL isopleth (459.5 m).

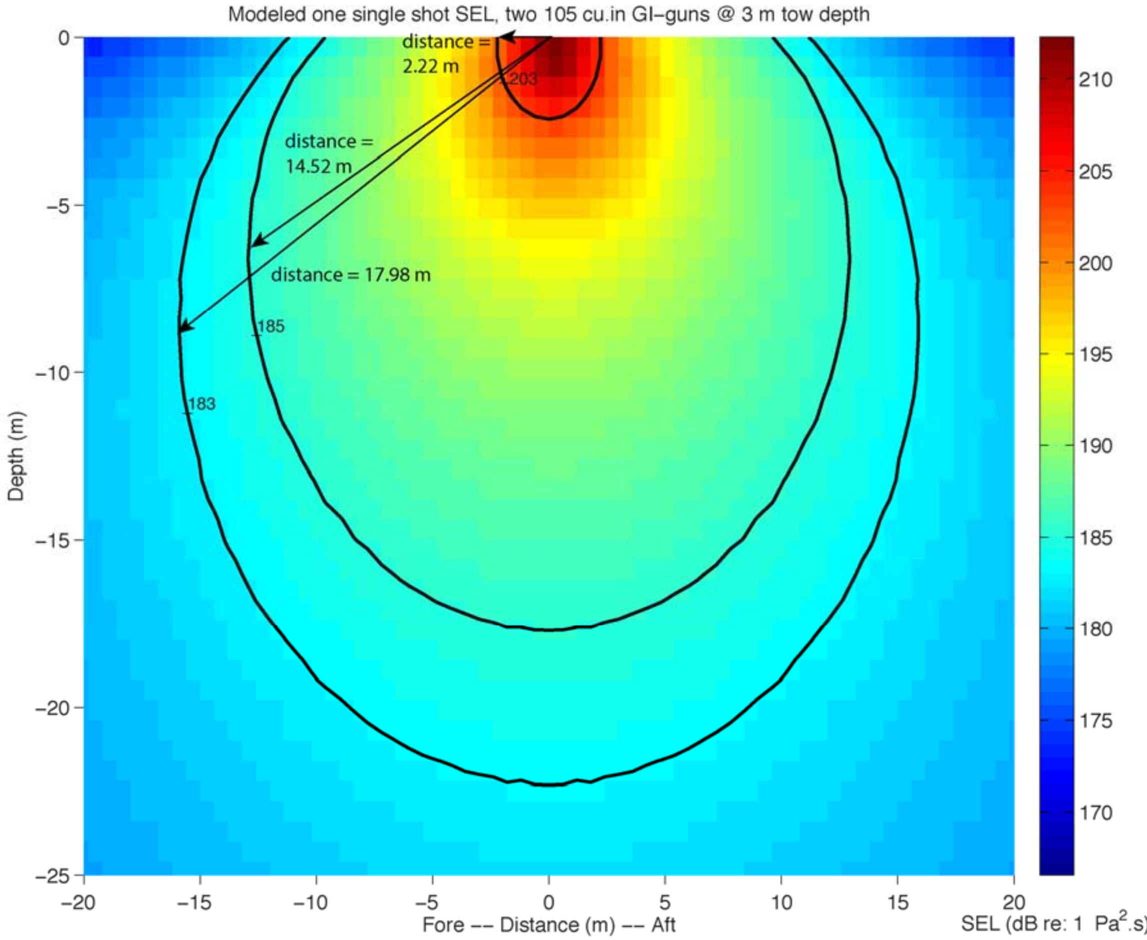

FIGURE C16: Modeled received sound levels (SELs) in deep water from the two 105 cu.in GI-guns at a 3-m tow depth. The plot provides the distance from the geometrical center of the source array to the 183 and 185 dB SEL isopleths

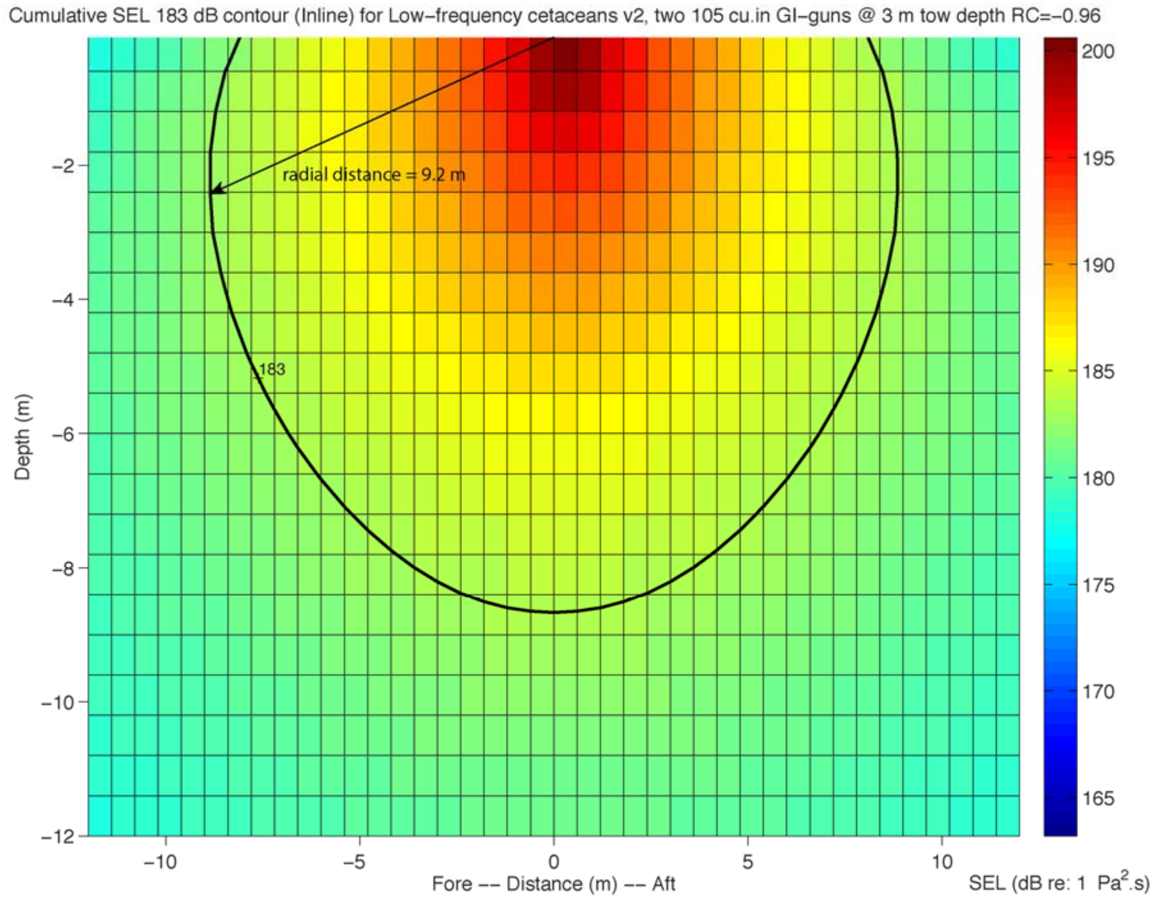

FIGURE C17: Modeled received sound exposure levels (SELs) from the two 105 cu.in GI-guns at a 3-m tow depth, after applying the auditory weighting function for the Low Frequency Cetaceans hearing group following to the new technical guidance. The plot provides the radial distance to the 183-dB SELcum isopleth for one shot. The difference in radial distances between Fig. 4 (17.98 m) and this figure (9.17 m) allows us to estimate the adjustment in dB.

Peak Sound Pressure Level :

TABLE C9. LEVEL A. NMFS Level A acoustic thresholds (Peak SPL_{flat}) for impulsive sources for marine mammals and predicted radial distances to Level A thresholds for various marine mammal hearing groups that could be received from the two 105 cu.in airguns at a 3 m tow depth during the proposed seismic survey in the north western Atlantic Ocean.

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
PK Threshold	219	230	202	218	232
Radius to threshold (meters)	6.52	1.58	42.32	7.31	1.08

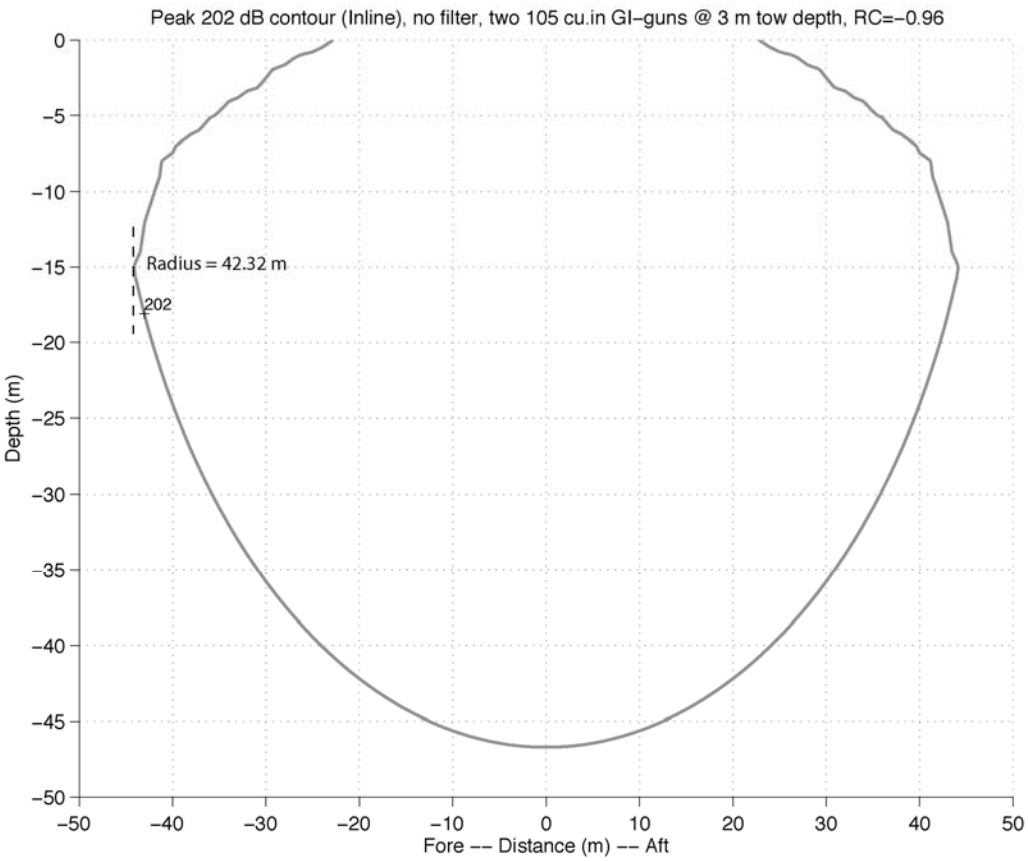

FIGURE C18: Modeled deep-water received Peak SPL from two 105 cu.in airguns at a 3-m tow depth. The plot provides the radius of the 202-dB peak isopleth (44.14 m).

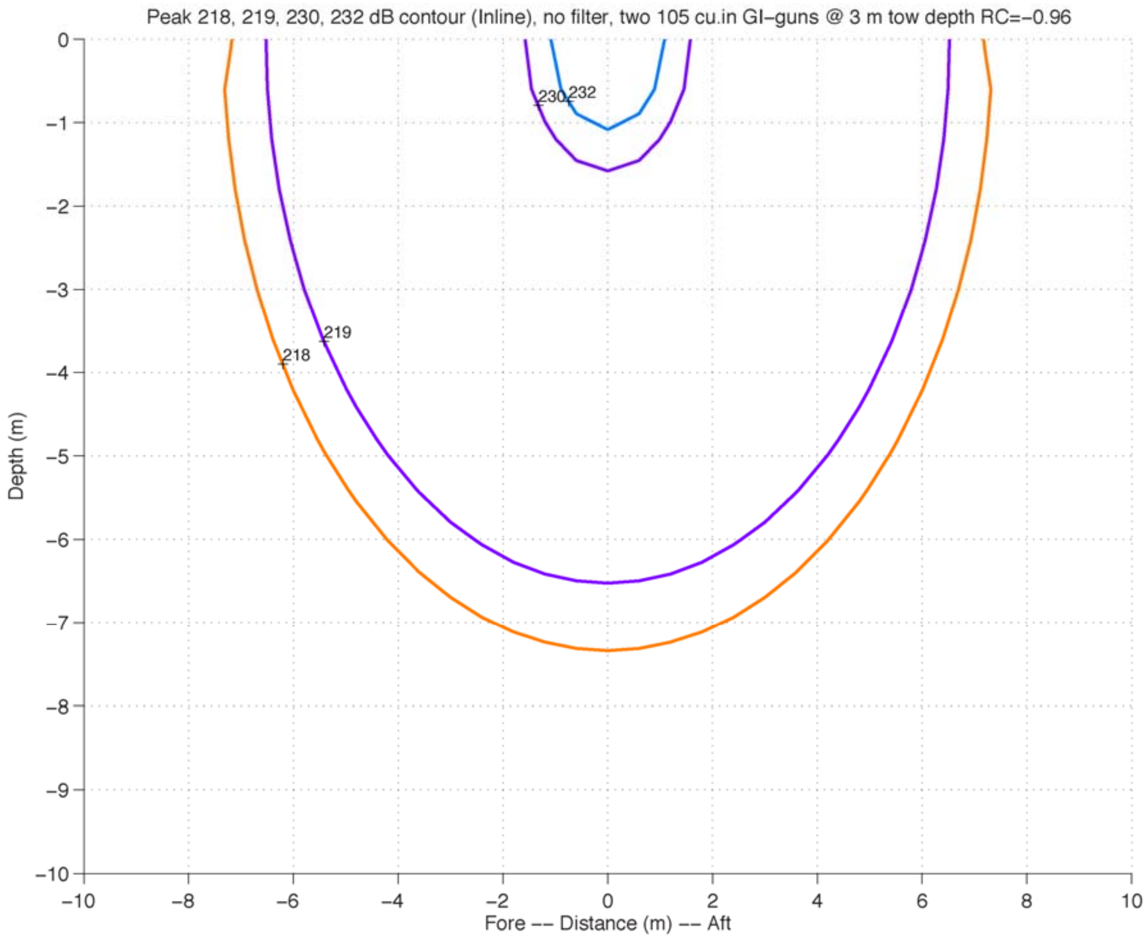

FIGURE C19: Modeled deep-water received Peak SPL from two 105 cu.in airguns at a 3-m tow depth. The plot provides the radius of the 218-219-230 and 232 dB peak isopleths.

Summary Tables for PTS SEL_{cum} and Peak SPL_{flat}.

Table C10. PTS SEL_{cum} isopleth to threshold in meters (*italics*) for each source configuration and hearing group, as calculated using the NMFS spreadsheet.

	Hearing Group		
	Low-Frequency Cetaceans	**Mid-Frequency Cetaceans**	**High-Frequency Cetaceans**
SEL_{cum} Threshold	183 dB	185 dB	155 dB
Base Configuration	*31.0 m*	*0.0*	*0.0*
GG Configuration	*39.5 m*	*0.0*	*0.1 m*
Backup Configuration	*10.6 m*	*0.0*	*0.0*

TABLE C11. SUMMARY LEVEL A. NMFS Level A acoustic thresholds (Peak SPL_{flat}) for impulsive sources and predicted radial distances to Level A thresholds in meters for the three source configurations.

	Hearing Group		
	Low-Frequency Cetaceans	**Mid-Frequency Cetaceans**	**High-Frequency Cetaceans**
PK Threshold	219 dB	230 dB	202 dB
Base configuration	*10.03 m*	*N/A (0)*	*70.426 m*
GG configuration	*11.56 m*	*N/A (0)*	*80.50 m*
Backup configuration	*6.52 m*	*1.58 m*	*42.32 m*

Appendix D: Affected Environment Text

As noted above, this section is taken verbatim from the Draft Scripps EA (2017) and has been incorporated by reference. It is reproduced here only for the sake of completeness.

Summary Effects of Airguns on Marine Mammals and Turtles (Section IV.1.a)

As noted in the NSF-USGS PEIS (§ 3.4.4.3, § 3.6.4.3, § 3.7.4.3, § 3.8.4.3), the effects of sounds from airguns could include one or more of the following: tolerance, masking of natural sounds, behavioral disturbance, and at least in theory, temporary or permanent hearing impairment, or non-auditory physical or physiological effects (e.g., Richardson et al. 1995; Gordon et al. 2004; Nowacek et al. 2007; Southall et al. 2007; Erbe 2012; Peng et al. 2015; Erbe et al. 2016; Kunc et al. 2016; National Academies of Sciences, Engineering, and Medicine 2017). In some cases, a behavioral response to a sound can reduce the overall exposure to that sound (e.g., Finneran et al. 2015; Wensveen et al. 2015).

Permanent hearing impairment (PTS), in the unlikely event that it occurred, would constitute injury, but temporary threshold shift (TTS) is not considered an injury (Southall et al. 2007; Le Prell 2012). Rather, the onset of TTS has been considered an indicator that, if the animal is exposed to higher levels of that sound, physical damage is ultimately a possibility. Nonetheless, research has shown that sound exposure can cause cochlear neural degeneration, even when threshold shifts and hair cell damage are reversible (Kujawa and Liberman 2009; Liberman 2016). These findings have raised some doubts as to whether TTS should continue to be considered a non-injurious effect (Weilgart 2014; Tougaard et al. 2015, 2016). Although the possibility cannot be entirely excluded, it is unlikely that the proposed surveys would result in any cases of temporary or permanent hearing impairment, or any significant non-auditory physical or physiological effects. If marine mammals encounter a survey while it is underway, some behavioral disturbance could result, but this would be localized and short-term.

Tolerance.—Numerous studies have shown that pulsed sounds from airguns are often readily detectable in the water at distances of many kilometers (e.g., Nieukirk et al. 2012). Several studies have shown that marine mammals at distances more than a few kilometers from operating seismic vessels often show no apparent response. That is often true even in cases when the pulsed sounds must be readily audible to the animals based on measured received levels and the hearing sensitivity of that mammal group. Although various baleen and toothed whales, and (less frequently) pinnipeds have been shown to react behaviorally to airgun pulses under some conditions, at other times mammals of all three types have shown no overt reactions. The relative responsiveness of baleen and toothed whales are quite variable.

***Masking*.—**Masking effects of pulsed sounds (even from large arrays of airguns) on marine mammal calls and other natural sounds are expected to be limited, although there are few specific data on this. Because of the intermittent nature and low duty cycle of seismic pulses, animals can emit and receive sounds in the relatively quiet intervals between pulses. However, in exceptional situations, reverberation occurs for much or all of the interval between pulses (e.g., Simard et al. 2005; Clark and Gagnon 2006), which could mask calls. Situations with prolonged strong reverberation are infrequent. However, it is common for reverberation to cause some lesser degree of elevation of the background level between airgun pulses (e.g., Gedamke 2011; Guerra et al. 2011, 2016; Klinck et al. 2012; Guan et al. 2015), and this weaker reverberation presumably reduces the detection range of calls and other natural sounds to some degree. Guerra et al. (2016) reported that ambient noise levels between seismic pulses were elevated as a result of reverberation at ranges of 50 km from the seismic source. Based on measurements in deep water of the Southern Ocean, Gedamke (2011) estimated that the slight elevation of background levels during intervals between pulses reduced blue and fin whale communication space by as much as 36–51% when a seismic survey was operating 450–2800 km away. Based on preliminary modeling, Wittekind et al. (2016) reported that airgun sounds could reduce the communication range of blue and fin whales at a distance of 2000 km from the seismic source. Nieukirk et al. (2012) and Blackwell et al. (2013) noted the potential for masking effects from seismic surveys on large whales.

Some baleen and toothed whales are known to continue calling in the presence of seismic pulses, and their calls usually can be heard between the pulses (e.g., Nieukirk et al. 2012; Thode et al. 2012; Bröker et al. 2013; Sciacca et al. 2016). Cerchio et al. (2014) suggested that the breeding display of humpback whales off Angola could be disrupted by seismic sounds, as singing activity declined with increasing received levels. In addition, some cetaceans are known to change their calling rates, shift their peak frequencies, or otherwise modify their vocal behavior in response to airgun sounds (e.g., Di Iorio and Clark 2010; Castellote et al. 2012; Blackwell et al. 2013, 2015). The hearing systems of baleen whales are undoubtedly more sensitive to low-frequency sounds than are the ears of the small odontocetes that have been studied directly (e.g., MacGillivray et al. 2014). The sounds important to small odontocetes are predominantly at much higher frequencies than are the dominant components of airgun sounds, thus limiting the potential for masking. In general, masking effects of seismic pulses are expected to be minor, given the normally intermittent nature of seismic pulses. Sills et al. (2017) reported that recorded airguns sounds masked the detection of low-frequency sounds by ringed and spotted seals, especially at the onset of the airgun pulse when signal amplitude was variable. We are not aware of any information concerning masking of hearing in sea turtles.

Disturbance Reactions.—Disturbance includes a variety of effects, including subtle to conspicuous changes in behavior, movement, and displacement. Based on NMFS (2001, p. 9293), National Research Council (NRC 2005), and Southall et al. (2007), we believe that simple exposure to sound, or brief reactions that do not disrupt behavioral patterns in a potentially significant manner, do not constitute harassment or "taking". By potentially significant, we mean, 'in a manner that might have deleterious effects to the well-being of individual marine mammals or their populations'.

Reactions to sound, if any, depend on species, state of maturity, experience, current activity, reproductive state, time of day, and many other factors (Richardson et al. 1995; Wartzok et al. 2004; Southall et al. 2007; Weilgart 2007; Ellison et al. 2012). 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, let alone the stock or population (e.g., New et al. 2013a). 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 (Lusseau and Bejder 2007; Weilgart 2007; New et al. 2013b; Nowacek et al. 2015; Forney et al. 2017). Some studies have attempted modeling to assess consequences of effects from underwater noise at the population level (e.g., New et al. 2013b; King et al. 2015; Costa et al. 2016a,b; Ellison et al. 2016; Harwood et al. 2016; Nowacek et al. 2016; Farmer et al. 2017). Various authors have noted that some marine mammals that show no obvious avoidance or behavioral changes may still be adversely affected by sound (e.g., Weilgart 2007; Wright et al. 2011; Gomez et al. 2016).

Given the many uncertainties in predicting the quantity and types of impacts of noise on marine mammals, it is common practice to estimate how many marine mammals would be present within a particular distance of industrial activities and/or exposed to a particular level of industrial sound. In most cases, this approach likely overestimates the numbers of marine mammals that would be affected in some biologically important manner.

The sound criteria used to estimate how many marine mammals could be disturbed to some biologically important degree by a seismic program are based primarily on behavioral observations of a few species. Detailed studies have been done on humpback, gray, bowhead, and sperm whales. Less detailed data are available for some other species of baleen whales and small toothed whales, but for many species, there are no data on responses to marine seismic surveys.

Baleen Whales

Baleen whales generally tend to avoid operating airguns, but avoidance radii are quite variable. Whales are often reported to show no overt reactions to pulses from large arrays of airguns at distances beyond a few kilometers, even though the airgun pulses remain well above ambient noise levels out to much longer distances. However, baleen whales exposed to strong noise pulses from airguns often react by deviating from their normal migration route and/or interrupting their feeding and moving away. In the cases of migrating gray and bowhead whales, the observed changes in behavior appeared to be of little or no biological consequence to the animals. They simply avoided the sound source by displacing their migration route to varying degrees, but within the natural boundaries of the migration corridors (Malme et al. 1984; Malme and Miles 1985; Richardson et al. 1995).

Responses of *humpback whales* to seismic surveys have been studied during migration, on summer feeding grounds, and on Angolan winter breeding grounds; there has also been discussion of effects on the Brazilian wintering grounds. Off Western Australia, avoidance reactions began at 5–8 km from the array, and those reactions kept most pods ~3–4 km from the operating seismic vessel; there was localized displacement during migration of 4–5 km by traveling pods and 7–12 km by more sensitive resting pods of cow-calf pairs (McCauley et al. 1998, 2000). However, some individual humpback whales, especially males, approached within distances of 100–400 m.

More recent studies examining the behavioral responses of humpback whales to airguns have also been conducted off eastern Australia (Cato et al. 2011, 2012, 2013, 2016), although results are not yet available for all studies. Dunlop et al. (2015) reported that humpback whales responded to a vessel operating a 20 in^3 airgun by decreasing their dive time and speed of southward migration; however, the same responses were obtained during control trials without an active airgun, suggesting that humpbacks responded to the source vessel rather than the airgun. A ramp up was not superior to triggering humpbacks to move away from the vessel compared with a constant source at a higher level of 140 in^3, although an increase in distance from the airgun array was noted for both sources (Dunlop et al. 2016a). Avoidance was also shown when no airguns were operational, indicating that the presence of the vessel itself had an effect on the response (Dunlop et al. 2016a,b). Responses to ramp up and use of a 3130 in^3 array elicited greater behavioral changes in humpbacks when compared with small arrays (Dunlop et al. 2016c). Overall, the results showed that humpbacks were more likely to avoid active airgun arrays (of 20 and 140 in^3) within 3 km and at levels of at least 140 dB re 1 $\mu Pa^2 \cdot s$ (Dunlop et al. 2017). These results are consistent with earlier studies (e.g., McCauley et al. 2000). Although there was no clear evidence of avoidance by humpbacks on their summer feeding grounds in southeast Alaska, there were subtle behavioral effects at distance up to 3.2 km and received levels of 150 to 172 re 1 µPa on an approximate rms basis (Malme et al. 1985).

In the northwest Atlantic, sighting rates were significantly greater during non-seismic periods compared with periods when a full array was operating, and humpback whales were more likely to swim away and less likely to swim towards a vessel during seismic vs. non-seismic periods (Moulton and Holst 2010). In contrast, sightings of humpback whales from seismic vessels off the U.K. during 1994–2010 indicated that detection rates were similar during seismic and non-seismic periods, although sample sizes were small (Stone 2015). It has been suggested that South Atlantic humpback whales wintering off Brazil may be displaced or even strand upon exposure to seismic surveys (Engel et al. 2004), but data from subsequent years indicated that there was no observable direct correlation between strandings and seismic surveys (IWC 2007).

There are no data on reactions of *right whales* to seismic surveys. However, Rolland et al. (2012) suggested that ship noise causes increased stress in right whales; they showed that baseline levels of stress-related faecal hormone metabolites decreased in North Atlantic right whales with a 6-dB decrease in underwater noise from vessels. Wright et al. (2011), Bain et al. (2015), Houser et al. (2016), and Lyamin et al. (2016) also reported that sound could be a potential source of stress for marine mammals.

Bowhead whales show that their responsiveness can be quite variable depending on their activity (migrating vs. feeding). Bowhead whales migrating west across the Alaskan Beaufort Sea in autumn, in particular, are unusually responsive, with substantial avoidance occurring out to distances of 20–30 km from a medium-sized airgun source (Miller et al. 1999; Richardson et al. 1999). Subtle but statistically significant changes in surfacing–respiration–dive cycles were shown by traveling and socializing bowheads exposed to airgun sounds in the Beaufort Sea, including shorter surfacings, shorter dives, and decreased number of blows per surfacing (Robertson et al. 2013). More recent research on bowhead whales corroborates earlier evidence that, during the summer feeding season, bowheads are less responsive to seismic sources (e.g., Miller et al. 2005; Robertson et al. 2013).

Bowhead whale calls detected in the presence and absence of airgun sounds have been studied extensively in the Beaufort Sea. Bowheads continue to produce calls of the usual types when exposed to airgun sounds on their summering grounds, although numbers of calls detected are significantly lower in the presence than in the absence of airgun pulses (Blackwell et al. 2013, 2015). Blackwell et al. (2013) reported that calling rates in 2007 declined significantly where received SPLs from airgun sounds were 116–129 dB re 1 µPa; at SPLs <108 dB re 1 µPa, calling rates were not affected. When data for 2007–2010 were analyzed, Blackwell et al. (2015) reported an initial increase in calling rates when airgun pulses became detectable; however, calling rates leveled off at a received $CSEL_{10\text{-}min}$ (cumulative SEL over a 10-min period) of ~94 dB re 1 $\mu Pa^2 \cdot s$, decreased at $CSEL_{10\text{-}min}$ >127 dB re 1 $\mu Pa^2 \cdot s$, and whales were nearly silent at $CSEL_{10\text{-}min}$ >160 dB re 1 $\mu Pa^2 \cdot s$. Thus, bowhead whales in the Beaufort Sea apparently decreased their calling rates in response to seismic operations, although movement out of the area could also have contributed to the lower call detection rate (Blackwell et al. 2013, 2015).

A multivariate analysis of factors affecting the distribution of calling bowhead whales during their fall migration in 2009 noted that the southern edge of the distribution of calling whales was significantly closer to shore with increasing levels of airgun sound from a seismic survey a few hundred kilometers to the east of the study area (i.e., behind the westward-migrating whales; McDonald et al. 2010, 2011). It was not known whether this statistical effect represented a stronger tendency for quieting of the whales farther offshore in deeper water upon exposure to airgun sound, or an actual inshore displacement of whales.

There was no indication that *western gray whales* exposed to seismic sound were displaced from their overall feeding grounds near Sakhalin Island during seismic programs in 1997 (Würsig et al. 1999) or 2001 (Johnson et al. 2007; Meier et al. 2007; Yazvenko et al. 2007a). However, there were indications of subtle behavioral effects among whales that remained in the areas exposed to airgun sounds (Würsig et al. 1999; Gailey et al. 2007; Weller et al. 2006a) and localized redistribution of some individuals within the nearshore feeding ground so as to avoid close approaches by the seismic vessel (Weller et al. 2002, 2006b; Yazvenko et al. 2007a). Despite the evidence of subtle changes in some quantitative measures of behavior and local redistribution of some individuals, there was no apparent change in the frequency of feeding, as evident from mud plumes visible at the surface (Yazvenko et al. 2007b).

Similarly, no large changes in gray whale movement, respiration, or distribution patterns were observed during seismic programs conducted in 2010 (Bröker et al. 2015; Gailey et al. 2016). Although sighting distances of gray whales from shore increased slightly during a 2-week seismic survey, this result was not significant (Muir et al. 2015). However, there may have been a possible localized avoidance response to high sound levels in the area (Muir et al. 2016). The lack of strong avoidance or other strong responses during the 2001 and 2010 programs was presumably in part a result of the comprehensive combination of real-time monitoring and mitigation measures designed to avoid exposing western gray whales to received SPLs above ~163 dB re 1 µPa$_{rms}$ (Johnson et al. 2007; Nowacek et al. 2012, 2013b). In contrast, preliminary data collected during a seismic program in 2015 showed some displacement of animals from the feeding area and responses to lower sound levels than expected (Gailey et al. 2017; Sychenko et al. 2017).

Gray whales in British Columbia exposed to seismic survey sound levels up to ~170 dB re 1 µPa did not appear to be strongly disturbed (Bain and Williams 2006). The few whales that were observed moved away from the airguns but toward deeper water where sound levels were said to be higher due to propagation effects (Bain and Williams 2006).

Various species of *Balaenoptera* (blue, sei, fin, and minke whales) have occasionally been seen in areas ensonified by airgun pulses. Sightings by observers on seismic vessels using large arrays off the U.K. from 1994 to 2010 showed that the detection rate for minke whales was significantly higher when airguns were not operating; however, during surveys with small arrays, the detection rates for minke whales were similar during seismic and non-seismic periods (Stone 2015). Sighting rates for fin and sei whales were similar when large arrays of airguns were operating vs. silent (Stone 2015). All baleen whales combined tended to exhibit localized avoidance, remaining significantly farther (on average) from large arrays (median closest point of approach or CPA of ~1.5 km) during seismic operations compared with non-seismic periods (median CPA ~1.0 km; Stone 2015). In addition, fin and minke whales were more often oriented away from the vessel while a large airgun array was active compared with periods of inactivity (Stone 2015). Singing fin whales in the Mediterranean moved away from an operating airgun array, and their song notes had lower bandwidths during periods with vs. without airgun sounds (Castellote et al. 2012).

During seismic surveys in the northwest Atlantic, baleen whales as a group showed localized avoidance of the operating array (Moulton and Holst 2010). Sighting rates were significantly lower during seismic operations compared with non-seismic periods. Baleen whales were seen on average 200 m farther from the vessel during airgun activities vs. non-seismic periods, and these whales more often swam away from the vessel when seismic operations were underway compared with periods when no airguns were operating (Moulton and Holst 2010). Blue whales were seen significantly farther from the vessel during single airgun operations, ramp up, and all other airgun operations compared with non-seismic periods (Moulton and Holst 2010). Similarly, fin whales were seen at significantly farther distances during ramp up than during periods without airgun operations; there was also a trend for fin whales to be sighted farther from the vessel during other airgun operations, but the difference was not significant (Moulton and Holst 2010). Minke whales were seen significantly farther from the vessel during periods with than without seismic operations (Moulton and Holst 2010). Minke whales were also more likely to swim away and less likely to approach during seismic operations compared to periods when airguns were not operating (Moulton and Holst 2010). However, Matos (2015) reported no change in sighting rates of minke whales in Vestfjorden, Norway, during ongoing seismic surveys outside of the fjord. Vilela et al. (2016) cautioned that environmental conditions should be taken into account when comparing sighting rates during seismic surveys, as spatial modeling showed that differences in sighting rates of rorquals (fin and minke whales) during seismic periods and non-seismic periods during a survey in the Gulf of Cadiz could be explained by environmental variables.

Data on short-term reactions by cetaceans to impulsive noises are not necessarily indicative of long-term or biologically significant effects. It is not known whether impulsive sounds affect reproductive rate or distribution and habitat use in subsequent days or years. However, gray whales have continued to migrate annually along the west coast of North America with substantial increases in the population over recent years, despite intermittent seismic exploration (and much ship traffic) in that area for decades. In addition, bowhead whales have continued to travel to the eastern Beaufort Sea each summer, and their numbers have increased notably, despite seismic exploration in their summer and autumn range for many years.

Toothed Whales

Little systematic information is available about reactions of toothed whales to sound pulses. However, there are recent systematic studies on sperm whales, and there is an increasing amount of information about responses of various odontocetes to seismic surveys based on monitoring studies. Seismic operators and protected species observers on seismic vessels regularly see dolphins and other small toothed whales near operating airgun arrays, but in general there is a tendency for most delphinids to show some avoidance of operating seismic vessels (e.g., Stone and Tasker 2006; Moulton and Holst 2010; Barry et al. 2012; Wole and Myade 2014; Stone 2015; Monaco et al. 2016). In most cases, the avoidance radii for delphinids appear to be small, on the order of 1 km or less, and some individuals show no apparent avoidance.

Observations from seismic vessels using large arrays off the U.K. from 1994–2010 indicated that detection rates were significantly higher for killer whales, white-beaked dolphins, and Atlantic white-sided dolphins when airguns were not operating; detection rates during seismic vs. non-seismic periods were similar during seismic surveys using small arrays (Stone 2015). Detection rates for long-finned pilot whales, Risso's dolphins, bottlenose dolphins, and short-beaked common dolphins were similar during seismic (small or large array) vs. non-seismic operations (Stone 2015). CPA distances for killer whales, white-beaked dolphins, and Atlantic white-sided dolphins were significantly farther (>0.5 km) from large airgun arrays during periods of airgun activity compared with periods of inactivity, with significantly more animals traveling away from the vessel during airgun operation (Stone 2015). Observers' records suggested that fewer cetaceans were feeding and fewer delphinids were interacting with the survey vessel (e.g., bow-riding) during periods with airguns operating (Stone 2015).

During seismic surveys in the northwest Atlantic, delphinids as a group showed some localized avoidance of the operating array (Moulton and Holst 2010). The mean initial detection distance was significantly farther (by ~200 m) during seismic operations compared with periods when the seismic source was not active; however, there was no significant difference between sighting rates (Moulton and Holst 2010). The same results were evident when only long-finned pilot whales were considered.

Preliminary findings of a monitoring study of *narwhals* in Melville Bay, Greenland (summer and fall 2012) showed no short-term effects of seismic survey activity on narwhal distribution, abundance, migration timing, and feeding habits (Heide-Jørgensen et al. 2013a). In addition, there were no reported effects on narwhal hunting. These findings do not seemingly support a suggestion by Heide-Jørgensen et al. (2013b) that seismic surveys in Baffin Bay may have delayed the migration timing of narwhals, thereby increasing the risk of narwhals to ice entrapment.

The beluga, however, is a species that (at least at times) shows long-distance (10s of km) avoidance of seismic vessels (e.g., Miller et al. 2005). Captive bottlenose dolphins and beluga whales exhibited changes in behavior when exposed to strong pulsed sounds similar in duration to those typically used in seismic surveys, but the animals tolerated high received levels of sound before exhibiting aversive behaviors (e.g., Finneran et al. 2000, 2002, 2005). Schlundt et al. (2016) also reported that bottlenose dolphins exposed to multiple airgun pulses exhibited some anticipatory behavior.

Most studies of *sperm whales* exposed to airgun sounds indicate that the sperm whale shows considerable tolerance of airgun pulses; in most cases the whales do not show strong avoidance (e.g., Stone and Tasker 2006; Moulton and Holst 2010). However, foraging behavior can be altered upon exposure to airgun sound (e.g., Miller et al. 2009) which, according to Farmer et al. (2017), could have significant consequences on individual fitness. Based on data collected by observers on seismic vessels off the U.K. from 1994–2010, detection rates for sperm whales were similar when large arrays of airguns were operating vs. silent; however, during surveys with small arrays, the detection rate was significantly higher when the airguns were not in operation (Stone 2015). Preliminary data from the Gulf of Mexico show a correlation between reduced sperm whale acoustic activity during periods with airgun operations (Sidorovskaia et al. 2014).

There are almost no specific data on the behavioral reactions of *beaked whales* to seismic surveys. Most beaked whales tend to avoid approaching vessels of other types (e.g., Würsig et al. 1998) and/or change their behavior in response to sounds from vessels (e.g., Pirotta et al. 2012). Thus, it is likely that most beaked whales would also show strong avoidance of an approaching seismic vessel. Observations from seismic vessels off the U.K. from 1994–2010 indicated that detection rates of beaked whales were significantly higher (p<0.05) when airguns were not operating vs. when a large array was in operation, although sample sizes were small (Stone 2015). Some northern bottlenose whales remained in the general area and continued to produce high-frequency clicks when exposed to sound pulses from distant seismic surveys (e.g., Simard et al. 2005).

The limited available data suggest that *harbor porpoises* show stronger avoidance of seismic operations than do Dall's porpoises. Based on data collected by observers on seismic vessels off the U.K. from 1994–2010, detection rates of harbor porpoises were significantly higher when airguns were silent vs. when large or small arrays were operating (Stone 2015). In addition, harbor porpoises were seen farther away from the array when it was operating vs. silent, and were most often seen traveling away from the airgun array when it was in operation (Stone 2015). Thompson et al. (2013) reported decreased densities and reduced acoustic detections of harbor porpoise in response to a seismic survey in Moray Firth, Scotland, at ranges of 5–10 km (SPLs of 165–172 dB re 1 µPa, SELs of 145–151 dB $\mu Pa^2 \cdot s$). For the same survey, Pirotta et al. (2014) reported that the probability of recording a porpoise buzz decreased by 15% in the ensonified area, and that the probability was positively related to the distance from the seismic ship; the decreased buzzing occurrence may indicate reduced foraging efficiency. Nonetheless, animals returned to the area within a few hours (Thompson et al. 2013). Kastelein et al. (2013a) reported that a harbor porpoise showed no response to an impulse sound with an SEL below 65 dB, but a 50% brief response rate was noted at an SEL of 92 dB and an SPL of 122 dB re 1 $\mu Pa_{0\text{-peak}}$. However, Kastelein et al. (2012a) reported a 50% detection threshold at a SEL of 60 dB to a similar impulse sound; this difference is likely attributable to the different transducers used during the two studies (Kastelein et al. 2013a). The apparent tendency for greater responsiveness in the harbor porpoise is consistent with its relative responsiveness to boat traffic and some other acoustic sources (Richardson et al. 1995; Southall et al. 2007).

Odontocete reactions to large arrays of airguns are variable and, at least for delphinids, seem to be confined to a smaller radius than has been observed for the more responsive of the mysticetes and some other odontocetes. A ≥170 dB disturbance criterion (rather than ≥160 dB) is considered appropriate for delphinids (in particular mid-frequency cetaceans), which tend to be less responsive than the more responsive cetaceans. NMFS is currently developing new guidance for predicting behavioral effects (Scholik-Schlomer 2015). As behavioral responses are not consistently associated with received levels, some authors have made recommendations on different approaches to assess behavioral reactions (e.g., Gomez et al. 2016; Harris et al. 2017).

Sea Turtles

Several recent papers discuss the morphology of the turtle ear (e.g., Christensen-Dalsgaard et al. 2012; Willis et al. 2013) and the hearing ability of sea turtles (e.g., Martin et al. 2012; Piniak et al. 2012a,b; Lavender et al. 2014). The limited available data indicate that sea turtles will hear airgun sounds and sometimes exhibit localized avoidance (see NSF-USGS PEIS, § 3.4.4.3). In additional, Nelms et al. (2016) suggest that sea turtles could be excluded from critical habitats during seismic surveys.

DeRuiter and Doukara (2012) observed that immediately following an airgun pulse, small numbers of basking loggerhead turtles (6 of 86 turtles observed) exhibited an apparent startle response (sudden raising of the head and splashing of flippers, occasionally accompanied by blowing bubbles from the beak and nostrils, followed by a short dive). Diving turtles (49 of 86 individuals) were observed at distances from the center of the airgun array ranging from 50–839 m. The estimated sound level at the median distance of 130 m was 191 dB re 1 μPa_{peak}. These observations were made during ~150 h of vessel-based monitoring from a seismic vessel operating an airgun array (13 airguns, 2440 in^3) off Algeria; there was no corresponding observation effort during periods when the airgun array was inactive (DeRuiter and Doukara 2012).

Based on available data, it is likely that sea turtles will exhibit behavioral changes and/or avoidance within an area of unknown size near a seismic vessel. To the extent that there are any impacts on sea turtles, seismic operations in or near areas where turtles concentrate would likely have the greatest impact; however, concentration areas are not known to occur within the proposed project area. There are no specific data that demonstrate the consequences to sea turtles if seismic operations with large or small arrays of airguns occur in important areas at biologically important times of the year. However, a number of mitigation measures can, on a case-by-case basis, be considered for application in areas important to sea turtles (e.g., Pendoley 1997; van der Wal et al. 2016).

***Hearing Impairment and Other Physical Effects*.—**Temporary or permanent hearing impairment is a possibility when marine mammals are exposed to very strong sounds. TTS has been demonstrated and studied in certain captive odontocetes and pinnipeds exposed to strong sounds (reviewed by Southall et al. 2007; Finneran 2015). However, there has been no specific documentation of TTS let alone permanent hearing damage, i.e., PTS, in free-ranging marine mammals exposed to sequences of airgun pulses during realistic field conditions.

Additional data are needed to determine the received sound levels at which small odontocetes would start to incur TTS upon exposure to repeated, low-frequency pulses of airgun sound with variable received levels. To determine how close an airgun array would need to approach in order to elicit TTS, one would (as a minimum) need to allow for the sequence of distances at which airgun pulses would occur, and for the dependence of received SEL on distance in the region of the seismic operation (e.g., Breitzke and Bohlen 2010; Laws 2012). At the present state of knowledge, it is also necessary to assume that the effect is directly related to total received energy (SEL); however, this assumption is likely an over-simplification (Finneran 2012). There is recent evidence that auditory effects in a given animal are not a simple function of received acoustic energy (Finneran 2015). Frequency, duration of the exposure, and occurrence of gaps within the exposure can also influence the auditory effect (Finneran and Schlundt 2010, 2011, 2013; Finneran et al. 2010a,b; Popov et al. 2011, 2013; Finneran 2012, 2015; Kastelein et al. 2012b,c; 2013b,c, 2014, 2015a, 2016a,b; Ketten 2012; Supin et al. 2016).

Recent data have shown that the SEL required for TTS onset to occur increases with intermittent exposures, with some auditory recovery during silent periods between signals (Finneran et al. 2010b; Finneran and Schlundt 2011). Studies on bottlenose dolphins by Finneran et al. (2015) indicate that the potential for seismic surveys using airguns to cause auditory effects on dolphins could be lower than previously thought. Based on behavioral tests, no measurable TTS was detected in three bottlenose dolphins after exposure to 10 impulses from a seismic airgun with a cumulative SEL of up to ~195 dB re 1 $\mu Pa^2 \cdot s$ (Finneran et al. 2015; Schlundt et al. 2016). However, auditory evoked potential measurements were more variable; one dolphin showed a small (9 dB) threshold shift at 8 kHz (Finneran et al. 2015; Schlundt et al. 2016).

Recent studies have also shown that the SEL necessary to elicit TTS can depend substantially on frequency, with susceptibility to TTS increasing with increasing frequency above 3 kHz (Finneran and

Schlundt 2010, 2011; Finneran 2012). When beluga whales were exposed to fatiguing noise with sound levels of 165 dB re 1 µPa for durations of 1–30 min at frequencies of 11.2–90 kHz, the highest TTS with the longest recovery time was produced by the lower frequencies (11.2 and 22.5 kHz); TTS effects also gradually increased with prolonged exposure time (Popov et al. 2013). Additionally, Popov et al. (2015) demonstrated that the impacts of TTS include deterioration of signal discrimination. Kastelein et al. (2015b) reported that exposure to multiple pulses with most energy at low frequencies can lead to TTS at higher frequencies in some cetaceans, such as the harbor porpoise.

Popov et al. (2016) reported that TTS produced by exposure to a fatiguing noise was larger during the first session (or naïve subject state) with a beluga whale than TTS that resulted from the same sound in subsequent sessions (experienced subject state). Similarly, several other studies have shown that some marine mammals (e.g., bottlenose dolphins, false killer whales) can decrease their hearing sensitivity in order to mitigate the impacts of exposure to loud sounds (e.g., Nachtigall and Supin 2013, 2014, 2015, 2016).

Previous information on TTS for odontocetes was primarily derived from studies on the bottlenose dolphin and beluga, and that for pinnipeds has mostly been obtained from California sea lions and elephant seals (see § 3.6.4.3, § 3.7.4.3, § 3.8.4.3 and Appendix E of the NSF-USGS PEIS). Thus, it is inappropriate to assume that onset of TTS occurs at similar received levels in all cetaceans or pinnipeds (*cf.* Southall et al. 2007; NMFS 2016a). Some cetaceans or pinnipeds could incur TTS at lower sound exposures than are necessary to elicit TTS in the beluga and bottlenose dolphin or California sea lion and elephant seal, respectively.

Several studies on TTS in porpoises (e.g., Lucke et al. 2009; Popov et al. 2011; Kastelein et al. 2012c, 2013b,c, 2014, 2015a) have indicated that received levels that elicit onset of TTS are lower in porpoises than in other odontocetes. Kastelein et al. (2012c) exposed a harbor porpoise to octave band noise centered at 4 kHz for extended periods. A 6-dB TTS occurred with SELs of 163 dB and 172 dB for low-intensity sound and medium-intensity sound, respectively; high-intensity sound caused a 9-dB TTS at a SEL of 175 dB. Kastelein et al. (2013b) exposed a harbor porpoise to a long, continuous 1.5-kHz tone, which induced a 14-dB TTS with a total SEL of 190 dB. Popov et al. (2011) examined the effects of fatiguing noise on the hearing threshold of Yangtze finless porpoises when exposed to frequencies of 32– 128 kHz at 140–160 dB re 1 µPa for 1–30 min. They found that an exposure of higher level and shorter duration produced a higher TTS than an exposure of equal SEL but of lower level and longer duration. Popov et al. (2011) reported a TTS of 25 dB for a Yangtze finless porpoise that was exposed to high levels of 3-min pulses of half-octave band noise centered at 45 kHz with an SEL of 163 dB.

For the harbor porpoise, Tougaard et al. (2015) suggested an exposure limit for TTS as an SEL of 100–110 dB above the pure tone hearing threshold at a specific frequency; they also suggested an exposure limit of $L_{\text{eq-fast}}$ (rms average over the duration of the pulse) of 45 dB above the hearing threshold for behavioral responses (i.e., negative phonotaxis). According to Wensveen et al. (2014) and Tougaard et al. (2015), M-weighting, as used by Southall et al. (2007), might not be appropriate for the harbor porpoise. Thus, Wensveen et al. (2014) developed six auditory weighting functions for the harbor porpoise that could be useful in predicting TTS onset. Mulsow et al. (2015) suggested that basing weighting functions on equal latency/loudness contours may be more appropriate than M-weighting for marine mammals. Houser et al. (2017) provide a review of the development and application of auditory weighting functions, as well as recommendations for future work.

Initial evidence from exposures to non-pulses has also suggested that some pinnipeds (harbor seals in particular) incur TTS at somewhat lower received levels than do most small odontocetes exposed for similar durations (Kastak et al. 1999, 2005, 2008; Ketten et al. 2001). Kastelein et al. (2012b) exposed two harbor seals to octave-band white noise centered at 4 kHz at three mean received SPLs of 124, 136, and

148 dB re 1 µPa; TTS >2.5 dB was induced at an SEL of 170 dB (136 dB SPL for 60 min), and the maximum TTS of 10 dB occurred after a 120-min exposure to 148 dB re 1 µPa or an SEL of 187 dB. Kastelein et al. (2013c) reported that a harbor seal unintentionally exposed to the same sound source with a mean received SPL of 163 dB re 1 µPa for 1 h induced a 44 dB TTS. For a harbor seal exposed to octave-band white noise centered at 4 kHz for 60 min with mean SPLs of 124–148 re 1 µPa, the onset of PTS would require a level of at least 22 dB above the TTS onset (Kastelein et al. 2013c). Reichmuth et al. (2016) exposed captive spotted and ringed seals to single airgun pulses with SELs of 165–181 dB and SPLs (peak to peak) of 190–207 re 1 µPa; no low-frequency TTS was observed.

Hermannsen et al. (2015) reported that there is little risk of hearing damage to harbor seals or harbor porpoises when using single airguns in shallow water. Similarly, it is unlikely that a marine mammal would remain close enough to a large airgun array for sufficiently long to incur TTS, let alone PTS. However, Gedamke et al. (2011), based on preliminary simulation modeling that attempted to allow for various uncertainties in assumptions and variability around population means, suggested that some baleen whales whose CPA to a seismic vessel is 1 km or more could experience TTS.

There is no specific evidence that exposure to pulses of airgun sound can cause PTS in any marine mammal, even with large arrays of airguns. However, given the possibility that some mammals close to an airgun array might incur at least mild TTS, there has been further speculation about the possibility that some individuals occurring very close to airguns might incur PTS (e.g., Richardson et al. 1995, p. 372*ff*; Gedamke et al. 2011). In terrestrial animals, exposure to sounds sufficiently strong to elicit a large TTS induces physiological and structural changes in the inner ear, and at some high level of sound exposure, these phenomena become non-recoverable (Le Prell 2012). At this level of sound exposure, TTS grades into PTS. Single or occasional occurrences of mild TTS are not indicative of permanent auditory damage, but repeated or (in some cases) single exposures to a level well above that causing TTS onset might elicit PTS (e.g., Kastak and Reichmuth 2007; Kastak et al. 2008).

The new noise exposure criteria for marine mammals that were recently released by NMFS (2016a) account for the newly-available scientific data on TTS, the expected offset between TTS and PTS thresholds, differences in the acoustic frequencies to which different marine mammal groups are sensitive, and other relevant factors. For impulsive sounds, such airgun pulses, the thresholds use dual metrics of cumulative SEL (SEL_{cum} over 24 hours) and Peak SPL_{flat}. Onset of PTS is assumed to be 15 dB higher when considering SEL_{cum} and 6 dB higher when considering SPL_{flat}. Different thresholds are provided for the various hearing groups, including LF cetaceans (e.g., baleen whales), MF cetaceans (e.g., most delphinids), HF cetaceans (e.g., porpoise and *Kogia* spp.), phocids underwater (PW), and otariids underwater (OW).

Nowacek et al. (2013a) concluded that current scientific data indicate that seismic airguns have a low probability of directly harming marine life, except at close range. Several aspects of the planned monitoring and mitigation measures for this project are designed to detect marine mammals occurring near the airgun array, and to avoid exposing them to sound pulses that might, at least in theory, cause hearing impairment. Also, many marine mammals and (to a limited degree) sea turtles show some avoidance of the area where received levels of airgun sound are high enough such that hearing impairment could potentially occur. In those cases, the avoidance responses of the animals themselves would reduce or (most likely) avoid any possibility of hearing impairment. Aarts et al. (2016) noted that an understanding of animal movement is necessary in order to estimate the impact of anthropogenic sound on cetaceans.

Non-auditory physical effects may also occur in marine mammals exposed to strong underwater pulsed sound. Possible types of non-auditory physiological effects or injuries that might (in theory) occur in mammals close to a strong sound source include stress, neurological effects, bubble formation, and other types of organ or tissue damage. Gray and Van Waerebeek (2011) have suggested a cause-effect relationship between a seismic survey off Liberia in 2009 and the erratic movement, postural instability, and akinesia in a pantropical spotted dolphin based on spatially and temporally close association with the airgun array. It is possible that some marine mammal species (i.e., beaked whales) are especially susceptible to injury and/or stranding when exposed to strong transient sounds (e.g., Southall et al. 2007). Ten cases of cetacean strandings in the general area where a seismic survey was ongoing have led to speculation concerning a possible link between seismic surveys and strandings (Castellote and Llorens 2016). An analysis of stranding data found that the number of long-finned pilot whale stranding along Ireland's coast increased with seismic surveys operating offshore (McGeady et al. 2016). However, there is no definitive evidence that any of these effects occur even for marine mammals in close proximity to large arrays of airguns. Morell et al. (2017) examined the inner ears of long-finned pilot whales after a mass stranding in Scotland and reported damage to the cochlea compatible with over-exposure from underwater noise; however, no seismic surveys were occurring in the vicinity in the days leading up to the stranding.

Since 1991, there have been 62 Marine Mammal Unusual Mortality Events (UME) in the U.S. (NMFS 2015a). In a hearing to examine the Bureau of Ocean Energy Management's 2017–2022 OCS Oil and Gas Leasing Program (http://www.energy.senate.gov/public/index.cfm/hearings-and-business-meetings?ID=110E5E8F-3A65-4BEC-9D25-5D843A0284D3), it was Dr. Knapp's (a geologist from the University of South Carolina) interpretation that there was no evidence to suggest a correlation between UMEs and seismic surveys given the similar percentages of UMEs in the Pacific, Atlantic, and Gulf of Mexico, and the greater activity of oil and gas exploration in the Gulf of Mexico.

Non-auditory effects, if they occur at all, would presumably be limited to short distances and to activities that extend over a prolonged period. Marine mammals that show behavioral avoidance of seismic vessels, including most baleen whales, some odontocetes, and some pinnipeds, are especially unlikely to incur non-auditory physical effects. The brief duration of exposure of any given mammal, the deep water in the majority of the study area, and the planned monitoring and mitigation measures would further reduce the probability of exposure of marine mammals to sounds strong enough to induce non-auditory physical effects.

Sea Turtles

There is substantial overlap in the frequencies that sea turtles detect versus the frequencies in airgun pulses. We are not aware of measurements of the absolute hearing thresholds of any sea turtle to waterborne sounds similar to airgun pulses. Given the high source levels of airgun pulses and the substantial received levels even at distances many km away from the source, it is probable that sea turtles can also hear the sound source output from distant seismic vessels. In the absence of relevant absolute threshold data, we cannot estimate how far away an airgun array might be audible. Moein et al. (1994) and Lenhardt (2002) reported TTS for loggerhead turtles exposed to many airgun pulses (see § 3.4.4 of the NSF-USGS PEIS). This suggests that sounds from an airgun array might cause temporary hearing impairment in sea turtles if they do not avoid the (unknown) radius where TTS occurs (see Nelms et al. 2016). However, exposure duration during the proposed surveys would be much less than during the aforementioned studies. Also, recent monitoring studies show that some sea turtles do show localized movement away from approaching airguns. At short distances from the source, received sound level diminishes rapidly with increasing distance. In that situation, even a small-scale avoidance response could result in a significant reduction in sound exposure.

The U.S. Navy has proposed the following criteria for the onset of hearing impairment for sea turtles: 232 dB re 1 µPa SPL (peak) and 204 dB re 1 µPa²·s SEL_{cum} (weighted) for PTS; and 226 dB peak and 189 dB weighted SEL for TTS (USN 2017). Although it is possible that exposure to airgun sounds could cause mortality or mortal injuries in sea turtles close to the source, this has not been demonstrated and seems highly unlikely (Popper et al. 2014), especially because sea turtles appear to be highly resistant to explosives

(Ketten et al. 2005 *in* Popper et al. 2014). Nonetheless, Popper et al. (2014) proposed sea turtle mortality/mortal injury criteria of 210 dB SEL or >207 dB_{peak} for sounds from seismic airguns; however, these criteria were largely based on impacts of pile-driving sound on fish.

The PSOs stationed on R/V *Hugh R. Sharp* would watch for sea turtles, and airgun operations would be shut down if a turtle enters the designated EZ.

There is no overlap between the auditory range of sea turtles and that of the EK80 instrument operated with a 38 kHz transducer.

Appendix E. Impact of Ship Noise

(additional material for §IV.1c, adopted nearly verbatim from the Draft Scripps EA (LGL, 2017).

Other possible effects of seismic surveys on marine mammals and/or sea turtles include masking by vessel noise, disturbance by vessel presence or noise, and injury or mortality from collisions with vessels or entanglement in seismic gear. The Proposed Action lies entirely within the Atlantic Large Whale Take Reduction Plan Regulated Waters (GARFO, 2015; 50CFR 229), which manages the use of certain fishing equipment to prevent entanglement of particularly North American right, humpbank, minke, and fin whales. Seismic streamers are inherently simpler than longlines, gill nets, trawls, or vertical lines that mark or support various fishing gear. These streamers also move through the water behind a sound source and do not extend more than a few meters below the water's surface. For all of these reasons, the risk of entanglement with seismic gear is considered lower than that for fishing gear for marine mammals.

Houghton et al. (2015) proposed that vessel speed is the most important predictor of received noise levels. Sounds produced by large vessels generally dominate ambient noise at frequencies from 20–300 Hz (Richardson et al. 1995). However, some energy is also produced at higher frequencies (Hermannsen et al. 2014); low levels of high-frequency sound from vessels has been shown to elicit responses in harbor porpoise (Dyndo et al. 2015). Increased levels of ship noise have been shown to affect foraging by porpoise (Teilmann et al. 2015) and humpback whales (Blair et al. 2016).

Ship noise, through masking, can reduce the effective communication distance of a marine mammal if the frequency of the sound source is close to that used by the animal, and if the sound is present for a significant fraction of time (e.g., Richardson et al. 1995; Clark et al. 2009; Jensen et al. 2009; Gervaise et al. 2012; Hatch et al. 2012; Rice et al. 2014; Dunlop 2015; Erbe et al. 2016; Jones et al. 2017). In addition to the frequency and duration of the masking sound, the strength, temporal pattern, and location of the introduced sound also play a role in the extent of the masking (Branstetter et al. 2013, 2016; Finneran and Branstetter 2013; Sills et al. 2017). In order to compensate for increased ambient noise, some cetaceans are known to increase the source levels of their calls in the presence of elevated noise levels from shipping, shift their peak frequencies, or otherwise change their vocal behavior (e.g., Parks et al. 2011, 2012, 2016a,b; Castellote et al. 2012; Melcón et al. 2012; Azzara et al. 2013; Tyack and Janik 2013; Luís et al. 2014; Sairanen 2014; Papale et al. 2015; Bittencourt et al. 2016; Dahlheim and Castellote 2016; Gospić and Picciulin 2016; Gridley et al. 2016; Heiler et al. 2016; Martins et al. 2016; O'Brien et al. 2016; Tenessen and Parks 2016). Similarly, harbor seals increased the minimum frequency and amplitude of their calls in response to vessel noise (Matthews 2017); however, harp seals did not increase their call frequencies in environments with increased low-frequency sounds (Terhune and Bosker 2016).

Holt et al. (2015) reported that changes in vocal modifications can have increased energetic costs for individual marine mammals. A negative correlation between the presence of some cetacean species and the number of vessels in an area has been demonstrated by several studies (e.g., Campana et al. 2015; Culloch et al. 2016; Oakley et al. 2017). Based on modeling, Halliday et al. (2017) suggested that shipping noise can be audible more than 100 km away and could affect the behavior of a marine mammal at a distance of 52 km in the case of tankers.

Baleen whales are thought to be more sensitive to sound at these low frequencies than are toothed whales (e.g., MacGillivray et al. 2014), possibly causing localized avoidance of the proposed project area during seismic operations. Reactions of gray and humpback whales to vessels have been studied, and there is limited information available about the reactions of right whales and rorquals (fin, blue, and minke whales). Reactions of humpback whales to boats are variable, ranging from approach to avoidance (Payne 1978; Salden 1993). Baker et al. (1982, 1983) and Baker and Herman (1989) found humpbacks often move away when vessels are within several kilometers. Humpbacks seem less likely to react overtly when actively feeding than when resting or engaged in other activities (Krieger and Wing 1984, 1986). Increased levels of ship noise have been shown to affect foraging by humpback whales (Blair et al. 2016). Fin whale sightings in the western Mediterranean were negatively correlated with the number of vessels in the area (Campana et al. 2015). Minke whales and gray seals have shown slight displacement in response to construction-related vessel traffic (Anderwald et al. 2013).

Many odontocetes show considerable tolerance of vessel traffic, although they sometimes react at long distances if confined by ice or shallow water, if previously harassed by vessels, or have had little or no recent exposure to ships (Richardson et al. 1995). Dolphins of many species tolerate and sometimes approach vessels (e.g., Anderwald et al. 2013). Some dolphin species approach moving vessels to ride the bow or stern waves (Williams et al. 1992). Physical presence of vessels, not just ship noise, has been shown to disturb the foraging activity of bottlenose dolphins (Pirotta et al. 2015) and blue whales (Lesage et al. 2017). Sightings of striped dolphin, Risso's dolphin, sperm whale, and Cuvier's beaked whale in the western Mediterranean were negatively correlated with the number of vessels in the area (Campana et al. 2015).

There are few data on the behavioral reactions of beaked whales to vessel noise, though they seem to avoid approaching vessels (e.g., Würsig et al. 1998) or dive for an extended period when approached by a vessel (e.g., Kasuya 1986). Based on a single observation, Aguilar Soto et al. (2006) suggest foraging efficiency of Cuvier's beaked whales may be reduced by close approach of vessels. Tyson et al. (2017) suggested that a juvenile green sea turtle dove during vessel passes and remained still near the sea floor.

The NSF-USGS PEIS concluded that project vessel sounds would not be at levels expected to cause anything more than possible localized and temporary behavioral changes in marine mammals or sea turtles, and would not be expected to result in significant negative effects on individuals or at the population level. In addition, in all oceans of the world, large vessel traffic is currently so prevalent that it is commonly considered a usual source of ambient sound.

Another concern with vessel traffic is the potential for striking marine mammals or sea turtles (e.g., Redfern et al. 2013). Information on vessel strikes is reviewed in § 3.4.4.4, § 3.6.4.4, and § 3.8.4.4 of the NSF-USGS PEIS. Wiley et al. (2016) concluded that reducing ship speed is one of the most reliable ways to avoid ship strikes. However, McKenna et al. (2015) noted the potential absence of lateral avoidance demonstrated by blue whales and perhaps other large whale species to vessels. The NSF-USGS PEIS concluded that the risk of collision of seismic vessels or towed/deployed equipment with marine mammals or sea turtles exists but is extremely unlikely, because of the relatively slow operating speed (typically 7–9 km/h) of the vessel during seismic operations, and the generally straight-line movement of the seismic vessel. During the proposed cruise, most (70%) of the seismic survey effort is expected to occur at a speed of ~15 km/h, and 30% is expected to occur at 9 km/h. However, the number of seismic survey km are low relative to other fast-moving vessels in the area (see Cumulative Effects section). There has been no history of marine mammal vessel strikes by vessels in the U.S. marine academic research fleet in the past two decades.

Appendix F. Direct Effects

Effects of seismic sound on marine invertebrates (crustaceans and cephalopods), marine fish, and their fisheries are discussed in § 3.2.4 and § 3.3.4 and Appendix D of the NSF-USGS PEIS. Relevant new studies on the effects of sound on marine invertebrates, fish, and fisheries that have been published since the release of the NSF-USGS PEIS are summarized below. Although research on the effects of exposure to airgun sound on marine invertebrates and fishes is increasing, many data gaps remain (Hawkins et al. 2015; Carroll et al. 2016).

(a) Effects of Sound on Marine Invertebrates

Noise effects on marine invertebrates are varied, ranging from no overt reactions to behavioral/ physiological responses, injuries, or mortalities (Aguilar de Soto 2016; Carroll et al. 2016; Edmonds et al. 2016). Unknowns that remain include how particle motion, rather than sound pressure levels, affect invertebrates exposed to sound (Hawkins and Popper 2017). The small amount of available information suggests that invertebrates, particularly crustaceans, may be relatively resilient to airgun sounds (Day et al. 2016a,b). Fewtrell and McCauley (2012) exposed captive squid (*Sepioteuthis australis*) to pulses from a single airgun, with received sound levels ranging from 120 to 184 dB re 1 dB re 1 $\mu Pa^2 \cdot s$ SEL. Increases in alarm responses (ink discharge, change in swim pattern or vertical position in water column) were seen at SELs >147–151 dB re 1 $\mu Pa^2 \cdot s$. Solé et al. (2013) exposed four caged cephalopod species to low-frequency (50–400 Hz) sinusoidal wave sweeps (with a 1-s sweep period for 2 h) with received levels of 157 ± 5 dB re 1 µPa and peak levels up to 175 dB re 1 µPa. Besides exhibiting startle responses, all four species examined received damage to the statocyst, which is the organ responsible for equilibrium and movement. The animals showed stressed behavior, decreased activity, and loss of muscle tone.

When New Zealand scallop (*Pecten novaezelandiae*) larvae were exposed to recorded seismic pulses, significant developmental delays were reported, and 46% of the larvae exhibited body abnormalities; it was suggested that the malformations could be attributable to cumulative exposure (Aguilar de Soto et al. 2013). The experiment used larvae enclosed in 60-mL flasks suspended in a 2-m diameter by 1.3-m water depth tank and exposed to a playback of seismic sound at a distance of 5–10 cm.

Day et al. (2016a,b, 2017) exposed scallops (*Pecten fumatus*) and egg-bearing female spiny lobsters (*Jasus edwardsi*) at a location 10–12 m below the surface to airgun sounds. The airgun source was started ~1–1.5 km from the study subjects and passed over the animals; thus, the scallops and lobsters were exposed to airgun sounds as close as 5–8 m away and up to 1.5 km from the source. Three different airgun configurations were used in the field: 45 in^3, 150 in^3 (low pressure), and 150 in^3 (high pressure), each with maximum peak-to-peak source levels of 191–213 dB re 1 µPa; maximum cumulative SEL source levels were 189–199 dB re 1 $\mu Pa^2 \cdot s$. Exposure to seismic sound was found to significantly increase mortality in the scallops, especially over a chronic time scale (i.e., months post-exposure), although not beyond naturally occurring rates of mortality (Day et al. 2017). Non-lethal effects were also recorded, including changes in reflex behavior time, other behavioral patterns, and haemolymph chemistry (Day et al. 2016b, 2017). The female lobsters were maintained until the eggs hatched; no significant differences were found in the quality or quantity of larvae for control versus exposed subjects, indicating that the embryonic development of spiny lobster was not adversely affected by airgun sounds (Day et al. 2016a,b). However, there were non-lethal effects, including changes in reflex behavior time and haemolymph chemistry, as well as apparent damage to statocysts; no mortalities were reported for control or exposed lobsters (Day et al. 2016a,b).

Fitzgibbon et al. (2017) also examined the impact of airgun exposure on spiny lobster through a companion study to the Day et al. (2016a,b, 2017) studies; the same study site, experimental treatment methodologies, and airgun exposures were used. The objectives of the study were to examine the haemolymph biochemistry and nutritional condition of groups of lobsters over a period of up to 365 days post-airgun exposure. Overall, no mortalities were observed across both the experimental and control groups; however, lobster total haemocyte count decreased by 23–60% for all lobster groups up to 120 days post-airgun exposure in the experimental group when compared to the control group. A lower haemocyte count increases the risk of disease through a lower immunological response. The only other haemolyph parameter that was significantly affected by airgun exposure was the Brix index of haemolymph at 120 and 365 days post-airgun exposure in one of the experiments involving egg-laden females. Other studies conducted in the field have shown no effects on Dungeness crab larvae or snow crab embryos to seismic sounds (Pearson et al. 1994; DFO 2004; Morris et al. 2017).

Payne et al. (2015) undertook two pilot studies which (i) examined the effects of a seismic airgun recording in the laboratory on lobster (*Homerus americanus*) mortality, gross pathology, histopathology, serum biochemistry, and feeding; and (ii) examined prolonged or delayed effects of seismic airgun pulses in the laboratory on lobster mortality, gross pathology, histopathology, and serum biochemistry. For experiment (i), lobsters were exposed to peak-to-peak and root-mean-squared received sound levels of 180 dB re 1 µPa and 171 dB re 1 μPa_{rms} respectively. Overall there was no mortality, loss of appendages, or other signs of gross pathology observed in exposed lobster. No differences were observed in haemolymph, feeding, ovary histopathology, or glycogen accumulation in the heptapancreas. The only observed differences were greater degrees of tubular vacuolation and tubular dilation in the hepatopancreas of the exposed lobsters. For experiment (ii), lobsters were exposed to 20 airgun shots per day for five successive days in a laboratory setting. The peak-to-peak and root-mean-squared received sound levels ranged from ~176 to 200 dB re 1 µPa and 148 to 172 dB re 1 μPa_{rms} respectively. The lobsters were returned to their aquaria and examined after six months. No differences in mortality, gross pathology, loss of appendages, hepatopancreas/ovary histopathology or glycogen accumulation in the hepatopacreas were observed between exposed and control lobsters. The only observed difference was a slight statistically significant difference for calcium-protein concentration in the haemolymph, with lobsters in the exposed group having a lower concentration than the control group.

Celi et al. (2013) exposed captive red swamp crayfish (*Procambarus clarkia*) to linear sweeps with a frequency range of 0.1–25 kHz and a peak amplitude of 148 dB re 1 μPa_{rms} at 12 kHz for 30 min. They found that the noise exposure caused changes in the haemato-immunological parameters (indicating stress) and reduced agonistic behaviors. Wale et al. (2013a,b) showed increased oxygen consumption and effects on feeding and righting behavior of shore crabs when exposed to ship sound playbacks.

McCauley et al. (2017) conducted a 2-day study to examine the potential effects of sound exposure of a 150 in^3 airgun on zooplankton off the coast of Tasmania; they concluded that exposure to airgun sound decreased zooplankton abundance compared to control samples, and caused a two- to three-fold increase in adult and larval zooplankton mortality. They observed impacts on the zooplankton as far as 1.2 km from the exposure location – a much greater impact range than previously thought; however, there was no consistent decline in the proportion of dead zooplankton as distance increased and received levels decreased. The conclusions by McCauley et al. (2017) were based on a relatively small number of zooplankton samples, and more replication is required to increase confidence in the study findings. Richardson et al. (2017) presented results of a modeling exercise intended to investigate the impact of exposure to airgun sound on zooplankton over a much larger temporal and spatial scale than that employed by McCauley et al. (2017). The exercise modeled a hypothetical survey over an area 80 km by 36 km during a 35-day period. Richardson et al. (2017) postulated that the decrease in zooplankton abundance observed by McCauley et al. (2017) could have been due to active avoidance behavior by larger zooplankton. The modeling results did indicate that there would be substantial impact on the zooplankton populations at a local spatial scale but not at a large spatial scale; zooplankton biomass recovery within the exposure area and out to 15 km occurred 3 days after completion of the seismic survey.

Leite et al. (2016) reported observing a dead giant squid (*Architeuthis dux*) while undertaking marine mammal observation work aboard a vessel conducting a seismic survey offshore from Brazil. The seismic vessel was operating 48-airgun array with a total volume of 5085 in^3. As no further information on the squid could be obtained, it is unknown whether the airgun sounds played a factor in the death of the squid.

(b) Effects of Sound on Fish

Potential impacts of exposure to airgun sound on marine fishes have been reviewed by Popper (2009), Popper and Hastings (2009a,b), and Fay and Popper (2012); they include pathological, physiological, and behavioral effects. Radford et al. (2014) suggested that masking of key environmental sounds or social signals could also be a potential negative effect from sound. Popper et al. (2014) presented guidelines for seismic sound level thresholds related to potential effects on fish. The effect types discussed include mortality, mortal injury, recoverable injury, temporary threshold shift, masking, and behavioral effects. Seismic sound level thresholds were discussed in relation to fish without swim bladders, fish with swim bladders, and fish eggs and larvae. Hawkins and Popper (2017) cautioned that particle motion as well as sound pressure should be considered when assessing the effects of underwater sound on fishes.

Bui et al. (2013) examined the behavioral responses of Atlantic salmon (*Salmo salar* L.) to light, sound, and surface disturbance events. They reported that the fish showed short-term avoidance responses to the three stimuli. Salmon that were exposed to 12 Hz sounds and/or surface disturbances increased their swimming speeds.

Peña et al. (2013) used an omnidirectional fisheries sonar to determine the effects of a 3-D seismic survey off Vesterålen, northern Norway, on feeding herring (*Clupea harengus*). They reported that herring schools did not react to the seismic survey; no significant changes were detected in swimming speed, swim direction, or school size when the drifting seismic vessel approached the fish from a distance of 27 km to 2 km over a 6-h period. Peña et al. (2013) attributed the lack of response to strong motivation for feeding, the slow approach of the seismic vessel, and an increased tolerance to airgun sounds.

Miller and Cripps (2013) used underwater visual census to examine the effect of a seismic survey on a shallow-water coral reef fish community in Australia. The census took place at six sites on the reef before and after the survey. When the census data collected during the seismic program were combined with historical data, the analyses showed that the seismic survey had no significant effect on the overall abundance or species richness of reef fish. This was in part attributed to the design of the seismic survey (e.g., ≥400 m buffer zone around reef), which reduced the impacts of seismic sounds on the fish communities by exposing them to relatively low SELs (<187 dB re 1 $\mu Pa^2 \cdot s$). Fewtrell and McCauley (2012) exposed pink snapper (*Pagrus auratus*) and trevally (*Pseudocaranx dentex*) to pulses from a single airgun; the received sound levels ranged from 120 to 184 dB re 1 dB re 1 $\mu Pa^2 \cdot s$ SEL. Increases in alarm responses were seen in the fish at SELs >147–151 dB re 1 $\mu Pa^2 \cdot s$; the fish swam faster and formed more cohesive groups in response to the airgun sounds.

Hastings and Miksis-Olds (2012) measured the hearing sensitivity of caged reef fish following exposure to a seismic survey in Australia. When the auditory evoked potentials (AEP) were examined for fish that had been in cages as close as 45 m from the pass of the seismic vessel and at water depth of 5 m, there was no evidence of TTS in any of the fish examined, even though the cumulative SELs had reached 190 dB re 1 $\mu Pa^2 \cdot s$.

Radford et al. (2016) conducted experiments examining how repeated exposures of different sounds to European seabass (*Dicentrarchus labrax*) can reduce the fishes' response to that sound. They exposed postlarval seabass to playback recordings of seismic survey sound (single strike SEL 144 dB re 1 $\mu Pa^2 \cdot s$) in large indoor tanks containing underwater speakers. Their findings indicated that short-term exposure of seismic sound increased the ventilation rate (i.e., opercular beat rate [OBR]) of seabass that were not previously exposed to seismic relative to seabass in controlled, ambient sound conditions. Fish that were reared in tanks that were repeatedly exposed to seismic sound over a 12-week period exhibited a reduced OBR response to that sound type, but fish exposed over the same time period to pile-driving noise displayed a reduced response to both seismic and pile-driving noise. An increased ventilation rate is indicative of greater stress in seabass; however, there was no evidence of mortality or effects on growth of the seabass throughout the 12-week study period.

Popper et al. (2016) conducted a study that examined the effects of exposure to seismic airgun sound on caged pallid sturgeon (*Scaphirhynchus albus*) and paddlefish (*Polyodon spathula*); the maximum received peak SPL in this study was 224 dB re 1 μPa. Results of the study indicated no mortality, either during or seven days after exposure, and no statistical differences in effects on body tissues between exposed and control fish.

Andrews et al. (2014) conducted functional genomic studies on the inner ear of Atlantic salmon (*Salmo salar*) that had been exposed to seismic airgun sound. The airguns had a maximum SPL of ~145 dB re 1 $\mu Pa^2/Hz$ and the fish were exposed to 50 discharges per trial. The results provided evidence that fish exposed to seismic sound either increased or decreased their expressions of different genes, demonstrating that seismic sound can affect fish on a genetic level.

Sierra-Flores (2015) examined sound as a short-term stressor in Atlantic cod (*Gadus morhua*) using cortisol as a biomarker. An underwater loudspeaker emitted SPLs ranging from 104 to 110 dB re 1 μPa_{rms}. Plasma cortisol levels of fish increased rapidly with noise exposure, returning to baseline levels 20-40 min post-exposure. A second experiment examined the effects of long-term noise exposure on Atlantic cod spawning performance. Tanks were stocked with male and female cod and exposed daily to six noise events, each lasting one hour. The noise exposure had a total SPL of 133 dB re 1 μPa. Cod eggs were collected daily and measured for egg quality parameters as well as egg cortisol content. Total egg volume, floating fraction, egg diameter and egg weight did not appear to be negatively affected by noise exposure. However fertilization rate and viable egg productivity were reduced by 40% and 50%, respectively, compared with the control group Mean egg cortisol content was found to be 34% greater in the exposed group as compared to the control group. Elevated cortisol levels inhibit reproductive physiology for males and can result in a greater frequency of larval deformities for spawning females.

(c) Effects of Sound on Fisheries

Handegard et al. (2013) examined different exposure metrics to explain the disturbance of seismic surveys on fish. They applied metrics to two experiments in Norwegian waters, during which fish distribution and fisheries were affected by airguns. Even though the disturbance for one experiment was greater, the other appeared to have the stronger SEL, based on a relatively complex propagation model.

Handegard et al. (2013) recommended that simple sound propagation models should be avoided and that the use of sound energy metrics like SEL to interpret disturbance effects should be done with caution. In this case, the simplest model (exposures per area) best explained the disturbance effect.

Hovem et al. (2012) used a model to predict the effects of airgun sounds on fish populations. Modeled SELs were compared with empirical data and were then compared with startle response levels for cod. This work suggested that in the future, particular acoustic-biological models could be useful in designing and planning seismic surveys to minimize disturbance to fishing. Their preliminary analyses indicated that seismic surveys should occur at a distance of 5–10 km from fishing areas, in order to minimize potential effects on fishing.

In their introduction, Løkkeborg et al. (2012) described three studies in the 1990s that showed effects on fisheries. Results of a study off Norway in 2009 indicated that fishes reacted to airgun sound based on observed changes in catch rates during seismic shooting; gillnet catches increased during the seismic shooting, likely a result of increased movement of exposed fish, whereas longline catches decreased overall (Løkkeborg et al. 2012).

Streever et al. (2016) completed a Before-After/Control-Impact (BACI) study in the nearshore waters of Prudhoe Bay, Alaska in 2014 which compared fish catch rates during times with and without seismic activity. The airgun arrays used in the geophysical survey had sound pressure levels of 237 dB re 1$\mu Pa_{0\text{-}p}$, 243 dB re 1$\mu Pa_{p\text{-}p}$, and 218 dB re 1μPa_{rms}. Received SPL_{max} ranged from 107 to 144 dB re 1 µPa, and received SEL_{cum} ranged from 111 to 141 dB re 1μPa^2-s for airgun pulses measured by sound recorders at four fyke net locations. They determined that fyke nets closest to airgun activities showed decreases in catch per unit effort (CPUE) while nets further away from the airgun source showed increases in CPUE.

Paxton et al. (2017) examined the effects of seismic sounds on the distribution and behavior of fish on a temperate reef during a seismic survey conducted in the Atlantic Ocean on the inner continental shelf of North Carolina. Hydrophones were set up near the seismic vessel path to measure SPLs, and a video camera was set up to observe fish abundances and behaviors. Received SPLs were estimated at ~202 to 230 dB re 1 µPa. Overall abundance of fish was lower when undergoing seismic activity as opposed to days when no seismic occurred. Only one fish was observed to exhibit a startle response to the airgun shots. The authors claim that although the study was based on limited data, it contributes evidence that normal fish use of reef ecosystems is reduced when they are impacted by seismic sounds.

Morris et al. (2017) conducted a two-year (2015–2016) BACI study examining the effects of 2-D seismic exploration on catch rates of snow crab (*Chionoecetes opilio*) along the eastern continental slope (Lilly Canyon and Carson Canyon) of the Grand Banks of Newfoundland, Canada. The airgun array used was operated from a commercial seismic exploration vessel; it had a total volume of 4880 in^3, horizontal zero-to-peak SPL of 251 dB re 1 µPa, and SEL of 229 dB re 1 $\mu Pa^2 \cdot s$. The seismic source came 100 m of the sound recorders in 2016. Overall, the findings indicated that the sound from the commercial seismic survey did not significantly reduce snow crab catch rates in the short-term (i.e., days) or longer term (i.e., weeks) in which the study took place. Morris et al. (2017) attributed the natural temporal and spatial variations in the marine environment as a greater influence on observed differences in catch rates between control and experimental sites than exposure to seismic survey sounds.

Appendix G. Other Effects

Sections adopted nearly verbatim from the Draft Scripps EA (LGL, 2017).

Direct Effects on Seabirds and Their Significance

The underwater hearing of seabirds (including loons, scaups, gannets, and ducks) has recently been investigated, and the peak hearing sensitivity was found to be between 1500 and 3000 Hz (Crowell 2016). Great cormorants were also found to respond to underwater sounds and may have special adaptations for hearing underwater (Hansen et al. 2016; Johansen et al. 2016). Effects of seismic sound and other aspects of seismic operations (collisions, entanglement, and ingestion) on seabirds are discussed in § 3.5.4 of the NSF-USGS PEIS. The NSF-USGS PEIS concluded that there could be transitory disturbance, but that there would be no significant impacts of NSF-funded marine seismic research on seabirds or their populations. Given the proposed activities and the mitigation measures, no significant impacts on seabirds would be anticipated. In decades of seismic surveys carried out by the U.S. academic research fleet, PSOs and other crew members have not observed any seismic sound-related seabird injuries or mortality.

Indirect Effects on Marine Mammals, Sea Turtles, Seabirds, Fish, and Their Significance

The proposed seismic operations would not result in any permanent impact on habitats used by marine mammals, sea turtles, seabirds, or fish, or to the food sources they use. The main impact issue associated with the proposed activities would be temporarily elevated anthropogenic sound levels and the associated direct effects on marine mammals, sea turtles, seabirds, and fish as discussed above.

During the proposed seismic surveys, only a small fraction of the available habitat would be ensonified at any given time. Disturbance to fish species and invertebrates, if any, would be short-term, and fish would return to their pre-disturbance behavior once the seismic activity ceased. Thus, the proposed surveys would have little impact on the abilities of marine mammals or sea turtles to feed in the area where seismic work is planned.

Appendix H. Request for Incidental Harassment Authorization, version April 10, 2018

Request by the U.S. Geological Survey for an Incidental Harassment Authorization to Allow the Incidental Take of Marine Mammals during the MATRIX Marine Geophysical Survey in the Northwest Atlantic Ocean, August 2018

Submitted by

U.S. Geological Survey

to

National Marine Fisheries Service
Office of Protected Resources
1315 East–West Hwy, Silver Spring, MD 20910-3282

March 19, 2018

TABLE OF CONTENTS

Page

Request by the U.S. Geological Survey for an Incidental Harassment Authorization to Allow the Incidental Take of Marine Mammals during a Low-Energy Marine Geophysical Survey by R/V *Hugh R. Sharp* in the Northwest Atlantic Ocean, August 2018

SUMMARY

The U.S. Geological Survey plans to conduct a seismic survey called MATRIX (Mid-Atlantic Resource Imaging Experiment) within the U.S. Exclusive Economic Zone in the Northwest Atlantic Ocean during August 2018. The seismic survey would use two to four Generator-Injector (GI) airguns with a total discharge volume of 210 in^3 to 840 in^3. The seismic surveys would take place in U.S. waters deeper than 100 m and extend to 3500 m water depth at the seaward end. The northern boundary of the survey area is 35 nm south of Hudson Canyon, and the southernmost survey would take place at approximately the latitude of Cape Hatteras. The USGS requests an Incidental Harassment Authorization (IHA) allowing non-lethal takes of marine mammals incidental to the planned seismic surveys. This request is submitted pursuant to Section 101 (a)(5)(D) of the Marine Mammal Protection Act (MMPA), 16 U.S.C. § 1371(a)(5).

Numerous species of marine mammals inhabit the proposed project area in the Northwest Atlantic Ocean. Under the U.S. Endangered Species Act (ESA), several of these species are listed as ***endangered***, including the North Atlantic right, sei, fin, blue, and sperm whales. The USGS is proposing a marine mammal monitoring and mitigation program to minimize the potential impacts of the proposed activity on marine mammals present during completion of the proposed research and to document the nature and extent of any effects.

ESA-listed sea turtle species that could occur in the project area include the ***endangered*** leatherback, hawksbill, Kemp's ridley, and loggerhead (Northeast Atlantic Ocean Distinct Population Segment or DPS) turtles; and the ***threatened*** green (North Atlantic DPS) and loggerhead (Northwest Atlantic Ocean DPS) turtles. ESA-listed sea turtle species that could occur in the project area include the ***endangered*** leatherback, hawksbill, Kemp's ridley, and loggerhead (Northeast Atlantic Ocean Distinct Population Segment or DPS) turtles and the ***threatened*** green (North Atlantic DPS) and loggerhead (Northwest Atlantic Ocean DPS) turtles. ESA-listed seabirds that could be encountered in the area include the ***endangered*** Bermuda petrel, black capped petrel, and roseate tern. In addition, the ***endangered*** Atlantic sturgeon and shortnose sturgeon could be present, as well as the ***threatened*** giant manta ray and oceanic whitetip shark.

The items required to be addressed pursuant to 50 C.F.R. § 216.104, "Submission of Requests", are set forth below. They include descriptions of the specific operations to be conducted, the marine mammals occurring in the project area, proposed measures to mitigate against any potential injurious effects on marine mammals, and a plan to monitor any behavioral effects of the operations on those marine

mammals. Substantial additional information is provided in the *Draft Environmental Assessment of a Marine Geophysical Survey (MATRIX) by the US Geological Survey in the Northwestern Atlantic Ocean, August 2018 (*USGS, 2018), submitted to the National Marine Fisheries Service on March 13, 2018. Based in part on the consultation with NMFS on this IHA, that Environmental Assessment will be updated for consistency with changes introduced into this IHA when the Environmental Assessment is finalized prior to the Proposed Action. Many sections of that Draft MATRIX EA (USGS, 2018) and of this IHA have been taken verbatim or adapted only slight from the Draft Scripps EA (LGL, 2017a) prepared for a proposed Summer 2018 low-energy survey and from the associated Scripps IHA (LGL, 2017b).

I. OPERATIONS TO BE CONDUCTED

A detailed description of the specific activity or class of activities that can be expected to result in incidental taking of marine mammals.

Overview of the Activity

The U.S. Geological Survey intends to conduct a seismic survey aboard the *R/V Hugh R. Sharp*, a University National Oceanographic Laboratory (UNOLS) federal fleet vessel that is 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 seismic survey will take place in water depths ranging from ~100 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 nm 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 km. Exemplary seismic lines for the program are shown in Figure 1. 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.

The purpose of the Proposed MATRIX Action 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. To achieve the program’s goals, Drs. Carolyn Ruppel and Nathan C. Miller, both of the USGS Woods Hole Coastal and Marine Science Center, propose to collect up to 9 long (80 nm or more) high-resolution MCS profiles and linking/transit/interseismic lines constituting up to ~2400 km total of new seismic data. More background on MATRIX and past research in the area and a list of acronyms are given in the Draft MATRIX EA submitted to NMFS by the USGS on March 13, 2018 (Draft MATRIX EA, USGS 2018). MATRIX is funded by the U.S. Geological Survey, with additional funding from the Bureau of Ocean Energy Management’s Resource Evaluation Division, which has a long record of studying methane gas hydrates on U.S. margins and developing quantitative assessments of these deposits. The U.S. Department of Energy’s National Methane Hydrates R&D Program is also providing funding for this project.

The procedures to be used for the seismic surveys would be similar to those used during previous research seismic surveys funded by NSF or conducted by the USGS and would use 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 has discharge volume of 105 in^3) as an energy source. The GI guns could sometimes fired in a mode that gives them discharge volume of 210 in^3 each, but only at water depths greater than 1000 m (see below). An 120-channel, 1.2-km-long hydrophone streamer 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.

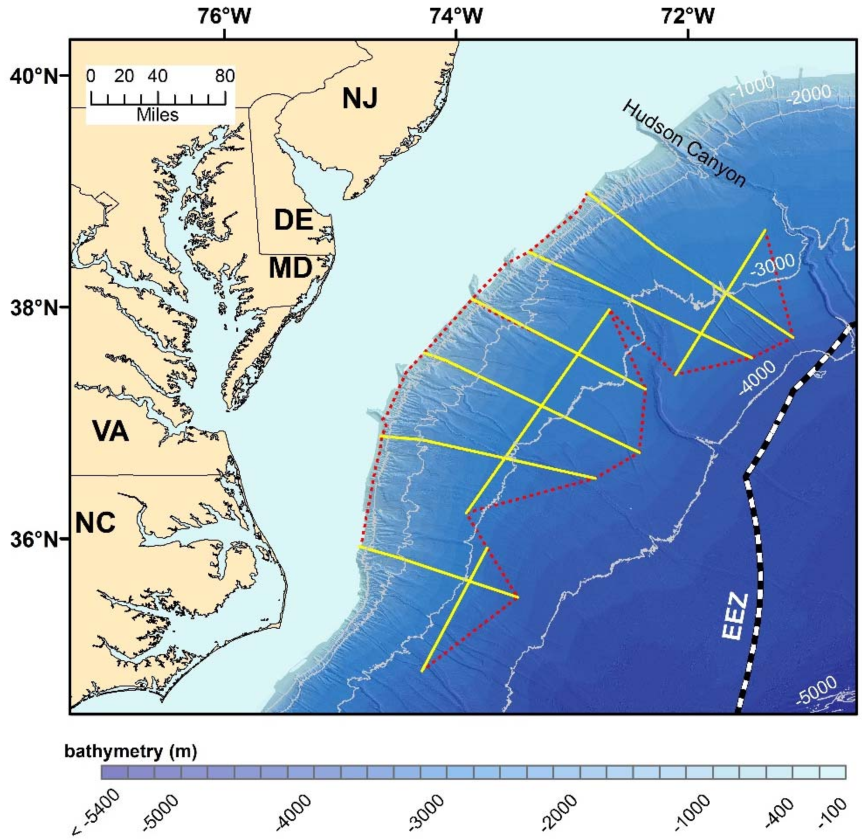

Figure 1. Exemplary seismic lines (yellow) to be acquired by the USGS during the Proposed Action, superposed on the USGS high-resolution bathymetric grid (Andrews et al., 2016). Red dashed lines are linking/transit/interseismic lines, and data will be acquired along only half of these lines. The dashed curve on the right side denotes the EEZ.

The **Optimal Survey** (Table 1) for the Proposed Action would acquire the portion of the solid lines in Figure 1 at greater than 1000 m water depth using the GI-guns in "GG" mode. In this mode, the 4 GI guns would produce a total of 840 in^3 of air (see (e) below), and sonobuoys would be deployed to passively record data at long distances. The rest of the survey, including the portion shallower than 1000 m water depth on the uppermost slope and the interseismic linking lines (dashed red in Figure 1), would be acquired with 4 GI guns operated in normal mode (also called GI mode), productng a total of 420 in^3 of air.

The **Base Survey** assumes that all of the solid lines in Figure 1, as well as all of the interseismic connecting lines, would be acquired using 4 GI guns operating in normal mode (GI mode), producing a total air volume of 420 in^3.

Takes (summarized in Table 7) were separately calculated for each of these surveys. However, the takes reported in Table 7 are those for the Optimal Survey, representing the maximum calculated takes and a conservative approach.

Note that only a maximum of half of the dashed lines in Figure 1 would be acquired and that these lines are longer and geometrically more complex at the deepwater side than near the shelf-break. To allow operational flexibility, takes are calculated in this IHA assuming **all** of the linking/interseismic lines would be shot, yielding an overestimate of takes, but also ensuring that the linking lines that make the most sense based on weather, sea state, and other logistical considerations could be the ones actually completed.

Table 1. General characteristics of exemplary survey scenarios for the Proposed Action.

	GI mode (4x105 in^3)		GG mode (4x210 in^3)	
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 its fisheries 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 Sharp*'s retractable keel and would typically ping 0.5 to 2 Hz with pings of 0.256 to 1.024 ms 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. As explained later in this IHA (§ VII), no takes are requested for use of the fisheries echosounder.

All planned geophysical data acquisition activities would be conducted by the USGS scientists, technical staff, and marine operations group, with support from UNOLS technical staff as necessary. The vessel will be self-contained, and the scientific party and crew will live aboard the vessel for the entire cruise.

Source Vessel Specifications

The *R/V Hugh R. Sharp* would be used for this survey. The R/V *Hugh R. Sharp* has an overall length of 46 m, a beam of 9.8 m, and a full load draft of 2.95 m (3.9 m with retractable keel positioned at 1 m down). The vessel is equipped with four Cummins KTA-19D diesel engines. Diesel-electric power is provided by two Schottel SRP 330 Z-drives. The ship also has a Schottel tunnel bow thruster operated with the S Green dynamic positioning system. An operation speed of up to ~7.4 km/h (4 kt) will be used during seismic acquisition. When not towing seismic survey gear, the R/V *Hugh R. Sharp* typically cruises at 14.8 to 16.7 km/h (8-9 kt). It has a normal operating range of ~6500 km (~3500 nm).

The R/V *Hugh R. Sharp* will also serve as the platform from which vessel-based protected species observers (PSOs) will watch for marine mammals and sea turtles before and during airgun operations. The PSO platform is an area covered by an awning and equipped with chairs and Big Eye binocular stands, located on the flying bridge of the *R/V Hugh R. Sharp*, 10.6 m above the water's surface. This area has previously been used by NMFS scientists for beaked whale observations during research cruises (e.g., Cholewiak, September 2017). The vantage point provides a 360° view of the water's surface. During inclement weather too challenging to remain on the flying bridge, the PSOs have access to the bridge of the vessel for their activities. In addition, crew members on the bridge and on other parts of the vessel will be instructed to keep a watch for protected species.

Other details of the R/V *Hugh R. Sharp* include the following:

Owner:	University of Delaware
Operator:	University of Delaware
Flag:	United States of America
Launch Date:	2006
Domestic Tonnage:	256 T
Accommodation Capacity:	22, including 14 scientists

Airgun Description

The R/V *Hugh R. Sharp* will tow two or four 105-in^3 Sercel generator-injector (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 kt), 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. When shooting to sonobuoys during the Proposed Action, the GI guns will also sometimes be operated with both chambers releasing air simultaneously (i.e., "generator-generator" or "GG" mode). In GG mode, each gun simultaneously releases an air volume of 105 in^3 + 105 in^3= 210 in^3. On this cruise, 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 **Backup Configuration** is described in Appendix A. The text below describes the two preferred modes for operations.

The **Base Configuration**, **Configuration 1,** will use 4 GI guns and generate 420 in^3 total volume, as shown in Figure 2. Guns 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.

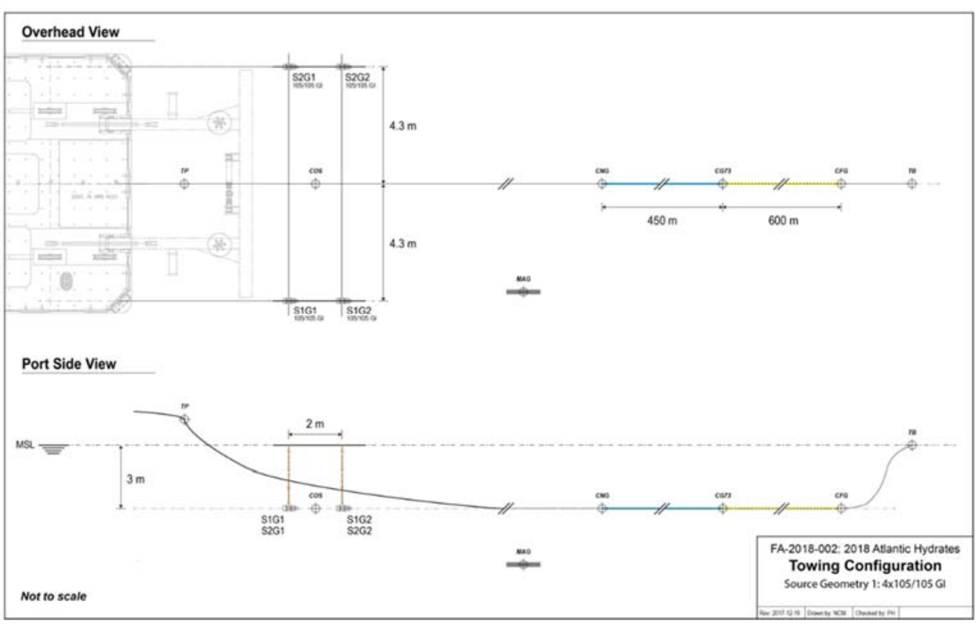

Figure 2. Base configuration (Source configuration 1): 420 in^3 total volume consisting of 4x105/105in^3 GI guns (S#G*, where # is the side and * is the gun number) firing in standard GI mode.

The **GG Configuration, Configuration 2,** will use 4 GI guns and generate 840 in^3 total volume, as shown in Figure 3. In this configuration, the guns will be fired in GG mode, as described above. Guns 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 would be used **only at greater than 1000 m water depth** and on specific exemplary lines on which sonobuoy data are being collected.

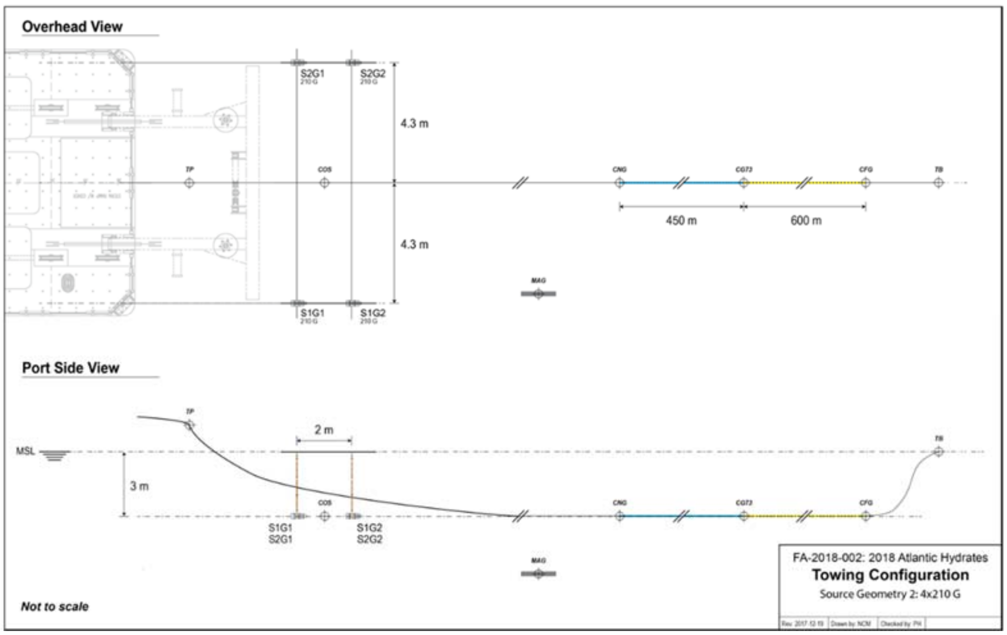

Figure 3. GG Configuration (Source configuration 2): 840 in^3 total volume consisting of 4x105/105in^3 GI guns firing both chambers simultaneously (i.e. GG mode). Guns are labelled as S#G*, where # is the side and * is the gun number.

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 (1200 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.

GI Airgun Specifications

Energy Source	Two (backup configuration, Appendix A) 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 Hz

The source levels for the GI gun configurations can be derived from the modeled farfield source signature, which was determined for the USGS by L-DEO using the PGS Nucleus software. Modeling information is provided below, with more complete details in Appendices B and C.

In July 2016, the National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service (NMFS) released new technical guidance for assessing the effects of anthropogenic sound on marine mammal hearing (NMFS 2016a). The guidance established new thresholds for permanent threshold shift (PTS) onset or Level A Harassment (injury), for marine mammal species. The new noise exposure criteria for marine mammals account for the newly-available scientific data on temporary threshold shifts (TTS), the expected offset between TTS and PTS thresholds, differences in the acoustic frequencies to which different marine mammal groups are sensitive, and other relevant factors, as summarized by Finneran (2016). Onset of PTS was assumed to be 15 dB or 6 dB higher when considering SEL_{cum} and SPL_{flat}, respectively. For impulsive sounds, such airgun pulses, the new guidance incorporates marine mammal auditory weighting functions (Fig. 4) and dual metrics of cumulative sound exposure level (SEL_{cum} over 24 hours) and peak sound pressure levels (SPL_{flat}). Different thresholds are provided for the various hearing groups, including low-frequency (LF) cetaceans (e.g., baleen whales), mid-frequency (MF) cetaceans (e.g., most delphinids), high-frequency (HF) cetaceans (e.g., porpoise and *Kogia* spp.), phocids underwater (PW), and otariids underwater (OW). As required by NMFS (2016a), the largest distance of the dual criteria (SEL_{cum} or Peak SPL_{flat}) would be used as the EZ and for calculating takes. For LF cetaceans the PTS SEL_{cum} criterion is used. For MF and HF cetaceans, the Peak SPL_{flat} yields a larger exclusion zone and is therefore used. Pinnipeds are not considered since they do not occur in the area of the Proposed Survey.

The SEL_{cum} and Peak SPL (Appendix C) for the planned airgun configurations are derived from calculating the modified farfield signature. The farfield signature is often used as a theoretical representation of the source level. To compute the farfield signature, the source level is estimated at a large distance below the array (e.g., 9 km), and this level is back projected mathematically to a notional distance of 1 m from the array's geometrical center. However, it has been recognized that the source level from the theoretical farfield signature is never physically achieved at the source when the source is an array of multiple airguns separated in space (Tolstoy et al. 2009). Near the source (at short ranges, distances <1 km), the pulses of sound pressure from each individual airgun in the source array do not stack constructively as they do for the theoretical farfield signature. The pulses from the different airguns spread out in time such that the source levels observed or modeled are the result of the summation of pulses from a few airguns, not the full array (Tolstoy et al. 2009). At larger distances, away from the source array center, sound pressure of all the airguns in the array stack coherently only in the vertical direction. In the horizontal direction, the sound pressure does not always constructively interfere and stack coherently, resulting in smaller source levels (a few dB) than the source level derived from the farfield signature. Because the farfield signature does not take into account the interactions of the two airguns that occur near the source center and is calculated as a point source (single airgun), the modified farfield signature is a more appropriate measure of the sound source level for large arrays. For this smaller array, the modified farfield changes will be correspondingly smaller as well, but we use this method for consistency across all array sizes.

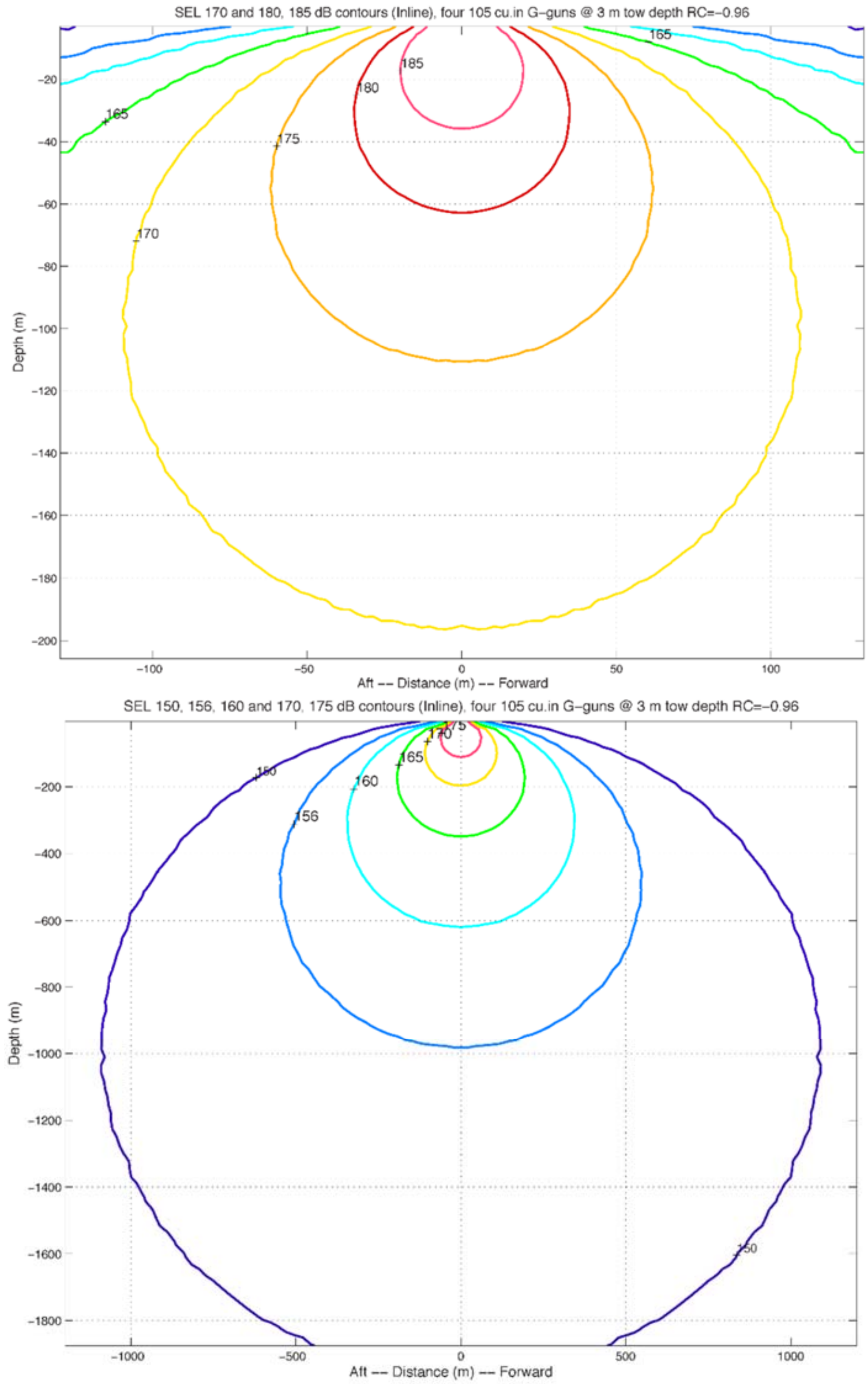

Figure 4. Modeled deep-water received sound exposure levels (SELs) from the Base Configuration (Configuration 1; four 105 in^3 GI-guns) towed at 3-m depth. Received rms levels (SPLs) are expected to be ~10 dB higher. The plot at the top provides the radius to the 170-dB SEL isopleth as a proxy for the 180-dB rms isopleth, and the plot at the bottom provides the radius to the 150 and 165-dB SEL isopleths as a proxy for the 160 and 175-dB rms isopleths, respectively. The top diagram is a blow-up of the bottom one.

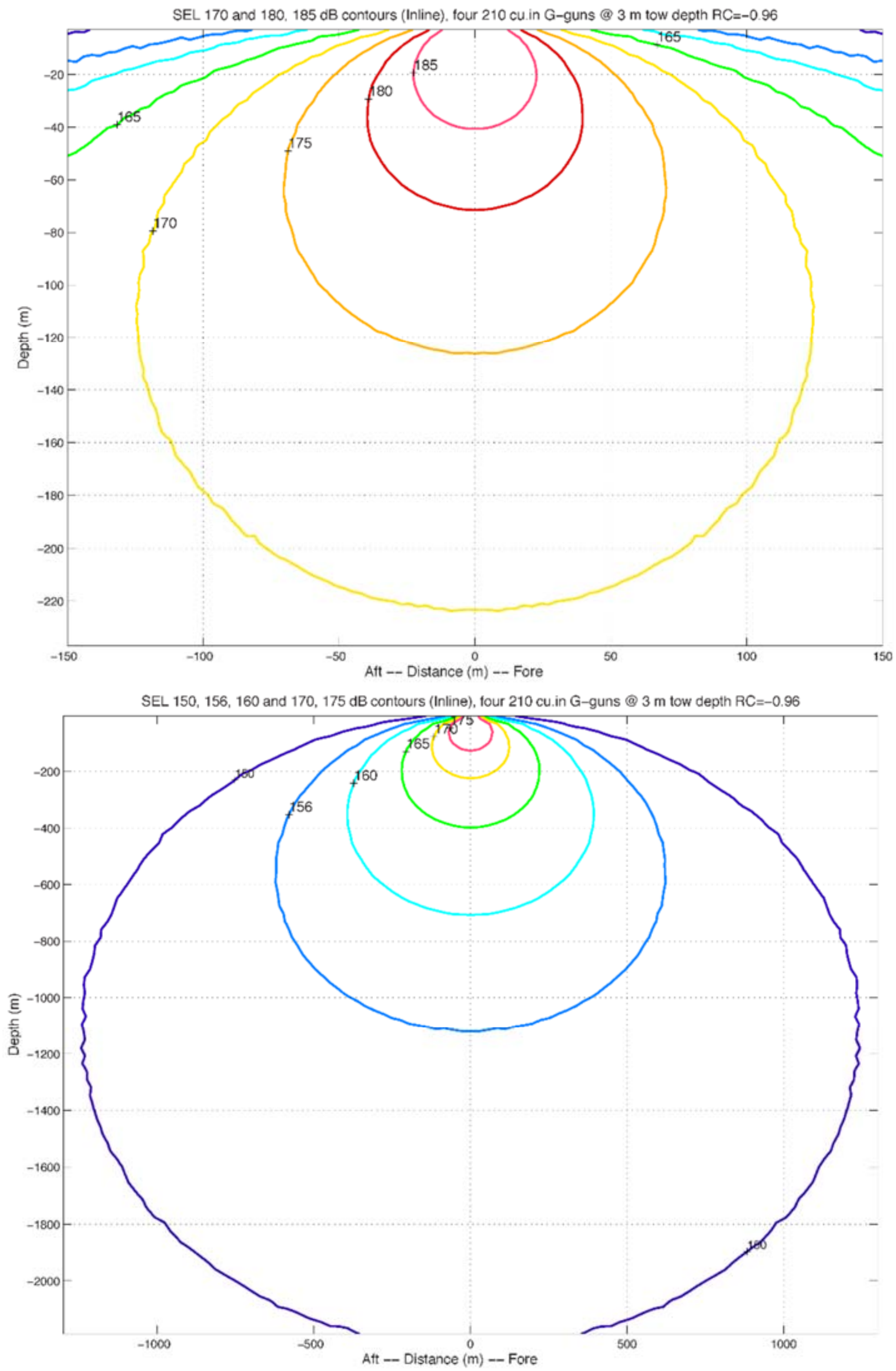

Figure 5. Modeled deep-water received sound exposure levels (SELs) from the GG configuration (Configuration 2), with four 210 in^3 GI-guns towed at 3-m depth and generating a total of 840 in^3. Received rms levels (SPLs) are expected to be ~10 dB higher. The plot at the top provides the radius to the 170-dB SEL isopleth as a proxy for the 180-dB rms isopleth, and the plot at the bottom provides the radius to the 150 and 165-dB SEL isopleths as a proxy for the 160 and 175-dB rms isopleths, respectively. The upper plot is a zoomed-in version of the lower plot.

Table 2. Summary of predicted distances to which sound levels ≥ 160-dB re 1 μPa_{rms} would be expected to be received during the proposed surveys in the Northwest Atlantic Ocean for the Base and GG configuration, based on modeling shown in Figures 4 and 5. Refer to Appendix A for the Backup Configuration. The Proposed Action would not involve ensonifying the seafloor at water depths shallower than 100 m. Further calculations and information are given in Appendix B.

Source and Volume	Tow Depth (m)	Water Depth (m)	Predicted RMS Radii (m)
			160 dB
Base Configuration (Configuration 1) Four 105 in³ G-guns	3	>1000 m	1091[1]
		100–1000 m	1637[2]
GG Configuration (Configuration 2) Four 210 in³ G-guns	3	>1000 m	1244[1]
		100–1000 m	1866[2]

[1] Distance is based on L-DEO model results.
[2] Distance is based on L-DEO model results with a 1.5 x correction factor between deep and intermediate water depths.

To estimate SEL_{cum} and Peak SPL to determine Exclusion Zones, we used the acoustic modeling developed at L-DEO (same as used for Level B takes) with a small grid step to provide better resolution in both the inline and depth directions, with results shown in Appendix C. The propagation modeling takes into account all airgun interactions at short distances from the source including interactions between subarrays. This is done by using the NUCLEUS software to estimate the notional signature and the MATLAB software to calculate the pressure signal at each mesh point of a grid.

PTS onset acoustic thresholds estimated in the NMFS User Spreadsheet rely on overriding default values and calculating individual adjustment factors (dB) and by using the difference between levels with and without weighting functions for each of the five categories of hearing groups. The new adjustment factors in the spreadsheet allow for the calculation of SEL_{cum} isopleths in the spreadsheet and account for the accumulation (Safe Distance Methodology) using the source characteristics (duty cycle and speed) after Sivle et al. (2014). The methodology (input) for calculating the distances to the SEL_{cum} PTS thresholds (Level A) for the airgun array is shown in Table 3.

Appendix C provides detailed information about the acoustic modeling used for Level A takes, including NMFS spreadsheet-based calculations. Appendix C also gives a summary of all of the SEL SL modeling with and without applying the weighting function for the 5 hearing groups and the full calculations for the PTS SEL_{cum} and the Peak SPL_{flat}.

TABLE 3. SEL_{cum} Methodology Parameters (Sivle et al. 2014)†.

Airgun Configuration	Source Velocity (meters/second)	1/Repetition rate^ (seconds)
All Configurations	2.05778*	12.149&

†Methodology assumes propagation of 20 log R; Activity duration (time) independent
^ Time between onset of successive pulses.
*Equivalent to 4 kts
&The USGS intends to use a nominal shot interval of 25 m (~12 s at 4 kts).

As shown in Appendix C, a new adjustment value is determined by computing the distance from the geometrical center of the source to where the 183 dB SEL_{cum} isopleth is the largest for LF cetaceans. The modeling is first run for one single shot without applying any weighting function. The maximum 183dB SEL_{cum} isopleth is located at 34.35 m, 39.42 m, and 17.98 m from the source for source Configurations 1 through 3, respectively. We then run the modeling for one single shot with the low frequency cetaceans weighting function applied to the full spectrum. The maximum 183 dB SEL_{cum} isopleth is located at 15.7 m, 17.7 m, and 9.2 m from the source for source Configurations 1 through 3, respectively. The difference between these values for each of the source configurations yields adjustment factors of -6.8 dB, -6.9 dB, and -5.8 dB, respectively, assuming a propagation of $20\log_{10}R$.

For MF and HF cetaceans, the modeling for a single shot with the weighted function applied leads to 0-m isopleths; the adjustment factors thus cannot be derived the same way as for LF cetaceans. Hence, for MF and HF cetaceans, the difference between weighted and unweighted spectral source levels at each frequency up to 3 kHz was integrated to actually calculate these adjustment factors in dB. These calculations also account for the accumulation (Safe Distance Methodology) using the source characteristics (duty cycle and speed) after Sivle et al. (2014).

Table 4. Summary Level A acoustic thresholds in meters for each source configuration and hearing group relevant to acquisition of the Base/Optimal Surveys for the Proposed Action. Corresponding values for the backup configuration of airguns, which would ideally not be used for the Base/Optimal Surveys, are provided in Tables C10 and C11.

	Hearing Group		
	Low-Frequency Cetaceans	**Mid-Frequency Cetaceans**	**High-Frequency Cetaceans**
Threshold	183 dB (SEL_{cum})	230 dB (Peak SPL_{flat})	202 dB (Peak SPL_{flat})
Base Configuration	*31.0 m*	*0.0*	*70.43 m*
GG Configuration	*39.5 m*	*0.0*	*80.5 m*

The NSF-USGS PEIS defined a low-energy source as any towed acoustic source whose received level is ≤180 dB re 1 μPa_{rms} (the Level A threshold under the former NMFS acoustic guidance) at 100 m. Table 3 of Appendix F of the NSF-USGS PEIS shows that a quadrilateral (4 GI gun) array of 105 in^3 guns would meet the low-energy criteria if towed at 3 m depth and separated by 8 m. Based on the modeling in Table 1 and the fact that the quadrilateral array of guns to be used for the Proposed Action would be separated by only 2 m front to back and 8.6 m side to side (and will be operated occasionally in GG mode, which generates 210 in^3 of air per GI gun), the Proposed Action slightly exceeds the criteria of a low-energy activity according to the NSF-USGS PEIS. Note that the sources to be used for the Proposed Action at maximum generate less than 20% of the air (usually > 6000 in^3) typically used for seismic surveys by a range of research and private sector operators.

In § 2.4.2 of the NSF-USGS PEIS, Alternative B (the Preferred Alternative) conservatively applied a 100-m EZ for low-energy acoustic sources in water depths >100 m. For the Proposed Action, which does not meet the ≤180 dB re 1 μPa_{rms} Level A criterion formerly applied by NMFS and outlined in Appendix F of the NSF-USGS PEIS, the actual calculated EZ (Table 4 and Appendix C) based on the 2016 NMFS Acoustic Guidelines are substantially smaller than this prescribed 100 m EZ. Adopting the calculated EZ instead of the prescribed 100 m EZ would therefore result in a less conservative approach to protection of marine mammals (and turtles) and higher actual takes during the Proposed Action. Thus, the Proposed Action will voluntarily adopt a 100 m EZ for marine mammals.

Enforcement of mitigation zones via shut downs would be implemented in the Operational Phase, as noted below. This IHA application has been prepared in accordance with the current NOAA acoustic practices, and procedures are based on best practices noted by Pierson et al. (1998), Weir and Dolman (2007), Nowacek et al. (2013a), Wright (2014), and Wright and Cosentino (2015).

Description of Operations

The survey will involve one source vessel, the R/V *Hugh R. Sharp*. The source vessel will deploy two to four low-energy Generator-Injector (GI) airguns (each has discharge volume of 105 in^3) as an energy source. An 120-channel, 1.2-km-long hydrophone streamer will be continuously towed to receive the seismic signals. In addition, up to 90 disposable sonobuoy receivers will be deployed only at water depths greater than 1000 m to provide velocity control and possibly wide-angle reflections along the highest priority transects.

The sonobuoys, which will be deployed as frequently as every 15 km along high-priority lines, record the returning acoustic signals at larger offsets than are possible with the streamer and transmit the information at radio frequencies to receivers on the ship. A maximum of ~2400 km of data will be collected (Fig. 1). Most lines are oriented subperpendicular to the strike of the margin (dip lines), but data will be acquired along some linking/interseismic lines oriented roughly parallel to the margin (strike lines) and along short strike interseismic/linking lines that connect the dip lines. Table 1 summarizes the survey plan for the Optimal and Base Surveys.

Along with the airgun operations, the USGS will use its EK60/80 fisheries echosounder with a single (38 kHz) transducer.

II. DATES, DURATION, AND REGION OF ACTIVITY

The date(s) and duration of such activity and the specific geographical region where it will occur.

The survey is bound within the region ~34.75ºN–40°N, ~71–75°W in the northwest Atlantic Ocean (Fig. 1), with the closest approach to the U.S. coastline 70 km (North Carolina) to 130 km (New Jersey). The survey area starts 35 nm 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. The seismic survey will be conducted entirely within the U.S. EEZ, with airgun operations scheduled to occur for up to 19 days of 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 especially weather.

The remainder of this document relies heavily on the text in the Incidental Harassment Authorization Application submitted by Scripps Institute of Oceanography for its June-July Northwestern Atlantic Survey, as prepared by LGL (LGL, 2017b). That document will henceforth be referred to as Scripps IHA (LGL, 2017). This IHA also relies heavily on the Draft Scripps EA (LGL, 2017a) and on the Draft MATRIX EA (USGS, 2018), which will be updated for consistency with the April 2018 revisions in this IHA when the EA is finalized prior to the Proposed Action.

III. SPECIES AND NUMBERS OF MARINE MAMMALS IN AREA

The species and numbers of marine mammals likely to be found within the activity area

To avoid redundancy, we have included the required information about the species and (insofar as it is known) numbers of these species in § IV, below.

Thirty-four marine mammal species could occur in the general survey area, including 7 mysticetes (baleen whales) and 27 odontocetes (toothed whales, such as dolphins) (Table 6). To avoid redundancy, we have included the required information about the species and (insofar as it is known) numbers of these species in § IV, below. Five of the species that could occur in the proposed project area are listed under the ESA as ***endangered***, including the sperm, sei, fin, blue, and North Atlantic right whales. General information on the taxonomy, ecology, distribution and movements, and acoustic capabilities of marine mammals are given in § 3.6.1, § 3.7.1, and § 3.8.1 of the NSF-USGS PEIS.

One of the detailed analysis areas (DAAs) defined in the NSF-USGS PEIS §2.3.1.1 is in the Northwest (NW) Atlantic and lies at the northernmost end of the Survey Area for this Proposed Action, encompassing the area out to 1500 m water depth. The distributions of mysticetes, odontocetes, and pinnipeds in the NW Atlantic DAA are discussed in §3.6.2.1, §3.7.2.1, and §3.8.2.1 of the NSF-USGS PEIS, respectively. The rest of this section deals specifically with species distribution in the area of the Proposed Action.

Three cetacean species occur in Atlantic arctic waters, and their ranges do not extend as far south as the proposed project area: the narwhal, *Monodon Monoceros*; the beluga, *Delphinapterus leucas*; and the bowhead, *Balaena mysticetus*. Two additional Atlantic cetacean species, the Atlantic humpback dolphin (*Souza teuszii*) found in coastal waters of western Africa, and the long-beaked common dolphin (*Delphinus capensis*) found in coastal waters of South America and western Africa, do not occur in the study area.

Pinniped species that are known to occur in North Atlantic waters, but that will not occur in the area of the Proposed Action, include the gray seal (*Halichoerus grypus*), harbor seal (*Phoca vitulina*), and bearded seal (*Erignathus barbatus*). Pinniped species are not discussed further in this EA, nor are takes calculated for these species given that they would not be encountered.

Two cetacean species occur in arctic waters, and their ranges generally do not extend as far south as the proposed project area: the narwhal, *Monodon monoceros*, and the beluga, *Delphinapterus leucas*. Two additional cetacean species, the Atlantic humpback dolphin (*Souza teuszii*) found in coastal waters of western Africa, and the long-beaked common dolphin (*Delphinus capensis*) found in coastal waters of South America and western Africa, do not occur in deep offshore waters. Pinniped species that are known to occur in North Atlantic waters, but are not expected to occur in the deep offshore proposed project area, include the gray seal (*Halichoerus grypus*), harbor seal (*Phoca vitulina*), bearded seal (*Erignathus barbatus*), and walrus (*Odobenus rosmarus*).

IV. STATUS, DISTRIBUTION AND SEASONAL DISTRIBUTION OF AFFECTED SPECIES OR STOCKS OF MARINE MAMMALS

A description of the status, distribution, and seasonal distribution (when applicable) of the affected species or stocks of marine mammals likely to be affected by such activities

Sections III and IV are integrated here to minimize repetition. The text here comes directly from the Draft MATRIX EA (USGS, 2018). Much of the following section is taken verbatim from the Draft Scripps EA (LGL, 2017), with modifications to reflect the specifics of the MATRIX project.

Mysticetes

The following information has mostly been copied verbatim from the Draft Scripps EA (LGL, 2017) and then modified for the specific circumstances of the USGS Proposed Action, when appropriate. Table 6 summarizes the conservation status, estimated population, habitat, and survey specific information for each species.

NORTH ATLANTIC RIGHT WHALE (EUBALAENA GLACIALIS)

The North Atlantic right whale occurs primarily in the continental shelf waters of the eastern U.S. and Canada, from Florida to Nova Scotia (Winn et al. 1986; Jefferson et al. 2015). Survey data have identified seven major habitats or congregation areas for North Atlantic right whales: coastal waters of the southeastern United States; Great South Channel; Jordan Basin; Georges Basin along the northern edge of Georges Bank; Cape Cod and Massachusetts Bays; Bay of Fundy; and Roseway Basin on the Scotian Shelf (Hayes et al. 2017). There is a general seasonal north-south migration between feeding and calving areas (Gaskin 1982). The migration route between the Cape Cod spring/summer feeding grounds and the Georgia/Florida winter calving grounds is known as the mid-Atlantic corridor, and whales move through these waters regularly in all seasons (Reeves and Mitchell 1986; Winn et al. 1986; Kenney et al. 2001; Reeves 2001; Knowlton et al. 2002; Whitt et al. 2013). The majority of sightings (94%) along the migration corridor are within 56 km of shore (Knowlton et al. 2002).

During the summer and into fall (June–November), right whales are most commonly seen on feeding grounds in Canadian waters off Nova Scotia, with peak abundance during August, September, and early October (Gaskin 1987). Some right whales, including mothers and calves, remain on the feeding grounds through the fall and winter. However, the majority of the right whale population leaves the feeding grounds for unknown wintering habitats and returns when the cow-calf pairs return. The majority of the right whale population is unaccounted for on the southeastern U.S. winter calving ground, and not all reproductively-active females return to the area each year (Kraus et al. 1986; Winn et al. 1986; Kenney et al. 2001). Other wintering areas have been suggested, based on sparse data or historical whaling logbooks; these include the Gulf of St. Lawrence, Newfoundland and Labrador, coastal waters of New York and between New Jersey and North Carolina, Bermuda, and Mexico (Payne and McVay 1971; Aguilar 1986; Mead 1986; Lien et al. 1989; Knowlton et al. 1992; Cole et al. 2009; Patrician et al. 2009).

In more than 5000 recorded global sightings of North Atlantic right whales, there have been 11 within the polygon that bounds the exemplary surveys (OBIS, 2017). No sightings have been reported in July, August or September within the survey area (Figure 6). Given the small size of the population and their typical summer range, North Atlantic right whales should not be encountered during the USGS surveys.

HUMPBACK WHALE (MEGAPTERA NOVAEANGLIAE)

The humpback whale is found throughout all of the oceans of the world (Clapham 2009). Although considered to be mainly a coastal species, humpbacks often traverse deep pelagic areas while migrating (Clapham and Mattila 1990; Norris et al. 1999; Calambokidis et al. 2001). Humpback whales migrate between summer feeding grounds in high latitudes and winter calving and breeding grounds in tropical waters (Winn and Reichley 1985; Clapham and Mead 1999; Smith et al. 1999). The summer feeding grounds in the North Atlantic range from the northeast coast of the U.S. to the Barents Sea (Katona and Beard 1990; Smith et al. 1999). Humpbacks in the North Atlantic primarily migrate to wintering areas in the West Indies (Jann et al. 2003), but some also migrate to Cape Verde (Carrillo et al. 1999; Wenzel et al. 2009). A small proportion of the Atlantic humpback whale population remains in high latitudes in the eastern North Atlantic during winter (e.g., Christensen et al. 1992).

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 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 (Figure 6). Three of these sitings have been at or seaward of the shelf break, near the landward ends of the two northernmost exemplay 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.

MINKE WHALE (BALAENOPTERA ACUTOROSTRATA)

The minke whale has a cosmopolitan distribution that spans from tropical to polar regions in both hemispheres (Jefferson et al. 2015). Some populations migrate from high latitude summering grounds to lower latitude wintering grounds (Jefferson et al. 2015). In the Northern Hemisphere, the minke whale is usually seen in coastal areas, but can also occur in pelagic waters during northward migrations in spring and summer, and southward migration in autumn (Stewart and Leatherwood 1985; Perrin and Brownell 2009). There are four recognized minke whale populations in the North Atlantic: Canadian east coast, west Greenland, central North Atlantic, and northeast Atlantic (Donovan 1991). 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.

Most minke whale sitings south of 40°N have been on the continental shelf, at water depths shallower than the proposed USGS seismic lines. Minke whales may occasionally be encountered seaward of the shelf-break during the proposed USGS surveys. Of the more than 15,000 sightings of minke whale individuals or groups dating back more than 50 years in the OBIS database, 51 occurred within a rectangular block containing the exemplary proposed USGS seismic survey lines. Of these, twelve sightings comprising 21 individuals occurred during July, August, or September (Figure 6). Only two of the sightings were seaward of the shelf break, including one near Washington Canyon and another beyond the distal, deepwater termini of the three central USGS exemplary seismic transects.

Minke whales could be encountered near the survey lines in August, but this would be a rare occurrence.

BRYDE'S WHALE (BALAENOPTERA EDENI/BRYDEI)

Bryde's whale is found in tropical and subtropical waters throughout the world between 40ºN and 40ºS, generally in waters warmer than 20ºC, but at minimum 15ºC (Reeves et al. 1999; Kanda et al. 2007; Kato and Perrin 2009). It can be pelagic as well as coastal (Jefferson et al. 2015). It does not undertake long north/south migrations, although local seasonal movements toward the Equator in winter and to higher latitudes in summer take place in some areas (Evans 1987; Jefferson et al. 2015). Of 914 usable sightings in the iOBIS database, none occurred within the larger box enclosing the proposed survey in any season (Figure 6). Still, Bryde's whales could possibly be encountered in the proposed project area.

SEI WHALE (*BALAENOPTERA BOREALIS*)

The distribution of the sei whale is not well known, but it is found in all oceans and appears to prefer mid-latitude temperate waters (Gambell 1985a). The sei whale is pelagic and generally not found in coastal waters (Harwood and Wilson 2001; Jefferson et al. 2015). It is found 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). On feeding grounds, sei whales associate with oceanic frontal systems (Horwood 1987). Sei whales migrate from temperate zones occupied in winter to higher latitudes in the summer, where most feeding takes place (Gambell 1985a). A small number of individuals have been sighted in the eastern North Atlantic between October and December, indicating that some animals may remain at higher latitudes during winter (Evans 1992). Sei whales have been seen from South Carolina south into the Gulf of Mexico and the Caribbean during winter (Rice 1998); however, the location of sei whale wintering grounds in the North Atlantic is unknown (Víkingsson et al. 2010).

There are three sei whale stocks in the North Atlantic: Nova Scotia, Iceland-Denmark Strait, and Eastern (Donovan 1991). 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 7 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 (Figure 6). Sei whales could be encountered in the proposed project area during an August survey, but this would be an extremely rare occurrence.

FIN WHALE (*BALAENOPTERA PHYSALUS*)

Fin whales are widely distributed in all the world's oceans in coastal, shelf, and oceanic waters, and typically occur in temperate and polar regions (Gambell 1985b; Perry et al. 1999; Gregr and Trites 2001; Jefferson et al. 2015). Fin whales tend to follow steep slope contours, either because they detect them readily or because biological productivity is high along steep contours because of tidal mixing and perhaps current mixing (Sergeant 1977). Fin whales appear to have complex seasonal movements and are seasonal migrants; they mate and calve in temperate waters during the winter and migrate to feed at northern latitudes during the summer (Gambell 1985b). They are known to use the shelf edge as a migration route (Evans 1987).

In the North Atlantic, fin whales are found in summer from Baffin Bay, Spitsbergen, and the Barents Sea, south to North Carolina and the coast of Portugal (Rice 1998). In winter, they have been sighted from Newfoundland to the Gulf of Mexico and the Caribbean, and from the Faroes and Norway south to the Canary Islands (Rice 1998). Based on geographic differences in fin whale calls, Delarue et al. (2014) suggested that there are four distinct stocks in the Northwest Atlantic, including a central North Atlantic stock that and extends south along the Mid-Atlantic Ridge. Similarly, the four stocks in the Northwest Atlantic currently recognized by NAMMCO (2016) are located off West Iceland (in the Central Atlantic), Eastern Greenland, Western Greenland, and Eastern Canada.

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, 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 (Figure 6). Fin whales could be encountered during the proposed August surveys, particularly closer to the shelf edge and near the uppermost continental slope.

BLUE WHALE (BALAENOPTERA MUSCULUS)

The blue whale has a cosmopolitan distribution and tends to be pelagic, only coming nearshore to feed and possibly to breed (Jefferson et al. 2015). It is most often found in cool, productive waters where upwelling occurs (Reilly and Thayer 1990). The distribution of the species, at least during times of the year when feeding is a major activity, occurs in areas that provide large seasonal concentrations of euphausiids (Yochem and Leatherwood 1985). Seamounts and other deep ocean structures may be important habitat for blue whales (Lesage et al. 2016). Generally, blue whales are seasonal migrants between high latitudes in summer, where they feed, and low latitudes in winter, where they mate and give birth (Lockyer and Brown 1981). Their summer range in the North Atlantic extends from Davis Strait, Denmark Strait, and the waters north of Svalbard and the Barents Sea, south to the Gulf of St. Lawrence and the Bay of Biscay (Rice 1998). Although the winter range is mostly unknown, some occur near Cape Verde at that time of year (Rice 1998).

Of the more than 16,000 sightings of blue whale individuals or groups dating back more than 50 years in the OBIS database, only 2 occurred within a rectangular block containing the exemplary proposed USGS seismic survey lines. One of these, comprising a single individual, occurred during July, August, or September and was located ~85 nautical miles offshore New Jersey, on the upper continental slope between the two northernmost exemplary USGS seismic lines to be acquired down the continental slope (dip lines) and may either be an extralimital animal or a misidentification (Figure 6). While it would be a very rare occurrence, it is possible that a blue whale could be encountered in the proposed project area during an August seismic survey.

Odontocetes

SPERM WHALE (PHYSETER MACROCEPHALUS)

The sperm whale is the largest of the toothed whales, with an extensive worldwide distribution (Rice 1989). Sperm whale distribution is linked to social structure: mixed groups of adult females and juvenile animals of both sexes generally occur in tropical and subtropical waters, whereas adult males are commonly found alone or in same-sex aggregations, often occurring in higher latitudes outside the breeding season (Best 1979; Watkins and Moore 1982; Arnbom and Whitehead 1989; Whitehead and Waters 1990). Sperm whales generally are distributed over large areas that have high secondary productivity and steep underwater topography, in waters at least 1000 m deep (Jaquet and Whitehead 1996; Whitehead 2009). They are often found far from shore, but can occur closer to oceanic islands that rise steeply from deep ocean waters (Whitehead 2009).

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, 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.

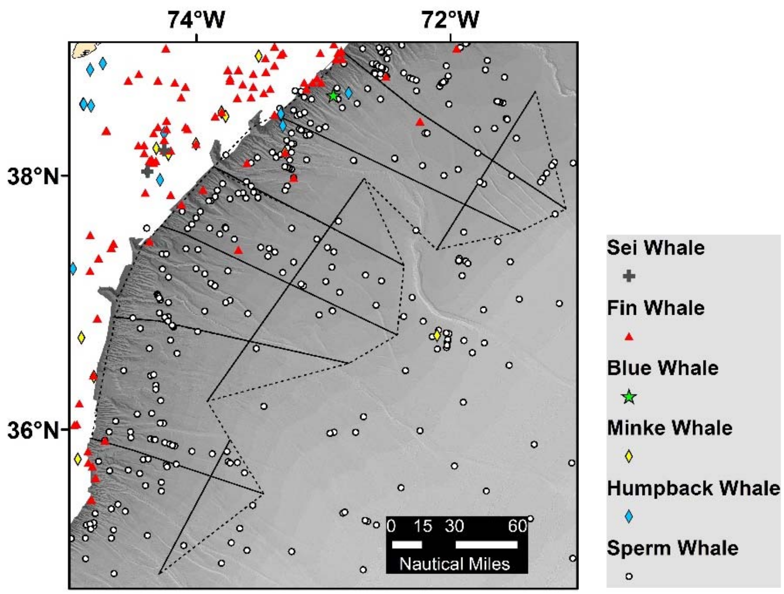

Figure 6. Sightings of endangered cetaceans and all baleen whales simultaneously overlapping the survey area and occurring during the summer (July through September) months as compiled from the iOBIS database by the USGS based on usable records. Note that there are no relevant sightings of North American right whales or Byrde's whales that meet the spatial and temporal criteria.

PYGMY AND DWARF SPERM WHALES (KOGIA BREVICEPS AND K. SIMA)

The pygmy sperm and dwarf sperm whales are high-frequency cetaceans distributed widely throughout tropical and temperate seas, but their precise distributions are unknown as most information on these species comes from strandings (McAlpine 2009). They are difficult to sight at sea, perhaps because of their avoidance reactions to ships and behavior changes in relation to survey aircraft (Würsig et al. 1998). The two species are difficult to distinguish from one another when sighted (McAlpine 2009) and are combined in the Roberts et al. (2015) density modeling under the auspices of the *Kogia* guild.

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 of the pygmy sperm whale sightings in the OBIS database occur 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 (ZIPHIUS CAVIROSTRIS)

Cuvier's beaked whale is probably the most widespread of the beaked whales. Cuvier's beaked whale appears to prefer steep continental slope waters (Jefferson et al. 2015) and is most common in water depths >1000 m (Heyning 1989). 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.

NORTHERN BOTTLENOSE WHALE (HYPEROODON AMPULLATUS)

The northern bottlenose whale is found only in the North Atlantic, from the subarctic to ~30°N (Jefferson et al. 2015). Northern bottlenose whales are most common in deep waters beyond the continental shelf or over submarine canyons, usually near or beyond the 1000-m isobath (Jefferson et al. 2015). 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.

TRUE'S BEAKED WHALE (MESOPLODON MIRUS)

True's beaked whale is mainly oceanic and occurs in warm temperate waters of the North Atlantic and southern Indian oceans (Pitman 2009). In the western North Atlantic, strandings have been recorded from Nova Scotia (~26°N) to Florida (46°N; MacLeod et al. 2006). Two sightings in the OBIS database occur in the general survey area, but only one of these was during the summer season that overlaps the Proposed Action. True's beaked whale likely would be rare in the proposed project area.

GERVAIS' BEAKED WHALE (MESOPLODON EUROPAEUS)

Gervais' beaked whale is mainly oceanic and occurs in tropical and warmer temperate waters of the Atlantic Ocean (Jefferson et al. 2015). It occurs in the Atlantic from ~54ºN to ~18ºS (MacLeod et al. 2006). Gervais' beaked whale is more common in the western than the eastern part of the Atlantic (Mead 1989). No OBIS sightings of the Gervais' beaked whale have occurred in the survey area. Given the geographic and depth range of the species, though, Gervais' beaked whale could be encountered in the proposed project area.

SOWERBY'S BEAKED WHALE (MESOPLODON BIDENS)

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). Sowerby's beaked whale is known primarily from strandings, which are more common in the eastern than the western North Atlantic (MacLeod et al. 2006). It is mainly a pelagic species and is found in deeper waters of the shelf edge and slope (Mead 1989). Eleven OBIS database sightings are in the polygon enclosing the larger area of the proposed surveys, and nine of these were during the summer months. Sowerby's beaked whale could be encountered in the proposed project area.

BLAINVILLE'S BEAKED WHALE (MESOPLODON DENSIROSTRIS)

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). Like other beaked whales, Blainville's beaked whales are generally found in deep water, 200–1400 m deep (Gannier 2000; Jefferson et al. 2015). In the OBIS database, one sighting occurred in the survey area, and it was during the summer months. Blainville's beaked whale could be encountered in the proposed project area.

Rough-toothed Dolphin (*Steno bredanensis*)

The rough-toothed dolphin occurs in tropical and subtropical waters, rarely ranging farther north than 40°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 (*Tursiops truncatus*)

The bottlenose dolphin is distributed worldwide in coastal and shelf waters of tropical and temperate oceans (Jefferson et al. 2015). There are two distinct bottlenose dolphin types in the Northwest Atlantic: a shallow water type, mainly found in coastal waters, and a deep water type, mainly found in oceanic waters (Duffield et al. 1983; Hoelzel et al. 1998; Walker et al. 1999). 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.

Pantropical Spotted Dolphin (*Stenella attenuata*)

The pantropical spotted dolphin can be found throughout tropical oceans of the world (Jefferson et al. 2015). 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.

Atlantic Spotted Dolphin (*Stenella frontalis*)

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.

Striped Dolphin (*Stenella coeruleoalba*)

The striped dolphin has a cosmopolitan distribution in tropical to warm temperate waters (Perrin et al. 1994); however, it also occurs in temperate waters as far north as 50°N (Jefferson et al. 2015). 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.

Atlantic White-sided Dolphin (*Lagenorhynchus acutus*)

The Atlantic white-sided dolphin occurs in cold temperate and subpolar waters in the North Atlantic; in the western Atlantic, its range is from ~38°N to southern Greenland (Jefferson et al. 2015). It appears to prefer deep waters of the outer shelf and slope, but can also occur in shallow and pelagic waters (Jefferson et al. 2015). In the OBIS database, 28 sightings of the Atlantic white-sided dolphin occur in the general area of the survey, and 9 of these are during the summer months. Atlantic white-sided dolphins could be encountered in the proposed project area.

WHITE-BEAKED DOLPHIN (LAGENORHYNCHUS ALBIROSTRIS)

The white-beaked dolphin occurs in cold temperate and subpolar regions of the North Atlantic; its range extends from Cape Cod to southern Greenland in the west and Portugal to Svalbard in the east (Kinze 2009; Jefferson et al. 2015). It appears to prefer deep waters along the outer shelf and slope, but can also occur in shallow areas and far offshore (Jefferson et al. 2015). There are four main high-density centers in the North Atlantic, including (1) the Labrador Shelf, (2) Icelandic waters, (3) waters around Scotland, and (4) the shelf along the coast of Norway (Kinze 2009). One sighting in the OBIS database of over 2700 records is of a white-beaked dolphin in the general survey area, and none occurred during the summer. White-beaked dolphins are unlikely to be encountered in the proposed project area.

SHORT-BEAKED COMMON DOLPHIN (DELPHINUS DELPHIS)

The short-beaked common dolphin is distributed in tropical to cool temperate waters of the Atlantic and the Pacific oceans from 60ºN to ~50ºS (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 ~35ºN (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% 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.

RISSO'S DOLPHIN (GRAMPUS GRISEUS)

Risso's dolphin is distributed worldwide in temperate and tropical oceans (Baird 2009), although it shows a preference for mid-temperate waters between 30° and 45° (Jefferson et al. 2014). Although it is known to occur in coastal and oceanic habitats (Jefferson et al. 2014), it appears to prefer steep sections of the continental shelf, 400–1000 m deep (Baird 2009), and is known to frequent seamounts and escarpments (Kruse et al. 1999; Baird 2009). 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.

PYGMY KILLER WHALE (FERESA ATTENUATA)

The pygmy killer whale is pantropical, inhabiting waters generally between 40°N and 35°S (Jefferson et al. 2015). 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.

FALSE KILLER WHALE (PSEUDORCA CRASSIDENS)

The false killer whale is found in all tropical and warmer temperate oceans, especially in deep, offshore waters (Jefferson et al. 2015). However, it is also known to occur in nearshore areas (e.g., Stacey and Baird 1991). The pelagic range in the North Atlantic is usually southward of ~30°N but extralimit individuals 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.

KILLER WHALE (ORCINUS ORCA)

The killer whale is globally fairly abundant, and it has been observed in all oceans of the world (Ford 2009). It is very common in temperate waters and also frequents tropical waters, at least seasonally (Heyning and Dahlheim 1988). 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% 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.

SHORT-FINNED PILOT WHALE (GLOBICEPHALA MACRORHYNCHUS)

The short-finned pilot whale is found in tropical, subtropical, and warm temperate waters (Olson 2009); it is seen as far south as ~40ºS and as far north as ~50ºN (Jefferson et al. 2015). 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 (GLOBICEPHALA MELAS)

The long-finned pilot whale occurs in temperate and sub-polar zones (Jefferson et al. 2015). It can be found in inshore or offshore waters of the North Atlantic (Olson 2009). In the western North Atlantic, high densities of long-finned pilot whales occurred over the continental slope in winter and spring, and they move to the shelf during summer and autumn (Jefferson et al. 2015). 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. (2015), meaning that there are no specific model density grids applicable to short-finned pilot whales.

MELON-HEADED WHALE (PEPONOCEPHALA ELECTRA)

The melon-headed whale is a pantropical species usually occurring between 40ºN and 35ºS (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 U.S., 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. (2015) 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 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.

HARBOR PORPOISE (PHOCOENA PHOCOENA)

The harbor porpoise inhabits temperate, subarctic, and arctic waters. It is typically found in shallow water (<100 m) nearshore, but it is occasionally sighted in deeper offshore water (Jefferson et al. 2015). The subspecies *P.p. phocoena* inhabits the Atlantic Ocean. In the western North Atlantic, it occurs from the southeastern U.S. to Baffin Island; in the eastern North Atlantic (Jefferson et al. 2015). Despite their abundance and the over 49,000 usable sightings of harbor porpoises in the OBIS database, only 7 occurred within the larger rectangular area encompassing the Proposed Action, and only 1 of these was during the summer months. Given their preference for coastal waters, harbor porpoises are expected to be seen during transits across the shelf, but are not expected to be encountered in the survey area during seismic operations.

FRASER'S DOLPHIN (LAGENODELPHIS HOSEI)

This information is compiled from the NOAA OPR website: http://www.nmfs.noaa.gov/pr/species/mammals/dolphins/frasers-dolphin.html. 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 Western North Atlantic stock of Fraser's dolphins, which is a population division recognized by NOAA, was unknown as of 2007 (http://www.nmfs.noaa.gov/pr/pdfs/sars/ao2007dofr-wn.pdf). The dolphins often occur in large groups (100 or more). The OBIS database has fewer than 200 sightings of Fraser dolphins. Only 3 sightings were within the larger project area, and only 2 of those were during the summer months. Fraser's dolphins could be encountered within the survey area during the Proposed Action.

SPINNER DOLPHIN (STENELLA LONGIROSTIS)

The following is taken verbatim from the Final EA for the ENAM project (LGL, 2014): 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 40ºN and 40ºS (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.

CLYMENE'S DOLPHIN (STENELLA CLYMENE)

The following is taken verbatim from the Final EA for the ENAM project (LGL, 2014). 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 analysesi, 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.

Table 5. The habitat, abundance, and conservation status of marine mammals that could occur in or near the proposed seismic project area in the Northwest Atlantic Ocean. Elements of this table were adopted directly from the Draft Scripps EA (LGL, 2017) and the ENAM EA (RPS, 2014c), with supplementary information from other sources for the populations. The iOBIS information in the far right columns was compiled by the USGS for this Draft EA using a polygon that roughly enclosed the entire area of the Proposed Action. Usable iOBIS sightings exclude those with dates entered in an incorrect format. Note that some iOBIS sightings lack dates, but were included in the overall count of usable sightings. The algorithm arbitrarily assigned those sightings without dates to January. Abundance values are mostly taken from the Draft Scripps EA (LGL 2017), with some additional values added as footnoted.

Species	Occurrence near survey location	Habitat	Abundance in North Atlantic	ESA[1]	IUCN[2]	CITES[3]	Usable iOBIS sightings compiled by USGS	Subset of sightings within survey area polygon	Subset of sightings in area that occurred July-Sept
Mysticetes									
North Atlantic right whale	Rare	Mainly coastal and shelf	440-736[4]	EN	EN	I	5695	11	0
Humpback whale	Uncommon	Mainly nearshore waters and	11,570[6]	NL (Atlantic)	LC	I	41354	79	14
Common minke whale	Uncommon	Coastal, offshore	157,000[7]	NL	LC	I	15843	51	12
Bryde's whale	Uncommon	Coastal,	N.A.	NL	DD	I	914	0	0
Sei whale	Uncommon	Mostly pelagic	10,300[8]	EN	EN	I	11127	7	2
Fin whale	Possible	Slope, mostly pelagic	24,887[9]	EN	EN	I	68029	131	29
Blue whale	Rare	Coastal, shelf, pelagic	855[10]	EN	EN	I	16949	2	1
Odontocetes									
Sperm whale	Likely	Usually deep pelagic, steep topography	13,190[11]	EN	VU	I	53789	686	395
Pygmy sperm whale (Kogia)	Possible	Deep waters off shelf	3785[12,13]	NL	DD	II	432	4	3
Dwarf sperm whale (Kogia)	Possible	Deep waters off shelf		NL	DD	II			
Cuvier's beaked whale	Possible	Slope, pelagic	3532[12]	NL	LC	II	1675	155	76
Northern bottlenose whale	Possible	Pelagic	~40,000[15]	NL	DD	I	2293	1	0
True's beaked whale	Possible	Pelagic	7092[12,14]	NL	DD	II	25	2	1
Gervais beaked whale	Possible	Pelagic	7092[12,14]	NL	DD	II	121	0	0
Sowerby's beaked whale	Possible	Pelagic	7092[12,14]	NL	DD	II	246	11	9
Blainville's beaked whale	Possible	Pelagic	7092[12,14]	NL	DD	II	574	1	1
Rough-toothed dolphin	Possible	Mostly pelagic	N.A.	NL	LC	II	1052	9	7

Table 6 (continued)

Species	Occurrence near survey location	Habitat	Abundance in North Atlantic	ESA[1]	IUCN[2]	CITES[3]	Usable iOBIS sightings compiled by USGS	Subset of sightings within survey area polygon	Subset of sightings in area that occurred July-Sept
Clymene dolphin	Likely	Deepwater	6068[20]	NL	DD	II	140	23	14
Spinner dolphin	Possible	Coastal	NA [22]	NL	DD	II	2278	0	0
Common bottlenose dolphin	Likely	Coastal, shelf, pelagic	77,532[16]	NL	LC	II	57879	1873	776
Fraser's dolphin	Possible	Deep offshore	492 * (sum of abundance in Roberts et al. 2016 grid)	NL	LC	II	177	3	2
Pantropical spotted dolphin	Possible	Shelf, slope, pelagic	3333[12]	NL	LC	II	4240	48	29
Melon-headed whale	Possible	Seaward of continental	3451 northern	NL	LC	II	327	0	0
Atlantic spotted dolphin	Likely	Shelf, offshore	44,715[12]	NL	DD	II	7655	125	58
Striped dolphin	Likely	Off continental shelf	54,807[12]	NL	LC	II	15620	183	95
Atlantic white-sided dolphin	Possible	Coastal, shelf	48,819[12]	NL	LC	II	7932	28	9
Short-beaked common dolphin	Likely	Shelf, pelagic, high relief	70,184[12]	NL	LC	II	42829	43	3
Risso's dolphin	Likely	Shelf, slope,	18,250[12]	NL	LC	II	7241	471	238
Pygmy killer whale	Uncommon	Pelagic	N.A.	NL	DD	II	204	3	3
False killer whale	Uncommon	Pelagic	442	NL	DD	II	1173	2	1
Killer whale	Uncommon	Coastal, widely distributed	15,014[17]	NL	DD	II	3077	3	0
Long-finned pilot whale	Likely	Mostly pelagic	5636[12] 780,000[18]	NL	DD	II	9082	51	16
Short-finned pilot whale	Likely	Mostly pelagic, high-relief	21,515[12] 780,000[18]	NL	DD	II	2514	414	105
Harbor porpoise	Uncommon	Coastal and shelf, also pelagic	79,833[19]	NL	LC	II	49502	7	1
White Beaked Dolphin	Uncommon	Cold waters < 200 m	2003[21]	NL	LC	II	2717	1	0

N.A. Not available or not assessed. NL = Not listed.
[1] U.S. Endangered Species Act: EN = Endangered.
[2] Codes for IUCN classifications: EN = Endangered; VU = Vulnerable; LC = Least Concern; DD = Data Deficient. Classifications are from the IUCN Red List of Threatened Species (IUCN 2017)
[3] Convention on International Trade in Endangered Species of Wild Fauna and Flora (UNEP-WCMC 2017); Appendix I = Threatened with extinction; Appendix II = not necessarily now threatened with extinction but may become so unless trade is closely controlled.
[4] Based on Pettis et al. (2017), Hayes et al. (2017), and IWC (2017)
[5] Doniol-Valcroze (2015)
[6] West Indies breeding ground (Stevick et al. 2003)
[7] Central (50,000), Northeast Atlantic (90,000), and West Greenland (17,000) populations (IWC 2017)
[8] North Atlantic (Cattanach et al. 1993)
[9] Central and Northeast Atlantic for 2001 (Víkingsson et al. 2009)
[10] Central and Northeast Atlantic for 2001 (Pike et al. 2009)
[11] For the northeast Atlantic, Faroes-Iceland, and the U.S. east coast (Whitehead 2002)
[12] Western North Atlantic (Hayes et al. 2017)
[13] Both *Kogia* species
[14] All *Mesoplodon* spp. combined
[15] Eastern North Atlantic (NAMMCO 1995)
[16] Offshore, Western North Atlantic (Hayes et al. 2017)
[17] Northeast Atlantic (Foote et al. *in* NAMMCO 2016)
[18] *Globicephala sp*. combined, Central and Eastern North Atlantic (IWC 2017)
[19] Gulf of Maine/Bay of Fundy stock (Hayes et al. 2017)
[20] Waring et al. (2008); Note that the Roberts et al. (2016) abundance grid would correspond to 12526 individuals.
[21] From NMFS stock assessment. http://www.nmfs.noaa.gov/pr/pdfs/sars/ao2007dowb-wn.pdf
[22] Spinner dolphins have no minimum population assessment. https://www.nefsc.noaa.gov/publications/tm/tm228/190_spinner.pdf

V. TYPE OF INCIDENTAL TAKE AUTHORIZATION REQUESTED

The type of incidental taking authorization that is being requested (i.e., takes by harassment only, takes by harassment, injury and/or death), and the method of incidental taking.

Much of the following material is taken verbatim from the Scripps IHAA (LGL, 2017b), with adaptations to the particulars of the USGS MATRIX effort.

The USGS requests an IHA pursuant to Section 101 (a)(5)(D) of the MMPA for incidental take by harassment during its planned seismic surveys in the Northwest Atlantic Ocean during August 2018. The operations outlined in § I have the potential to take marine mammals by harassment. Sounds would be generated by the GI airguns used during the surveys, by a fisheries echosounder, and by general vessel operations. "Takes" by harassment would potentially result when marine mammals near the activities are exposed to the pulsed sounds generated by the GI airguns. The effects would depend on the species of marine mammal, the behavior of the animal at the time of reception of the stimulus, as well as the distance and received level of the sound (see § VII). Disturbance reactions are likely amongst some of the marine mammals near the tracklines of the source vessel.

At most, effects on marine mammals would be anticipated as falling within the MMPA definition of "Level B Harassment" for those species managed by NMFS. No take by serious injury is expected, given the nature of the planned operations and the mitigation measures that are planned (see § XI, MITIGATION MEASURES), and no lethal takes are expected. Because of the characteristics of the proposed study and the proposed monitoring and mitigation measures, in addition to the general avoidance by marine mammals of loud sounds, Level A takes are considered highly unlikely and are not requested.

VI. NUMBERS OF MARINE MAMMALS THAT COULD BE TAKEN

By age, sex, and reproductive condition (if possible), the number of marine mammals (by species) that may be taken by each type of taking identified in [section V], and the number of times such takings by each type of taking are likely to occur.

The material for § VI and § VII has been combined and presented in reverse order to minimize duplication between sections.

The anticipated impact of the activity upon the species or stock of marine mammal.

VII. ANTICIPATED IMPACT ON SPECIES OR STOCKS

The following material is taken directly from the Draft Scripps EA (LGL, 2017a) and/or the Scripps IHAA (LGL, 2017b), with modifications to reflect the particulars of the USGS MATRIX program as described in detail in the Draft MATRIX EA (USGS, 2018).

The material for § VI and § VII has been combined and presented in reverse order to minimize duplication between sections.

- First we summarize the potential impacts on marine mammals of airgun operations, as called for in § VII, and refer to recent literature that has become available since the PEIS was released in 2011. A more comprehensive review of the relevant background information appears in § 3.6.4.3, § 3.7.4.3, and Appendix E of the PEIS.
- Then we summarize the potential impacts of operations by the fisheries echosounder.
- Finally, we estimate the numbers of marine mammals that could be affected by the proposed surveys in the Northwest Atlantic Ocean during August 2018. This section includes a description of the rationale for the estimates of the potential numbers of harassment "takes" during the planned surveys, as called for in § VI.

Summary of Potential Effects of Airgun Sounds

The following text is taken verbatim from the Scripps IHAA (LGL, 2017), with very minor changes to ensure consistency with USGS nomenclature.

As noted in the PEIS (§ 3.6.4.3, § 3.7.4.3, § 3.8.4.3), the effects of sounds from airguns could include one or more of the following: tolerance, masking of natural sounds, behavioral disturbance, and at least in theory, temporary or permanent hearing impairment, or non-auditory physical or physiological effects (Richardson et al. 1995; Gordon et al. 2004; Nowacek et al. 2007; Southall et al. 2007; Erbe 2012; Peng et al. 2015; Erbe et al. 2015, 2016). In some cases, a behavioral response to a sound can reduce the overall exposure to that sound (e.g., Finneran et al. 2015; Wensveen et al. 2015).

Permanent hearing impairment (PTS), in the unlikely event that it occurred, would constitute injury, but temporary threshold shift (TTS) is not considered an injury (Southall et al. 2007; Le Prell 2012). Rather, the onset of TTS has been considered an indicator that, if the animal is exposed to higher levels of that sound, physical damage is ultimately a possibility. Nonetheless, research has shown that sound exposure can cause cochlear neural degeneration, even when threshold shifts and hair cell damage are reversible (Kujawa and Liberman 2009; Liberman 2016). These findings have raised some doubts as to whether TTS should continue to be considered a non-injurious effect (Weilgart 2014; Tougaard et al. 2015, 2016). Although the possibility cannot be entirely excluded, it is unlikely that the proposed surveys would result in any cases of temporary or permanent hearing impairment, or any significant non-auditory physical or physiological effects. If marine mammals encounter a survey while it is underway, some behavioral disturbance could result, but this would be localized and short-term.

TOLERANCE

Numerous studies have shown that pulsed sounds from airguns are often readily detectable in the water at distances of many kilometers (e.g., Nieukirk et al. 2012). Several studies have shown that marine mammals at distances more than a few kilometers from operating seismic vessels often show no apparent response. That is often true even in cases when the pulsed sounds must be readily audible to the animals based on measured received levels and the hearing sensitivity of that mammal group. Although various baleen and toothed whales, and (less frequently) pinnipeds have been shown to react behaviorally to airgun pulses under some conditions, at other times mammals of all three types have shown no overt reactions. The relative responsiveness of baleen and toothed whales are quite variable.

MASKING

Masking effects of pulsed sounds (even from large arrays of airguns) on marine mammal calls and other natural sounds are expected to be limited, although there are few specific data on this. Because of the intermittent nature and low duty cycle of seismic pulses, animals can emit and receive sounds in the relatively quiet intervals between pulses. However, in exceptional situations, reverberation occurs for much or all of the interval between pulses (e.g., Simard et al. 2005; Clark and Gagnon 2006), which could mask calls. Situations with prolonged strong reverberation are infrequent. However, it is common for reverberation to cause some lesser degree of elevation of the background level between airgun pulses (e.g., Gedamke 2011; Guerra et al. 2011, 2016; Klinck et al. 2012; Guan et al. 2015), and this weaker reverberation presumably reduces the detection range of calls and other natural sounds to some degree. Guerra et al. (2016) reported that ambient noise levels between seismic pulses were elevated as a result of reverberation at ranges of 50 km from the seismic source. Based on measurements in deep water of the Southern Ocean, Gedamke (2011) estimated that the slight elevation of background levels during intervals between pulses reduced blue and fin whale communication space by as much as 36–51% when a seismic survey was operating 450–2800 km away. Based on preliminary modeling, Wittekind et al. (2016) reported that airgun sounds could reduce the communication range of blue and fin whales at a distance of 2000 km from the seismic source. Nieukirk et al. (2012) and Blackwell et al. (2013) noted the potential for masking effects from seismic surveys on large whales.

Some baleen and toothed whales are known to continue calling in the presence of seismic pulses, and their calls usually can be heard between the pulses (e.g., Nieukirk et al. 2012; Thode et al. 2012; Bröker et al. 2013; Sciacca et al. 2016). Cerchio et al. (2014) suggested that the breeding display of humpback whales off Angola could be disrupted by seismic sounds, as singing activity declined with increasing received levels. In addition, some cetaceans are known to change their calling rates, shift their peak frequencies, or otherwise modify their vocal behavior in response to airgun sounds (e.g., Di Iorio and Clark 2010; Castellote et al. 2012; Blackwell et al. 2013, 2015). The hearing systems of baleen whales are undoubtedly more sensitive to low-frequency sounds than are the ears of the small odontocetes that have been studied directly (e.g., MacGillivray et al. 2014). The sounds important to small odontocetes are predominantly at much higher frequencies than are the dominant components of airgun sounds, thus limiting the potential for masking. In general, masking effects of seismic pulses are expected to be minor, given the normally intermittent nature of seismic pulses. Sills et al. (2017) reported that recorded airguns sounds masked the detection of low-frequency sounds by ringed and spotted seals, especially at the onset of the airgun pulse when signal amplitude was variable.

DISTURBANCE REACTIONS

Disturbance includes a variety of effects, including subtle to conspicuous changes in behavior, movement, and displacement. Based on NMFS (2001, p. 9293), National Research Council (NRC 2005), and Southall et al. (2007), we believe that simple exposure to sound, or brief reactions that do not disrupt behavioral patterns in a potentially significant manner, do not constitute harassment or “taking”. By potentially significant, we mean, ‘in a manner that might have deleterious effects to the well-being of individual marine mammals or their populations’.

Reactions to sound, if any, depend on species, state of maturity, experience, current activity, reproductive state, time of day, and many other factors (Richardson et al. 1995; Wartzok et al. 2004; Southall et al. 2007; Weilgart 2007; Ellison et al. 2012). 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, let alone the stock or population (e.g., New et al. 2013a). 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 (Lusseau and Bejder 2007; Weilgart 2007; New et al. 2013b; Nowacek et al. 2015; Forney et al. 2017). Some studies have attempted modeling to assess consequences of effects from underwater noise at the population level (e.g., New et al. 2013b; King et al. 2015; Costa et al. 2016a,b; Ellison et al. 2016; Harwood et al. 2016; Nowacek et al. 2016; Farmer et al. 2017). Various authors have noted that some marine mammals that show no obvious avoidance or behavioral changes may still be adversely affected by sound (e.g., Weilgart 2007; Wright et al. 2011; Gomez et al. 2016).

Given the many uncertainties in predicting the quantity and types of impacts of noise on marine mammals, it is common practice to estimate how many marine mammals would be present within a particular distance of industrial activities and/or exposed to a particular level of industrial sound. In most cases, this approach likely overestimates the numbers of marine mammals that would be affected in some biologically important manner.

The sound criteria used to estimate how many marine mammals could be disturbed to some biologically important degree by a seismic program are based primarily on behavioral observations of a few species. Detailed studies have been done on humpback, gray, bowhead, and sperm whales. Less detailed data are available for some other species of baleen whales and small toothed whales, but for many species, there are no data on responses to marine seismic surveys.

Baleen Whales.—Baleen whales generally tend to avoid operating airguns, but avoidance radii are quite variable. Whales are often reported to show no overt reactions to pulses from large arrays of airguns at distances beyond a few kilometers, even though the airgun pulses remain well above ambient noise levels out to much longer distances. However, baleen whales exposed to strong noise pulses from airguns often react by deviating from their normal migration route and/or interrupting their feeding and moving away. In the cases of migrating gray and bowhead whales, the observed changes in behavior appeared to be of little or no biological consequence to the animals. They simply avoided the sound source by displacing their migration route to varying degrees, but within the natural boundaries of the migration corridors (Malme et al. 1984; Malme and Miles 1985; Richardson et al. 1995).

Responses of *humpback whales* to seismic surveys have been studied during migration, on summer feeding grounds, and on Angolan winter breeding grounds; there has also been discussion of effects on the Brazilian wintering grounds. Off Western Australia, avoidance reactions began at 5–8 km from the array, and those reactions kept most pods ~3–4 km from the operating seismic vessel; there was localized displacement during migration of 4–5 km by traveling pods and 7–12 km by more sensitive resting pods of cow-calf pairs (McCauley et al. 1998, 2000). However, some individual humpback whales, especially males, approached within distances of 100–400 m.

More recent studies examining the behavioral responses of humpback whales to airguns have also been conducted off eastern Australia (Cato et al. 2011, 2012, 2013, 2016), although results are not yet available for all studies. Dunlop et al. (2015) reported that humpback whales responded to a vessel operating a 20 in^3 airgun by decreasing their dive time and speed of southward migration; however, the same responses were obtained during control trials without an active airgun, suggesting that humpbacks responded to the source vessel rather than the airgun. A ramp up was not superior to triggering humpbacks to move away from the vessel compared with a constant source at a higher level of 140 in^3, although an increase in distance from the airgun array was noted for both sources (Dunlop et al. 2016a). Avoidance was also shown when no airguns were operational, indicating that the presence of the vessel itself had an effect on the response (Dunlop et al. 2016a,b). Responses to ramp up and use of a 3130 in^3 array elicited greater behavioral changes in humpbacks when compared with small arrays (Dunlop et al. 2016c). Overall, the results showed that humpbacks were more likely to avoid active airgun arrays (of 20 and 140 in^3) within 3 km and at levels of at least 140 dB re 1 $\mu Pa^2 \cdot s$ (Dunlop et al. 2017). These results are consistent with earlier studies (e.g., McCauley et al. 2000). Although there was no clear evidence of avoidance by humpbacks on their summer feeding grounds in southeast Alaska, there were subtle behavioral effects at distance up to 3.2 km and received levels of 150 to 172 re 1 µPa on an approximate rms basis (Malme et al. 1985).

In the northwest Atlantic, sighting rates were significantly greater during non-seismic periods compared with periods when a full array was operating, and humpback whales were more likely to swim away and less likely to swim towards a vessel during seismic vs. non-seismic periods (Moulton and Holst 2010). In contrast, sightings of humpback whales from seismic vessels off the U.K. during 1994–2010 indicated that detection rates were similar during seismic and non-seismic periods, although sample sizes were small (Stone 2015). It has been suggested that South Atlantic humpback whales wintering off Brazil may be displaced or even strand upon exposure to seismic surveys (Engel et al. 2004), but data from subsequent years indicated that there was no observable direct correlation between strandings and seismic surveys (IWC 2007).

There are no data on reactions of *right whales* to seismic surveys. However, Rolland et al. (2012) suggested that ship noise causes increased stress in right whales; they showed that baseline levels of stress-related faecal hormone metabolites decreased in North Atlantic right whales with a 6-dB decrease in underwater noise from vessels. Wright et al. (2011), Atkinson et al. (2015), Houser et al. (2016), and Lyamin et al. (2016) also reported that sound could be a potential source of stress for marine mammals.

Bowhead whales show that their responsiveness can be quite variable depending on their activity (migrating vs. feeding). Bowhead whales migrating west across the Alaskan Beaufort Sea in autumn, in particular, are unusually responsive, with substantial avoidance occurring out to distances of 20–30 km from a medium-sized airgun source (Miller et al. 1999; Richardson et al. 1999). Subtle but statistically significant changes in surfacing–respiration–dive cycles were shown by traveling and socializing bowheads exposed to airgun sounds in the Beaufort Sea, including shorter surfacings, shorter dives, and decreased number of blows per surfacing (Robertson et al. 2013). More recent research on bowhead whales corroborates earlier evidence that, during the summer feeding season, bowheads are less responsive to seismic sources (e.g., Miller et al. 2005; Robertson et al. 2013).

Bowhead whale calls detected in the presence and absence of airgun sounds have been studied extensively in the Beaufort Sea. Bowheads continue to produce calls of the usual types when exposed to airgun sounds on their summering grounds, although numbers of calls detected are significantly lower in the presence than in the absence of airgun pulses (Blackwell et al. 2013, 2015). Blackwell et al. (2013) reported that calling rates in 2007 declined significantly where received SPLs from airgun sounds were 116–129 dB re 1 μPa; at SPLs <108 dB re 1 μPa, calling rates were not affected. When data for 2007–2010 were analyzed, Blackwell et al. (2015) reported an initial increase in calling rates when airgun pulses became detectable; however, calling rates leveled off at a received $CSEL_{10\text{-min}}$ (cumulative SEL over a 10-min period) of ~94 dB re 1 $\mu Pa^2 \cdot s$, decreased at $CSEL_{10\text{-min}}$ >127 dB re 1 $\mu Pa^2 \cdot s$, and whales were nearly silent at $CSEL_{10\text{-min}}$ >160 dB re 1 $\mu Pa^2 \cdot s$. Thus, bowhead whales in the Beaufort Sea apparently decreased their calling rates in response to seismic operations, although movement out of the area could also have contributed to the lower call detection rate (Blackwell et al. 2013, 2015).

A multivariate analysis of factors affecting the distribution of calling bowhead whales during their fall migration in 2009 noted that the southern edge of the distribution of calling whales was significantly closer to shore with increasing levels of airgun sound from a seismic survey a few hundred kilometers to the east of the study area (i.e., behind the westward-migrating whales; McDonald et al. 2010, 2011). It was not known whether this statistical effect represented a stronger tendency for quieting of the whales farther offshore in deeper water upon exposure to airgun sound, or an actual inshore displacement of whales.

There was no indication that *western gray whales* exposed to seismic sound were displaced from their overall feeding grounds near Sakhalin Island during seismic programs in 1997 (Würsig et al. 1999) or 2001 (Johnson et al. 2007; Meier et al. 2007; Yazvenko et al. 2007a). However, there were indications of subtle behavioral effects among whales that remained in the areas exposed to airgun sounds (Würsig et al. 1999; Gailey et al. 2007; Weller et al. 2006a) and localized redistribution of some individuals within the nearshore feeding ground so as to avoid close approaches by the seismic vessel (Weller et al. 2002, 2006b; Yazvenko et al. 2007a). Despite the evidence of subtle changes in some quantitative measures of behavior and local redistribution of some individuals, there was no apparent change in the frequency of feeding, as evident from mud plumes visible at the surface (Yazvenko et al. 2007b).

Similarly, no large changes in gray whale movement, respiration, or distribution patterns were observed during seismic programs conducted in 2010 (Bröker et al. 2015; Gailey et al. 2016). Although sighting distances of gray whales from shore increased slightly during a 2-week seismic survey, this result was not significant (Muir et al. 2015). However, there may have been a possible localized avoidance response to high sound levels in the area (Muir et al. 2016). The lack of strong avoidance or other strong responses during the 2001 and 2010 programs was presumably in part a result of the comprehensive combination of real-time monitoring and mitigation measures designed to avoid exposing western gray whales to received SPLs above ~163 dB re 1 μPa_{rms} (Johnson et al. 2007; Nowacek et al. 2012, 2013b). In contrast, preliminary data collected during a seismic program in 2015 showed some displacement of animals from the feeding area and responses to lower sound levels than expected (Gailey et al. 2017; Sychenko et al. 2017).

Gray whales in British Columbia exposed to seismic survey sound levels up to ~170 dB re 1 μPa did not appear to be strongly disturbed (Bain and Williams 2006). The few whales that were observed moved away from the airguns but toward deeper water where sound levels were said to be higher due to propagation effects (Bain and Williams 2006).

Various species of *Balaenoptera* (blue, sei, fin, and minke whales) have occasionally been seen in areas ensonified by airgun pulses. Sightings by observers on seismic vessels using large arrays off the U.K. from 1994 to 2010 showed that the detection rate for minke whales was significantly higher when airguns were not operating; however, during surveys with small arrays, the detection rates for minke whales were similar during seismic and non-seismic periods (Stone 2015). Sighting rates for fin and sei whales were similar when large arrays of airguns were operating vs. silent (Stone 2015). All baleen whales combined tended to exhibit localized avoidance, remaining significantly farther (on average) from large arrays (median closest point of approach or CPA of ~1.5 km) during seismic operations compared with non-seismic periods (median CPA ~1.0 km; Stone 2015). In addition, fin and minke whales were more often oriented away from the vessel while a large airgun array was active compared with periods of inactivity (Stone 2015). Singing fin whales in the Mediterranean moved away from an operating airgun array, and their song notes had lower bandwidths during periods with vs. without airgun sounds (Castellote et al. 2012).

During seismic surveys in the northwest Atlantic, baleen whales as a group showed localized avoidance of the operating array (Moulton and Holst 2010). Sighting rates were significantly lower during seismic operations compared with non-seismic periods. Baleen whales were seen on average 200 m farther from the vessel during airgun activities vs. non-seismic periods, and these whales more often swam away from the vessel when seismic operations were underway compared with periods when no airguns were operating (Moulton and Holst 2010). Blue whales were seen significantly farther from the vessel during single airgun operations, ramp up, and all other airgun operations compared with non-seismic periods (Moulton and Holst 2010). Similarly, fin whales were seen at significantly farther distances during ramp up than during periods without airgun operations; there was also a trend for fin whales to be sighted farther from the vessel during other airgun operations, but the difference was not significant (Moulton and Holst 2010). Minke whales were seen significantly farther from the vessel during periods with than without seismic operations (Moulton and Holst 2010). Minke whales were also more likely to swim away and less likely to approach during seismic operations compared to periods when airguns were not operating (Moulton and Holst 2010). However, Matos (2015) reported no change in sighting rates of minke whales in Vestfjorden, Norway, during ongoing seismic surveys outside of the fjord. Vilela et al. (2016) cautioned that environmental conditions should be taken into account when comparing sighting rates during seismic surveys, as spatial modeling showed that differences in sighting rates of rorquals (fin and minke whales) during seismic periods and non-seismic periods during a survey in the Gulf of Cadiz could be explained by environmental variables.

Data on short-term reactions by cetaceans to impulsive noises are not necessarily indicative of long-term or biologically significant effects. It is not known whether impulsive sounds affect reproductive rate or distribution and habitat use in subsequent days or years. However, gray whales have continued to migrate annually along the west coast of North America with substantial increases in the population over recent years, despite intermittent seismic exploration (and much ship traffic) in that area for decades. In addition, bowhead whales have continued to travel to the eastern Beaufort Sea each summer, and their numbers have increased notably, despite seismic exploration in their summer and autumn range for many years.

Toothed Whales.—Little systematic information is available about reactions of toothed whales to sound pulses. However, there are recent systematic studies on sperm whales, and there is an increasing amount of information about responses of various odontocetes to seismic surveys based on monitoring studies. Seismic operators and protected species observers on seismic vessels regularly see dolphins and other small toothed whales near operating airgun arrays, but in general there is a tendency for most delphinids to show some avoidance of operating seismic vessels (e.g., Stone and Tasker 2006; Moulton and Holst 2010; Barry et al. 2012; Wole and Myade 2014; Stone 2015; Monaco et al. 2016). In most cases, the avoidance radii for delphinids appear to be small, on the order of 1 km or less, and some individuals show no apparent avoidance.

Observations from seismic vessels using large arrays off the U.K. from 1994–2010 indicated that detection rates were significantly higher for killer whales, white-beaked dolphins, and Atlantic white-sided dolphins when airguns were not operating; detection rates during seismic vs. non-seismic periods were similar during seismic surveys using small arrays (Stone 2015). Detection rates for long-finned pilot whales, Risso's dolphins, bottlenose dolphins, and short-beaked common dolphins were similar during seismic (small or large array) vs. non-seismic operations (Stone 2015). CPA distances for killer whales, white-beaked dolphins, and Atlantic white-sided dolphins were significantly farther (>0.5 km) from large airgun arrays during periods of airgun activity compared with periods of inactivity, with significantly more animals traveling away from the vessel during airgun operation (Stone 2015). Observers' records suggested that fewer cetaceans were feeding and fewer delphinids were interacting with the survey vessel (e.g., bow-riding) during periods with airguns operating (Stone 2015).

During seismic surveys in the northwest Atlantic, delphinids as a group showed some localized avoidance of the operating array (Moulton and Holst 2010). The mean initial detection distance was significantly farther (by ~200 m) during seismic operations compared with periods when the seismic source was not active; however, there was no significant difference between sighting rates (Moulton and Holst 2010). The same results were evident when only long-finned pilot whales were considered.

Preliminary findings of a monitoring study of *narwhals* in Melville Bay, Greenland (summer and fall 2012) showed no short-term effects of seismic survey activity on narwhal distribution, abundance, migration timing, and feeding habits (Heide-Jørgensen et al. 2013a). In addition, there were no reported effects on narwhal hunting. These findings do not seemingly support a suggestion by Heide-Jørgensen et al. (2013b) that seismic surveys in Baffin Bay may have delayed the migration timing of narwhals, thereby increasing the risk of narwhals to ice entrapment.

The beluga, however, is a species that (at least at times) shows long-distance (10s of km) avoidance of seismic vessels (e.g., Miller et al. 2005). Captive bottlenose dolphins and beluga whales exhibited changes in behavior when exposed to strong pulsed sounds similar in duration to those typically used in seismic surveys, but the animals tolerated high received levels of sound before exhibiting aversive behaviors (e.g., Finneran et al. 2000, 2002, 2005). Schlundt et al. (2016) also reported that bottlenose dolphins exposed to multiple airgun pulses exhibited some anticipatory behavior.

Most studies of *sperm whales* exposed to airgun sounds indicate that the sperm whale shows considerable tolerance of airgun pulses; in most cases the whales do not show strong avoidance (e.g., Stone and Tasker 2006; Moulton and Holst 2010). However, foraging behavior can be altered upon exposure to airgun sound (e.g., Miller et al. 2009) which, according to Farmer et al. (2017), could have significant consequences on individual fitness. Based on data collected by observers on seismic vessels off the U.K. from 1994–2010, detection rates for sperm whales were similar when large arrays of airguns were operating vs. silent; however, during surveys with small arrays, the detection rate was significantly higher when the airguns were not in operation (Stone 2015). Preliminary data from the Gulf of Mexico show a correlation between reduced sperm whale acoustic activity during periods with airgun operations

(Sidorovskaia et al. 2014).

There are almost no specific data on the behavioral reactions of *beaked whales* to seismic surveys. Most beaked whales tend to avoid approaching vessels of other types (e.g., Würsig et al. 1998) and/or change their behavior in response to sounds from vessels (e.g., Pirotta et al. 2012). Thus, it is likely that most beaked whales would also show strong avoidance of an approaching seismic vessel. Observations from seismic vessels off the U.K. from 1994–2010 indicated that detection rates of beaked whales were significantly higher ($p<0.05$) when airguns were not operating vs. when a large array was in operation, although sample sizes were small (Stone 2015). Some northern bottlenose whales remained in the general area and continued to produce high-frequency clicks when exposed to sound pulses from distant seismic surveys (e.g., Simard et al. 2005).

The limited available data suggest that *harbor porpoises* show stronger avoidance of seismic operations than do Dall's porpoises. Based on data collected by observers on seismic vessels off the U.K. from 1994–2010, detection rates of harbor porpoises were significantly higher when airguns were silent vs. when large or small arrays were operating (Stone 2015). In addition, harbor porpoises were seen farther away from the array when it was operating vs. silent, and were most often seen traveling away from the airgun array when it was in operation (Stone 2015). Thompson et al. (2013) reported decreased densities and reduced acoustic detections of harbor porpoise in response to a seismic survey in Moray Firth, Scotland, at ranges of 5–10 km (SPLs of 165–172 dB re 1 μPa, SELs of 145–151 dB $\mu Pa^2 \cdot s$). For the same survey, Pirotta et al. (2014) reported that the probability of recording a porpoise buzz decreased by 15% in the ensonified area, and that the probability was positively related to the distance from the seismic ship; the decreased buzzing occurrence may indicate reduced foraging efficiency. Nonetheless, animals returned to the area within a few hours (Thompson et al. 2013). Kastelein et al. (2013a) reported that a harbor porpoise showed no response to an impulse sound with an SEL below 65 dB, but a 50% brief response rate was noted at an SEL of 92 dB and an SPL of 122 dB re 1 $\mu Pa_{0\text{-peak}}$. However, Kastelein et al. (2012a) reported a 50% detection threshold at a SEL of 60 dB to a similar impulse sound; this difference is likely attributable to the different transducers used during the two studies (Kastelein et al. 2013a). The apparent tendency for greater responsiveness in the harbor porpoise is consistent with its relative responsiveness to boat traffic and some other acoustic sources (Richardson et al. 1995; Southall et al. 2007).

Odontocete reactions to large arrays of airguns are variable and, at least for delphinids, seem to be confined to a smaller radius than has been observed for the more responsive of the mysticetes and some other odontocetes. A ≥170 dB disturbance criterion (rather than ≥160 dB) is considered appropriate for delphinids (in particular mid-frequency cetaceans), which tend to be less responsive than the more responsive cetaceans. NMFS is currently developing new guidance for predicting behavioral effects (Scholik-Schlomer 2015). As behavioral responses are not consistently associated with received levels, some authors have made recommendations on different approaches to assess behavioral reactions (e.g., Gomez et al. 2016; Harris et al. 2017).

HEARING IMPAIRMENT AND OTHER PHYSICAL EFFECTS

Temporary or permanent hearing impairment is a possibility when marine mammals are exposed to very strong sounds. TTS has been demonstrated and studied in certain captive odontocetes and pinnipeds exposed to strong sounds (reviewed by Southall et al. 2007; Finneran 2015). However, there has been no specific documentation of TTS let alone permanent hearing damage, i.e., PTS, in free-ranging marine mammals exposed to sequences of airgun pulses during realistic field conditions.

Additional data are needed to determine the received sound levels at which small odontocetes would start to incur TTS upon exposure to repeated, low-frequency pulses of airgun sound with variable received levels. To determine how close an airgun array would need to approach in order to elicit TTS, one would (as a minimum) need to allow for the sequence of distances at which airgun pulses would occur, and for the dependence of received SEL on distance in the region of the seismic operation (e.g., Breitzke and Bohlen 2010; Laws 2012). At the present state of knowledge, it is also necessary to assume that the effect is directly related to total received energy (SEL); however, this assumption is likely an over-simplification (Finneran 2012). There is recent evidence that auditory effects in a given animal are not a simple function of received acoustic energy (Finneran 2015). Frequency, duration of the exposure, and occurrence of gaps within the exposure can also influence the auditory effect (Finneran and Schlundt 2010, 2011, 2013; Finneran et al. 2010a,b; Popov et al. 2011, 2013; Finneran 2012, 2015; Kastelein et al. 2012b,c; 2013b,c, 2014, 2015a, 2016a,b; Ku 2012; Supin et al. 2016).

Recent data have shown that the SEL required for TTS onset to occur increases with intermittent exposures, with some auditory recovery during silent periods between signals (Finneran et al. 2010b; Finneran and Schlundt 2011). Studies on bottlenose dolphins by Finneran et al. (2015) indicate that the potential for seismic surveys using airguns to cause auditory effects on dolphins could be lower than previously thought. Based on behavioral tests, no measurable TTS was detected in three bottlenose dolphins after exposure to 10 impulses from a seismic airgun with a cumulative SEL of up to ~195 dB re 1 $\mu Pa^2 \cdot s$ (Finneran et al. 2015; Schlundt et al. 2016). However, auditory evoked potential measurements were more variable; one dolphin showed a small (9 dB) threshold shift at 8 kHz (Finneran et al. 2015; Schlundt et al. 2016).

Recent studies have also shown that the SEL necessary to elicit TTS can depend substantially on frequency, with susceptibility to TTS increasing with increasing frequency above 3 kHz (Finneran and Schlundt 2010, 2011; Finneran 2012). When beluga whales were exposed to fatiguing noise with sound levels of 165 dB re 1 μPa for durations of 1–30 min at frequencies of 11.2–90 kHz, the highest TTS with the longest recovery time was produced by the lower frequencies (11.2 and 22.5 kHz); TTS effects also gradually increased with prolonged exposure time (Popov et al. 2013). Additionally, Popov et al. (2015) demonstrated that the impacts of TTS include deterioration of signal discrimination. Kastelein et al. (2015b) reported that exposure to multiple pulses with most energy at low frequencies can lead to TTS at higher frequencies in some cetaceans, such as the harbor porpoise.

Popov et al. (2016) reported that TTS produced by exposure to a fatiguing noise was larger during the first session (or naïve subject state) with a beluga whale than TTS that resulted from the same sound in subsequent sessions (experienced subject state). Similarly, several other studies have shown that some marine mammals (e.g., bottlenose dolphins, false killer whales) can decrease their hearing sensitivity in order to mitigate the impacts of exposure to loud sounds (e.g., Nachtigall and Supin 2013, 2014, 2015, 2016).

Previous information on TTS for odontocetes was primarily derived from studies on the bottlenose dolphin and beluga, and that for pinnipeds has mostly been obtained from California sea lions and elephant seals (see § 3.6.4.3, § 3.7.4.3, § 3.8.4.3 and Appendix E of the PEIS). Thus, it is inappropriate to assume that onset of TTS occurs at similar received levels in all cetaceans or pinnipeds (*cf.* Southall et al. 2007; NMFS 2016a). Some cetaceans or pinnipeds could incur TTS at lower sound exposures than are necessary to elicit TTS in the beluga and bottlenose dolphin or California sea lion and elephant seal, respectively.

Several studies on TTS in porpoises (e.g., Lucke et al. 2009; Popov et al. 2011; Kastelein et al. 2012c, 2013b,c, 2014, 2015a) have indicated that received levels that elicit onset of TTS are lower in porpoises than in other odontocetes. Kastelein et al. (2012c) exposed a harbor porpoise to octave band noise centered at 4 kHz for extended periods. A 6-dB TTS occurred with SELs of 163 dB and 172 dB for low-intensity sound and medium-intensity sound, respectively; high-intensity sound caused a 9-dB TTS at a SEL of 175 dB. Kastelein et al. (2013b) exposed a harbor porpoise to a long, continuous 1.5-kHz tone, which induced a 14-dB TTS with a total SEL of 190 dB. Popov et al. (2011) examined the effects of fatiguing noise on the hearing threshold of Yangtze finless porpoises when exposed to frequencies of 32–128 kHz at 140–160 dB re 1 μPa for 1–30 min. They found that an exposure of higher level and shorter duration produced a higher TTS than an exposure of equal SEL but of lower level and longer duration. Popov et al. (2011) reported a TTS of 25 dB for a Yangtze finless porpoise that was exposed to high levels of 3-min pulses of half-octave band noise centered at 45 kHz with an SEL of 163 dB.

For the harbor porpoise, Tougaard et al. (2015) suggested an exposure limit for TTS as an SEL of 100–110 dB above the pure tone hearing threshold at a specific frequency; they also suggested an exposure limit of $L_{eq\text{-}fast}$ (rms average over the duration of the pulse) of 45 dB above the hearing threshold for behavioral responses (i.e., negative phonotaxis). According to Wensveen et al. (2014) and Tougaard et al. (2015), M-weighting, as used by Southall et al. (2007), might not be appropriate for the harbor porpoise. Thus, Wensveen et al. (2014) developed six auditory weighting functions for the harbor porpoise that could be useful in predicting TTS onset. Mulsow et al. (2015) suggested that basing weighting functions on equal latency/loudness contours may be more appropriate than M-weighting for marine mammals. Houser et al. (2017) provide a review of the development and application of auditory weighting functions, as well as recommendations for future work.

Initial evidence from exposures to non-pulses has also suggested that some pinnipeds (harbor seals in particular) incur TTS at somewhat lower received levels than do most small odontocetes exposed for similar durations (Kastak et al. 1999, 2005, 2008; Ketten et al. 2001). Kastelein et al. (2012b) exposed two harbor seals to octave-band white noise centered at 4 kHz at three mean received SPLs of 124, 136, and 148 dB re 1 μPa; TTS >2.5 dB was induced at an SEL of 170 dB (136 dB SPL for 60 min), and the maximum TTS of 10 dB occurred after a 120-min exposure to 148 dB re 1 μPa or an SEL of 187 dB. Kastelein et al. (2013c) reported that a harbor seal unintentionally exposed to the same sound source with a mean received SPL of 163 dB re 1 μPa for 1 h induced a 44 dB TTS. For a harbor seal exposed to octave-band white noise centered at 4 kHz for 60 min with mean SPLs of 124–148 re 1 μPa, the onset of PTS would require a level of at least 22 dB above the TTS onset (Kastelein et al. 2013c). Reichmuth et al. (2016) exposed captive spotted and ringed seals to single airgun pulses with SELs of 165–181 dB and SPLs (peak to peak) of 190–207 re 1 μPa; no low-frequency TTS was observed.

Hermannsen et al. (2015) reported that there is little risk of hearing damage to harbor seals or harbor porpoises when using single airguns in shallow water. Similarly, it is unlikely that a marine mammal would remain close enough to a large airgun array for sufficiently long to incur TTS, let alone PTS. However, Gedamke et al. (2011), based on preliminary simulation modeling that attempted to allow for various uncertainties in assumptions and variability around population means, suggested that some baleen whales whose CPA to a seismic vessel is 1 km or more could experience TTS.

There is no specific evidence that exposure to pulses of airgun sound can cause PTS in any marine mammal, even with large arrays of airguns. However, given the possibility that some mammals close to an airgun array might incur at least mild TTS, there has been further speculation about the possibility that some individuals occurring very close to airguns might incur PTS (e.g., Richardson et al. 1995, p. 372*ff*; Gedamke et al. 2011). In terrestrial animals, exposure to sounds sufficiently strong to elicit a large TTS induces physiological and structural changes in the inner ear, and at some high level of sound exposure, these phenomena become non-recoverable (Le Prell 2012). At this level of sound exposure, TTS grades into PTS. Single or occasional occurrences of mild TTS are not indicative of permanent auditory damage, but repeated or (in some cases) single exposures to a level well above that causing TTS onset might elicit PTS (e.g., Kastak and Reichmuth 2007; Kastak et al. 2008).

The new noise exposure criteria for marine mammals that were recently released by NMFS (2016a) account for the newly-available scientific data on TTS, the expected offset between TTS and PTS thresholds, differences in the acoustic frequencies to which different marine mammal groups are sensitive, and other relevant factors. For impulsive sounds, such airgun pulses, the thresholds use dual metrics of cumulative SEL (SEL_{cum} over 24 hours) and Peak SPL_{flat}. Onset of PTS is assumed to be 15 dB higher when considering SEL_{cum} and 6 dB higher when considering SPL_{flat}. Different thresholds are provided for the various hearing groups, including LF cetaceans (e.g., baleen whales), MF cetaceans (e.g., most delphinids), HF cetaceans (e.g., porpoise and *Kogia* spp.), phocids underwater (PW), and otariids underwater (OW).

Nowacek et al. (2013a) concluded that current scientific data indicate that seismic airguns have a low probability of directly harming marine life, except at close range. Several aspects of the planned monitoring and mitigation measures for this project are designed to detect marine mammals occurring near the airgun array and to avoid exposing them to sound pulses that might, at least in theory, cause hearing impairment (see § XI and § XIII). Also, many marine mammals and (to a limited degree) sea turtles show some avoidance of the area where received levels of airgun sound are high enough such that hearing impairment could potentially occur. In those cases, the avoidance responses of the animals themselves would reduce or (most likely) avoid any possibility of hearing impairment. Aarts et al. (2016) noted that an understanding of animal movement is necessary in order to estimate the impact of anthropogenic sound on cetaceans.

Non-auditory physical effects may also occur in marine mammals exposed to strong underwater pulsed sound. Possible types of non-auditory physiological effects or injuries that might (in theory) occur in mammals close to a strong sound source include stress, neurological effects, bubble formation, and other types of organ or tissue damage. Gray and Van Waerebeek (2011) have suggested a cause-effect relationship between a seismic survey off Liberia in 2009 and the erratic movement, postural instability, and akinesia in a pantropical spotted dolphin based on spatially and temporally close association with the airgun array. It is possible that some marine mammal species (i.e., beaked whales) are especially susceptible to injury and/or stranding when exposed to strong transient sounds (e.g., Southall et al. 2007). Ten cases of cetacean strandings in the general area where a seismic survey was ongoing have led to speculation concerning a possible link between seismic surveys and strandings (Castellote and Llorens 2016). An analysis of stranding data found that the number of long-finned pilot whale stranding along Ireland's coast increased with seismic surveys operating offshore (McGeady et al. 2016). However, there is no definitive evidence that any of these effects occur even for marine mammals in close proximity to large arrays of airguns. Morell et al. (2017) examined the inner ears of long-finned pilot whales after a mass stranding in Scotland and reported damage to the cochlea compatible with over-exposure from underwater noise; however, no seismic surveys were occurring in the vicinity in the days leading up to the stranding.

Since 1991, there have been 64 Marine Mammal Unusual Mortality Events (UME) in the U.S. (NMFS 2017a). In a hearing to examine the Bureau of Ocean Energy Management's 2017–2022 OCS Oil and Gas Leasing Program (http://www.energy.senate.gov/public/index.cfm/hearings-and-business-meetings?ID=110E5E8F-3A65-4BEC-9D25-5D843A0284D3), it was Dr. Knapp's (a geologist from the

University of South Carolina) interpretation that there was no evidence to suggest a correlation between UMEs and seismic surveys given the similar percentages of UMEs in the Pacific, Atlantic, and Gulf of Mexico, and the greater activity of oil and gas exploration in the Gulf of Mexico.

Non-auditory effects, if they occur at all, would presumably be limited to short distances and to activities that extend over a prolonged period. Marine mammals that show behavioral avoidance of seismic vessels, including most baleen whales, some odontocetes, and some pinnipeds, are especially unlikely to incur non-auditory physical effects. The brief duration of exposure of any given mammal, the deep water in the proposed project area, and the planned monitoring and mitigation measures would further reduce the probability of exposure of marine mammals to sounds strong enough to induce non-auditory physical effects.

Possible Effects of Other Acoustic Sources

The Simrad fisheries EK60/80 transceiver with a single (38 kHz) split-beam transducer would be operated from the source vessel at water depths less than ~1800 m. Such equipment was not commonly used when the NSF-USGS PEIS was completed, but is now installed and run routinely on many global class research ships (e.g., Okeanos Explorer) and NOAA fisheries vessels. The EK80 is the newer, broadband transceiver that is starting to replace the widely used EK60 transceiver on some federal fleet vessels.

The following is copied nearly verbatim from the NOAA Northeast Fisheries Science Center application for a Letter of Authorization (NEFSC, 2014) for small takes associated with their research operations. Minor modifications have been made to focus the text on the type of EK60/80 system the USGS will use during the Proposed Action. NMFS granted NEFSC a 5-year LOA in 2015.

"Category 2 active acoustic sources (as defined by NEFSC) have moderate to very high output frequencies (10 to 180 kHz), generally short ping durations, and are typically focused (highly directional) to serve their intended purpose of mapping specific objects, depths, or environmental features. A number of these sources, particularly those with relatively lower sound frequencies coupled with higher output levels can be operated in different output modes (e.g., energy can be distributed among multiple output beams) that may lessen the likelihood of perception by and potential impact on marine life." The USGS Proposed Action would use only the 38 kHz transducer.

"Category 2 active acoustic sources are likely to be audible to some marine mammal species. Among the marine mammals, most of these sources are unlikely to be audible to whales and most pinnipeds, whereas they may be detected by odontocete cetaceans (and particularly high frequency specialists such as harbor porpoise). There is relatively little direct information about behavioral responses of marine mammals, including the odontocete cetaceans, but the responses that have been measured in a variety of species to audible sounds (see Nowacek et al. 2007; Southall et al. 2007 for reviews) suggest that the most likely behavioral responses (if any) would be short-term avoidance behavior of the active acoustic sources.

The potential for direct physical injury from these types of active sources is low, but there is a low probability of temporary changes in hearing (masking and even temporary threshold shift) from some of the more intense sources in this category. Recent measurements by Finneran and Schlundt (2010) of TTS in mid-frequency cetaceans from high frequency sound stimuli indicate a higher probability of TTS in marine mammals for sounds within their region of best sensitivity; the TTS onset values estimated by Southall et al. (2007) were calculated with values available at that time and were from lower frequency sources. Thus, there is a potential for TTS from some of the Category 2 active sources, particularly for mid- and high-frequency cetaceans. However, even given the more recent data, animals would have to be either very close (few hundreds of meters) and remain near sources for many repeated pings to receive overall exposures sufficient to cause TTS onset (Lucke et al. 2009; Finneran and Schlundt 2010). If behavioral responses typically include the temporary avoidance that might be expected (see above), the potential for auditory effects considered physiological damage (injury) is considered extremely low so as to be negligible in relation to realistic operations of these devices." It should be noted that in 2015 the USGS experienced at least once instance of a large group of unidentified odontocetes (greater than 20) approaching the vessel and engaging with the vessel's wake while the EK60 was running in active mode using the 38 kHz transducer in relatively low power mode at < 200 m water depth.

Additional information added by the USGS in formulating this EA: A recent study by Cholewiak et al. (2017) describes beaked whale detections and sightings on the shelf and upper slope while operating the EK60 in passive (listening for sounds) and active (transmitting a pulse from the transducer) mode off New England. The reduced number of sightings and vocalizations during EK60 surveys led the authors to conclude that beaked whales exhibit a behavioral response to EK60 surveys and that the whales may detect the signals at some distance. Cholewiak et al. (2017) also cite unpublished data showing that bottom recorders 1.3 km from the *R/V Henry Bigelow* could detect her EK60 transmissions at depths of 800 m. The results of a 2016 farfield sound source verification experiment conducted at ~100 m water depth with the USGS 38 kHz EK60 transducer are not yet available.

Clear data about the impact of EK60/80 fisheries sonars are still lacking. There is a possibility of a behavioral response to the EK60 transmissions from some odontocetes, despite the fact that the modeled radii to the 160 dB isopleths is small.

Other Possible Effects of Seismic Surveys

Other possible effects of seismic surveys on marine mammals include masking by vessel noise, disturbance by vessel presence or noise, and injury or mortality from collisions with vessels or entanglement in seismic gear. Vessel noise from *R/V Hugh R. Sharp* could affect marine animals in the proposed project area. Houghton et al. (2015) proposed that vessel speed is the most important predictor of received noise levels. Sounds produced by large vessels generally dominate ambient noise at frequencies from 20–300 Hz (Richardson et al. 1995). However, some energy is also produced at higher frequencies (Hermannsen et al. 2014); low levels of high-frequency sound from vessels has been shown to elicit responses in harbor porpoise (Dyndo et al. 2015). Increased levels of ship noise have been shown to affect foraging by porpoise (Teilmann et al. 2015) and humpback whales (Blair et al. 2016).

While vessel noise from *R/V Hugh R. Sharp* could affect marine animals in the proposed project area, the ship was Navy-designed as a "quiet vessel" and produces underwater radiated noise at levels below the International Council on Exploration of the Seas (ICES) noise curve at 8 knots (cruising speed). Note that the USGS Proposed Surveys will be carried out at ~4 knots, which requires the use of only one generator on the *R/V Hugh R. Sharp*. According to the ship's radiated noise measurement report (2009), this mode of operation produces two primary signals at less than 200 kHz: 83 kHz with SEL of 146 dB re 1 µPa at 1 yard and 163 kHz with SEL of 151 dB re 1 µPa at 1 yard.

Ship noise, through masking, can reduce the effective communication distance of a marine mammal if the frequency of the sound source is close to that used by the animal, and if the sound is present for a significant fraction of time (e.g., Richardson et al. 1995; Clark et al. 2009; Jensen et al. 2009; Gervaise et al. 2012; Hatch et al. 2012; Rice et al. 2014; Dunlop 2015; Erbe et al. 2016; Jones et al. 2017). In addition to the frequency and duration of the masking sound, the strength, temporal pattern, and location of the introduced sound also play a role in the extent of the masking (Branstetter et al. 2013, 2016; Finneran and

Branstetter 2013; Sills et al. 2017). In order to compensate for increased ambient noise, some cetaceans are known to increase the source levels of their calls in the presence of elevated noise levels from shipping, shift their peak frequencies, or otherwise change their vocal behavior (e.g., Parks et al. 2011, 2012, 2016a,b; Castellote et al. 2012; Melcón et al. 2012; Azzara et al. 2013; Tyack and Janik 2013; Luís et al. 2014; Sairanen 2014; Papale et al. 2015; Bittencourt et al. 2016; Dahlheim and Castellote 2016; Gospić and Picciulin 2016; Gridley et al. 2016; Heiler et al. 2016; Martins et al. 2016; O'Brien et al. 2016; Tenessen and Parks 2016). Similarly, harbor seals increased the minimum frequency and amplitude of their calls in response to vessel noise (Matthews 2017); however, harp seals did not increase their call frequencies in environments with increased low-frequency sounds (Terhune and Bosker 2016).

Baleen whales are thought to be more sensitive to sound at these low frequencies than are toothed whales (e.g., MacGillivray et al. 2014), possibly causing localized avoidance of the proposed project area during seismic operations. Reactions of gray and humpback whales to vessels have been studied, and there is limited information available about the reactions of right whales and rorquals (fin, blue, and minke whales). Reactions of humpback whales to boats are variable, ranging from approach to avoidance (Payne 1978; Salden 1993). Baker et al. (1982, 1983) and Baker and Herman (1989) found humpbacks often move away when vessels are within several kilometers. Humpbacks seem less likely to react overtly when actively feeding than when resting or engaged in other activities (Krieger and Wing 1984, 1986). Increased levels of ship noise have been shown to affect foraging by humpback whales (Blair et al. 2016). Fin whale sightings in the western Mediterranean were negatively correlated with the number of vessels in the area (Campana et al. 2015). Minke whales and gray seals have shown slight displacement in response to construction-related vessel traffic (Anderwald et al. 2013).

Holt et al. (2015) reported that changes in vocal modifications can have increased energetic costs for individual marine mammals. A negative correlation between the presence of some cetacean species and the number of vessels in an area has been demonstrated by several studies (e.g., Campana et al. 2015; Culloch et al. 2016; Oakley et al. 2017). Based on modeling, Halliday et al. (2017) suggested that shipping noise can be audible more than 100 km away and could affect the behavior of a marine mammal at a distance of 52 km in the case of tankers.

Many odontocetes show considerable tolerance of vessel traffic, although they sometimes react at long distances if confined by ice or shallow water, if previously harassed by vessels, or have had little or no recent exposure to ships (Richardson et al. 1995). Dolphins of many species tolerate and sometimes approach vessels (e.g., Anderwald et al. 2013). Some dolphin species approach moving vessels to ride the bow or stern waves (Williams et al. 1992). Physical presence of vessels, not just ship noise, has been shown to disturb the foraging activity of bottlenose dolphins (Pirotta et al. 2015) and blue whales (Lesage et al. 2017). Sightings of striped dolphin, Risso's dolphin, sperm whale, and Cuvier's beaked whale in the western Mediterranean were negatively correlated with the number of vessels in the area (Campana et al. 2015).

There are few data on the behavioral reactions of beaked whales to vessel noise, though they seem to avoid approaching vessels (e.g., Würsig et al. 1998) or dive for an extended period when approached by a vessel (e.g., Kasuya 1986). Based on a single observation, Aguilar Soto et al. (2006) suggest foraging efficiency of Cuvier's beaked whales may be reduced by close approach of vessels.

The NSF-USGS PEIS concluded that project vessel sounds would not be at levels expected to cause anything more than possible localized and temporary behavioral changes in marine mammals, and would not be expected to result in significant negative effects on individuals or at the population level. In addition, in all oceans of the world, large vessel traffic is currently so prevalent that it is commonly considered a usual source of ambient sound.

Another concern with vessel traffic is the potential for striking marine mammals (e.g., Redfern et al. 2013). Information on vessel strikes is reviewed in § 3.6.4.4 and § 3.8.4.4 of the NSF-USGS PEIS. Wiley et al. (2016) concluded that reducing ship speed is one of the most reliable ways to avoid ship strikes. However, McKenna et al. (2015) noted the potential absence of lateral avoidance demonstrated by blue whales and perhaps other large whale species to vessels (McKenna et al. 2015). The NSF-USGS PEIS concluded that the risk of collision of seismic vessels or towed/deployed equipment with marine mammals exists but is extremely unlikely, because of the relatively slow operating speed (typically 7–9 km/h) of the vessel during seismic operations, and the generally straight-line movement of the seismic vessel. During the proposed cruise, most (70%) of the seismic survey effort is expected to occur at a speed of ~15 km/h, and 30% is expected to occur at 9 km/h. However, the number of seismic survey km are low relative to other fast-moving vessels in the area. There has been no history of marine mammal vessel strikes with any of the vessels in the U.S. academic research fleet in the last two decades.

Numbers of Marine Mammals that could be "Taken by Harassment"

All takes would be anticipated to be Level B "takes by harassment" as described in § I, involving temporary changes in behavior. In the sections below, we describe methods to estimate the number of potential exposures to Level B and Level A sound levels and present estimates of the numbers of marine mammals that could be affected during the proposed seismic surveys. The estimates are based on consideration of the number of marine mammals that could be disturbed appreciably by the seismic surveys in the Northwest Atlantic Ocean. The main sources of distributional and numerical data used in deriving the estimates are described in the next subsection.

It is assumed that, during simultaneous operations of the airgun array and the fisheries sonar (EK60/80), any marine mammals close enough to be affected by the MBES and SBP would already be affected by the airguns. However, whether or not the airguns are operating simultaneously with the other sources, marine mammals are expected to exhibit no more than short-term and inconsequential responses to the EK60/80, given their characteristics (e.g., narrow downward-directed beam) and other considerations described in the Draft MATRIX EA (USGS, 2018). Such reactions are not considered to constitute "taking" (NMFS 2001), and indeed NOAA vessels (e.g., *Okeanos Explorer* and others), as well as other U.S. federal fleet vessels, routinely use the fisheries EK60/EK80 and other non-airgun sound sources with no mitigation procedures. Therefore, no additional take allowance is included for animals that could be affected by sound sources other than airguns.

BASIS FOR ESTIMATING "TAKE BY HARASSMENT"

The Level B estimates are based on a consideration of the number of marine mammals that could be within the area around the operating airgun array where received levels of sound ≥160 dB re 1 μPa_{rms} are predicted to occur (see Table 1). The estimated numbers are based on abundances (numbers) of marine mammals expected to occur in the area of the Proposed Action in the absence of a seismic survey. To the extent that marine mammals tend to move away from seismic sources before the sound level reaches the criterion level and tend not to approach an operating airgun array, these estimates likely overestimate the numbers actually exposed to the specified level of sound. The overestimation is expected to be particularly large when dealing with the higher sound level criteria, i.e., the PTS thresholds (Level A), as animals are more likely to move away when received levels are higher. Likewise, animals are less likely to approach within the PTS threshold radii than they are to approach within the considerably larger ≥160 dB (Level B) radius.

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) and for the beaked whale guild (Blainville's, Cuvier's, Gervais', Sowerby's, and True's beaked whales). There are no data for the pygmy killer whale, and results for the false killer whale were adopted.

Due to the heterogeneous species' densities in the Survey Area and the USGS's direct use of quantitative species density grids from Roberts et al. (2016) in estimating the impact of the surveys on cetaceans, it would be inappropriate to report the type of generic species density values commonly given in some Environmental Assessments produced for research seismic surveys. Instead, Table 6 gives calculated species density and standard deviation in the area containing the entire Proposed Action as determined from the Roberts et al. (2016) density grid and summarizes group size, as taken primarily from the Draft Scripps EA (LGL, 2017).

To determine takes, the USGS combined the Duke density grids with buffer zones arrayed on either side of each exemplary seismic line and linking/interseismic line, with the buffer zone sizes determined based on the Level A EZ and Level B mitigation zones calculated from the acoustic modeling. The Level A and Level B takes for each species in each 10 km x 10 km block of the IMG density grids are calculated based on the fractional area of each block intersected by the buffer zones (EZ and MZ) for LF, MF, and HF cetaceans. Summing takes along all of the lines yields the total take for each species for the Proposed Action for the Base and Optimal (§ 1) 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.

The estimated numbers of individuals potentially exposed to Level B are based on the 160-dB re 1 μPa_{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 7 shows the estimates of the number of cetaceans that potentially could be exposed to ≥160 dB re 1 μPa_{rms} during the Proposed Action for the Base Survey and the Optimal Survey if no animals moved away from the survey vessel. The *Requested Take Authorization* is given in the far right column of Table 7 and represents 25% more than the number of takes calculated using the ArcGIS-based quantitative method devised by the USGS. The requested takes are sometimes increased to account for the size of animal groups (Table 6), to capture the possibility that a rare species could be encountered and taken during the surveys, or to account for the fact that the species is particularly abundant and take up to 1% of population size should be considered.

The calculated takes in Table 7 also assume that the proposed surveys would be completed. In fact, it is unlikely that the entire survey pattern (exemplary lines plus 50% of the interseismic, linking lines) would be completed given the limitations on ship time, likely logistical challenges (compressor and GI gun repairs), time spent on transits and refueling, and the historical problems with weather during August in the Northwest Atlantic. In fact, USGS calculated timelines indicate that 25 days, including contingency, could be required to complete the full survey pattern. In fact, 22 days or fewer would be scheduled for this survey with the ship operator. The lines that are actually acquired would be dependent on weather, strength of the Gulf Stream (affects ability to tow the streamer in the appropriate geometry), and other considerations.

Thus, fewer takes would be expected than have been calculated or requested. Nonetheless, as is common practice, the requested takes ***have been increased by 25%*** (see below). Thus, the estimates estimates of the numbers of marine mammals potentially exposed to Level B sounds≥160 dB re 1 μPa$_{rms}$ are precautionary (conservative) and probably overestimate the actual numbers of marine mammals that could be involved.

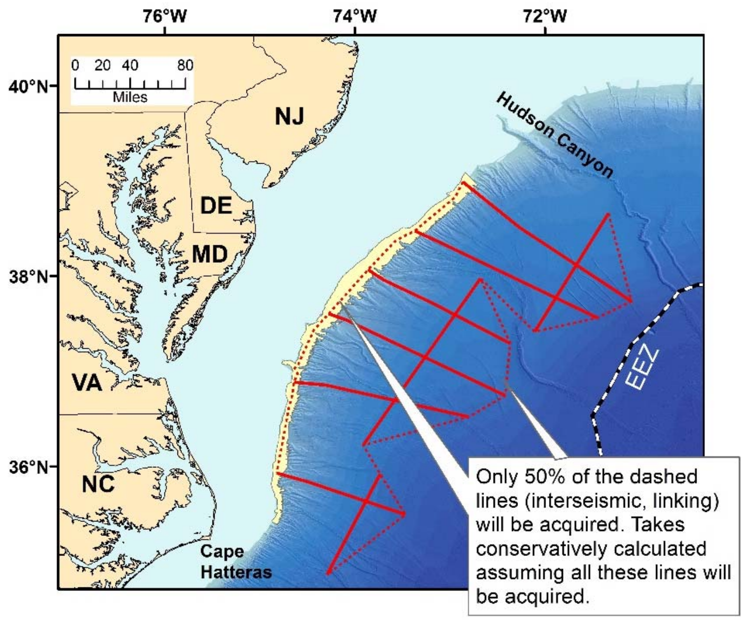

Figure 7. The Base Survey would acquire data along the exemplary lines (solid) and 50% of the interseismic linking lines using the base configuration of the GI guns (4 guns at 105 in^3 each). The Optimal Survey would acquire data on the exemplary lines using the GG gun configuration (4 guns at 210 in^3 each for the portions of these lines at greater than 1000 m water depth). For the Optimal Survey, the portion of the exemplary lines between 100 and 1000 m (yellow shading; bathymetry from Andrews et al., 2016) plus 50% of the linking interseismic lines with the base configuration. Takes are calculated for the entire survey pattern shown here even though only 50% of the linking, interseismic lines would be acquired.

In addition, it is possible that delphinids are less responsive to airgun sounds than are mysticetes, as referenced in both the NSF-USGS PEIS and in this document. The 160-dB (rms) criterion currently applied by NMFS, on which the Level B estimates are based, was developed primarily using data from gray and bowhead whales. The estimates of "takes by harassment" of delphinids are thus considered precautionary. Available data suggest that the current use of a 160-dB criterion could be improved upon, as behavioral response might not occur for some percentage of marine mammals exposed to received levels >160 dB, whereas other individuals or groups might respond in a manner considered as "taken" to sound levels <160 dB (NMFS 2013). It has become evident that the context of an exposure of a marine mammal to sound can affect the animal's initial response to the sound (NMFS 2013).

Table 6. Mean density and standard deviation of species' population in a polygon enclosing the entire survey based on ArcGIS analysis of the Roberts et al. (2016) grids. Month 8 (August) is used when

available. Otherwise, the generalized annual grid is used.

	Mean Density Per 100 km² in Polygon Enclosing Total Survey	Std Deviation on Mean Density Per 100 km²	Group Size	Source[1]
Mysticetes				
Low-Frequency Cetaceans				
North Atlantic Right Whale (*Eubalaena glacialis*)	0.00002	0.00013	1	J
Humpback Whale (*Megaptera novaeangliae*)	0.002	0.007	2	W
Minke Whale (*Balaenoptera acutorostrata*)	0.002	0.004	1	W
Bryde's Whale (*Balaenoptera edeni/brydei*)	<0.001	NA	1	W
Sei Whale (*Balaenoptera borealis*)	0.005	0.02	1.42	W
Fin Whale (*Balaenoptera physalus*)	0.041	0.077	1.71	W
Blue Whale (*Balaenoptera musculus*)	<0.001	NA	1	W
Odontocetes				
Mid-Frequency Cetaceans				
Sperm Whale (*Physeter macrocephalus*)	2.18	0.909	1.6	W
Cuvier's Beaked Whale (*Ziphius cavirostris*	2.42	2.51	3	W
True's Beaked Whale (*Mesoplodon mirus*)				
Gervais' Beaked Whale (*Mesoplodon europaeus*)				
Sowerby's Beaked Whale (*Mesoplodon bidens*)				
Blainville's Beaked Whale (*Mesoplodon densirostris*)				
Northern Bottlenose Whale (*Hyperoodon ampullatus*)	0.035	0.014	4-10	NOAA[5]
Rough-toothed Dolphin (*Steno bredanensis*)	0.068	0.006	10	J
Common Bottlenose Dolphin (*Tursiops truncatus*)	8.446	7.143	19	P
Pantropical Spotted Dolphin (*Stenella attenuata*)	0.607	0.055	26.3	P
Atlantic Spotted Dolphin (*Stenella frontalis*)	20.17	14.514	26.3	P
Striped Dolphin (*Stenella coeruleoalba*)	18.72	12.47	9.69	W
Atlantic White-sided Dolphin (*Lagenorhynchus acutus*)	0.064	0.083	14.71	W
White-beaked Dolphin (*Lagenorhynchus albirostris*)	<0.001	0.003	3	W
Short-beaked Common Dolphin (*Delphinus delphis*)	20.17	45.57	9.15	W
Risso's Dolphin (*Grampus griseus*)	2.683	5.01	11.5	P
Pygmy Killer Whale (*Feresa attenuata*)	No data	No data	12	J
False Killer Whale (*Pseudorca crassidens*)	0.008	NA	1	W
Killer Whale (*Orcinus orca*)	<0.001	NA	5	W
Short-finned Pilot Whale (*Globicephala macrorhynchus*)	4.153	2.738	25.76	W
Long-finned Pilot Whale (*Globicephala melas*)				
Clymene's dolphin (*Stenella clymene*)	1.365	1.262	60-80	NOAA[2]
Spinner dolphin (*Stenella longirostis*)	0.04	0.004	---	---
Fraser's dolphin (*Lagenodelphis hosei*)	0.042	0.051	10-100	NOAA[3]
Melon-headed whale (*Peponocephala electra*)	0.109	0.12	>100	NOAA[4]
High Frequency Cetaceans				
Harbor Porpoise (*Phocoena phocoena*)	0.009	0.019	3.6	P
Pygmy Sperm Whales (*Kogia breviceps*)	0.093	0.008	1.8	P
Dwarf Sperm Whales (*Kogia sima*)				

[1] Group sizes compiled primarily from the Draft Scripps EA (LGL, 2017); J = Jefferson et al., 2015; P = Palka, 2006; W=Waring et al., 2008. False killer whale group size based on that of unidentified small whales; Palka used data from the Northeast Navy Operating Area Offshore Stratum.[2]http://www.nmfs.noaa.gov/pr/species/mammals/dolphins/clymene-dolphin.html
[3]https://www.fisheries.noaa.gov/species/frasers-dolphin; [4] http://www.nmfs.noaa.gov/pr/species/mammals/whales/melon-headed-whale.html; [5]http://www.nmfs.noaa.gov/pr/species/mammals/whales/northern-bottlenose-whale.html

TABLE 7. Estimates of the possible numbers of individual marine mammals that could be exposed to Level B and Level A thresholds for various hearing groups during the proposed seismic surveys in the Northwest Atlantic Ocean in August 2018. As detailed in §1, the **base survey** corresponds to 4 GI guns producing a total of 420 in^3 of air. The **optimal survey** acquires the exemplary seismic lines with 4 GI guns operated in GG mode (840 in^3 of air) and interseismic linking lines collected with 4 GI guns operated at 105 in^3 each. Species in italics are listed under the ESA as *endangered*. Requested takes in **bold** have been increased over the calculations to reflect group size or other issues, as explained in the text.

Species	Base Survey[2]		Optimal Survey[2]		Max Level A Take	Max Level B Take for Optimal or Base Surveys +25%	Popula-tion used from Table 6	Level A + (Level B+25 %) as % of Pop.[5]	Requested Take Authorization (all Level B)[6]
	Level A[3]	Level B[4]	Level A[3]	Level B[4]					
LOW FREQUENCY CETACEANS									
North Atlantic right whale	0	*0*	0	*0*	0	*0*	*440*	*0*	*0*
Humpback whale	0	0	0	0	0	0	11,570	<0.1	1[7]
Minke whale	0	0	0	0	0	0	157,000	<0.1	0
Bryde's whale	0	0	0	0	0	0	N.A.	N.A.	0
Sei whale	0	*1*	*0*	*1*	0	*1*	*10,300*	*<0.01*	*1*
Fin whale	0	*4*	*0*	*4*	0	*5*	*24,887*	*0.02*	*5*
Blue whale	0	*0*	*0*	*0*	0	*0*	*855*	*<0.1*	*0*
MID-FREQUENCY CETACEANS									
Sperm whale	*0*	*119*	*0*	*128*	0	*160*	*13,190*	*1.2*	*160*
Cuvier's beaked whale True's beaked whale Gervais beaked whale Sowerby's beaked whale Blainville's beaked whale	0	94[11]	0	103[11]	0	128	3,532 7092[9] (non-Cuvier)	1.2, As proportion of total beaked whale population	128 (sum of all beaked whale takes)
Northern bottlenose whale	0	2	0	2	0	2	40,000	0.01	5
Rough-toothed dolphin	0	4	0	5	0	8	NA	N.A.	**60**
Common bottlenose dolphin	0	572	0	606	0	757	77,532	0.98	757
Pantropical spotted dolphin	0	38	0	40	0	50	3,333	1.5	50
Atlantic spotted dolphin	0	1191	0	1278	0	1598	44,715	3.6	1598
Striped dolphin	0	1086	0	1167	0	1458	54,807	2.7	1458
Atlantic white-sided dolphin	0	5	0	5	0	6	48,819	<0.1	**15**
White-beaked dolphin	0	0	0	0	0	0	2003	0	0
Short-beaked common dolphin	0	1253	0	1296	0	1620	70,184	2.3	1620
Risso's dolphin	0	181	0	189	0	236	18,250	1.5	236
Pygmy killer whale	0	1	0	1	0	1	NA	N.A.	1
False killer whale	0	1	0	1	0	1	442	0.15	1
Killer whale	0	3	0	3	0	4	15,014	0.03	4
Long-finned pilot whale	0	215	0	231	0	288	5,636-16,058[8]	1.7-4.9[10]	278 (sum of pilot whales)
Short-finned pilot whale					0		21,515	1.3[10]	
Clymene's dolphin	0	91	0	97	0	121	6,068	2	121
Spinner dolphin	0	3	0	3	0	3	ND	ND	3
Fraser's dolphin	0	3	0	3	0	4	492	0.8	**5**
Melon-headed whale	0	8	0	8	0	10	3451	0.3	10
HIGH-FREQUENCY CETACEANS									
Pygmy/dwarf sperm whale	0	6	0	7	0	9	3,785	0.2	9

Harbor porpoise	0	0	0	0	0	0	79,833	<0.01	0

[1] See text for density sources. N.A. = population size not available (see Table 6).
[2] Take calculated using method described in text and discussed with NMFS on USGS-managed webinar on March 8, 2018.
[3] Level A takes if there were no mitigation measures. Ensonified areas are based on PTS thresholds.
[4] Level B takes, based on the 160-dB criterion, excluding exposures to sound levels equivalent to PTS thresholds.
[5] Level A and B takes (used by NMFS as proxy for number of individuals exposed), expressed as % of population.
[6] Requested takes (Level A+Level B); increased to mean group size in some instances (see Table 9 for sources).
[7] Very small take requested because these species are very abundant, but the calculated take is zero based on the Duke density maps, which cannot capture all of the complexity in species distribution. In fact, the map of summer season sitings compiled from the OBIS database (Figure 6) by the applicant shows that humpback whales have been seen in the northern part of the Proposed Action area during this period.
[8] Low end estimate from https://www.nefsc.noaa.gov/publications/tm/tm241/86_F2016_longfinnedpilotwhale.pdf. High end estimate from TNASS (Western North Atlantic) surveys that counted pilot whales in habitat where the whales present are interpreted to be solely long-finned pilot whales, as described in the NMFS FR notice, 82 FR 26244.
[9] The combined number for *Mesoplodon sp*. Is the only one provided by NOAA in: https://www.nefsc.noaa.gov/publications/tm/tm228/91_blainvilles.pdf
[10] Calculated assuming that all takes were attributed to each of the two types of pilot whales, even though the take calculated for pilot whales represents the sum of the takes for the two types. Thus, the calculation shown here yields a maximum possible percentage of the population.
11 The species density maps treat beaked whales as an entire guild. Furthermore, NEFSC states that the population breakdown among the four species of beaked whales other than Cuvier's is unknown (https://www.nefsc.noaa.gov/publications/tm/tm228/91_blainvilles.pdf). The calculated take mathematically represents the sum of all beaked whale takes. The sum cannot be broken into individual species because the underlying data were for the guild and the fractional representation of each species among the total is unknown.

POTENTIAL NUMBER OF MARINE MAMMALS EXPOSED

As noted above, the number of cetaceans that could be exposed to airgun sounds with received levels ≥160 dB re 1 μPa_{rms} (Level B) for marine mammals on one or more occasions has been estimated by combining the gridded animal abundances available from the Duke University cetacean density website (http://seamap.env.duke.edu/models/Duke-EC-GOM-2015/) with the exemplary track lines/linking lines and Level B PTS threshold buffers calculated by LDEO. The method intersects the ensonified area along each track line for the appropriate Level B threshold buffer with the gridded animal abundances. For each block of the underlying abundance grid intersected by the trackline and associated ensonified area, the take is calculated as the percentage of that block's area that is ensonified multipled by the abundance of animals in the block. The takes are summed along each trackline and linking line and added to determine the total take for the surveys. The approach assumes that no marine mammals would move away or toward the trackline in response to increasing sound levels before the levels reach the specific thresholds as R/V *Sharp* approaches. The amount of overlap of the ensonified area is minimal and confined to areas of turns at the ends of exemplary survey lines or where linking lines join exemplary lines. The small amount of overlap reflects in part the fact that most exemplary dip lines are spaced at more than 20 km.

Total estimated takes for the entire survey are reported in Table 7 for the Optimal and Base surveys. The table also reports the maximum take of each species for the two survey configurations (see below) with 25% added as a buffer and the requested take authorization. The Optimal Survey includes most dip lines and one strike line acquired with the GG configuration (840 in^3 of air), with the remaining lines and linking lines acquired using the base (4x105 in^3 or 420 in^3 of air) configuration (Figure 7). Note that this is an overestimate since it assumes that **all** of the interseismic linking lines would have data acquisition, even though at most only half of the lines will be acquired. Some of the linking lines would not even be surveyed with seismic methods since transit between exemplary lines is faster with no streamer in the water, and such transits provide an opportunity to fix gear, refuel compressors, and address other issues. The take calculations for the Base Survey assume all of the exemplary lines and linking lines are acquired with the base (420 in^3 of air) configuration and, again, that all of the interseismic linking lines are acquired.

The *maximum* estimate of the number of cetaceans that could be exposed to seismic sounds with received levels ≥160 dB re 1 μPa_{rms} in the survey area is 5185 for the Optimal Survey (Table 7). This number was calculated assuming that seismic data would be acquired along all the shelf-break and deepwater interseismic connecting lines shown in the red dashed pattern in Figure 1 and assuming the maximum source levels are used for the major exemplary seismic lines (Optimal Survey). At most, only about half of the interseismic connecting lines will be acquired at either the shelf-break or deepwater. The maximum Level B take estimate of 5185 cetaceans includes ~133 cetacean individuals listed under the ESA: 1 sei whale, 4 fin whales, 128 sperm whales, and no blue or North Atlantic right whales. Adding the nominal 25% extra take to these values, the sperm whale figure represents 1.2% of the estimated population, fin whale take is ~0.02%, and sei whale take is 0.01%. Most Level B exposures would accrue to mid-frequency cetaceans. The largest potential takes would be for species that are plentiful and widespread, such as Atlantic spotted dolphin, striped dolphin, short-beaked common dolphin, and common bottlenose dolphin.

The take authorizations requested in the last column of Table 7 are precautionary and assume that certain extralimital mysticetes could be encountered during the Proposed Survey. For example, although no minke or humpback whales have historically been observed within the study area during the summer months, these species are very abundant in the North Atlantic, and a single Level B take has been requested for each species. Note also that the basis of the Take Authorization Request is the maximum A + B takes +25% for the Base and Optimal surveys, so the requested takes are very conservative. Were an equipment failure to force the Proposed Action to be carried out with the Base Configuration, takes would be far smaller based on the much smaller MZ given in Appendix A.

All of the calculated takes fall well within the typical definition of “small takes” as implemented under the MMPA. Some of the requested takes, but not all, have been increased to account for the average group size (Table 6). In other cases, group size was not taken into consideration. For example, melon-headed whales often occur in very large groups, but the requested take has been kept at the calculated value of 10 individuals. Harbor porpoise take is requested due to the sheer abundance of these animals and the remote possibility that they could occur extralimitally in the Proposed Survey Area. In some cases, the take request was increased to 1% of the population for particularly abundant species that are likely to be encountered in the Survey Area (e.g., common bottlenose dolphin).

Per NMFS requirement, estimates of the numbers of cetaceans that could be exposed to seismic sounds with received levels equal to Level A thresholds for various hearing groups, if there were no mitigation measures (shut downs when PSOs observed animals approaching or inside the EZs), are also given in Table 7. Level A takes were determined to be less than 0.5 individuals (and thus recorded as 0, the nearest whole number) for all species and for both survey configurations, even after the calculated takes were increased by 25%, as is common practice. Even those small calculated take numbers likely overestimate actual Level A takes because the predicted Level A EZs are very small and mitigation measures would further reduce the chances of, if not eliminate, any such takes. Level A takes are considered highly unlikely and are not requested.

CONCLUSIONS

The Proposed Action would involve towing an array of two to four GI airguns that introduce pulsed sounds into the ocean. Routine vessel operations and use of a fisheries sonar are conventionally assumed not to affect marine mammals sufficiently to constitute "taking".

This section incorporates by reference and adopts nearly verbatim the Draft Scripps EA (2017), with minor changes to reflect the particular circumstances applicable to the Proposed Action.

In § 3.6.2, 3.7.2, and 3.8.2, the NSF-USGS PEIS concluded that airgun operations with implementation of the proposed monitoring and mitigation measures could result in a small number of Level B behavioral effects in some cetaceans in the Northwest Atlantic DAA, that Level A effects were highly unlikely, and that operations were unlikely to adversely affect ESA-listed species. No Level A takes are requested for the Proposed Action. For five past NSF-funded seismic surveys and the 2014/15 USGS ECS survey (RPS, 2014a), NMFS issued small numbers of Level A take for some marine mammal species for the remote possibility of low-level physiological effects; however, NMFS expected neither mortality nor serious injury of marine mammals to result from the surveys (NMFS 2015b, 2016b,c, NMFS 2017a,b).

In the Draft MATRIX EA (USGS, 2018), estimates of the numbers of marine mammals that could be exposed to airgun sounds during the proposed program have been presented, together with the requested "take authorization". The estimated numbers of animals potentially exposed to sound levels sufficient to cause appreciable disturbance are very low percentages of the regional population sizes (Table 7).

The take calculations are likely to yield significant overestimates of the actual number of animals that would be exposed to and would react to the seismic sounds, particularly because most mammals, except some delphinids, tend to move away from sound sources. The relatively short-term exposures are unlikely to result in any long-term negative consequences for the individuals or their populations. Therefore, no significant impacts on marine mammals would be anticipated from the proposed activities.

In decades of seismic surveys carried out by the U.S. academic research fleet, PSOs and other crew members have not observed any seismic sound-related marine mammal injuries or mortality. Also, actual numbers of animals potentially exposed to sound levels sufficient to cause disturbance (i.e., to be considered takes) have almost always been much lower than predicted and authorized takes. For example, during the NSF-funded, ~5000-km, 2-D ENAM seismic survey conducted by the R/V *Langseth* off the coast of North Carolina in September–October 2014, only 296 cetaceans were observed within the predicted 160-dB zone and potentially taken, representing <2% of the 15,498 takes authorized by NMFS (RPS 2015). During the ~2700 km, 2-D ECS seismic survey conducted by the USGS aboard the R/V *Langseth* in the northwestern Atlantic Ocean in August–September 2014, only 3 unidentified dolphins were observed within the predicted 160-dB zone and potentially taken, representing <0.03% of the 11,367 authorized takes (RPS 2014b). Furthermore, as defined, all animals exposed to sound levels >160 dB are Level B 'takes' whether or not a behavioral response occurred. The 160-dB zone, which is based on predicted sound levels, is thought to be conservative given the type of acoustic modeling used to calculate the distance from the source to this isopleth; thus, not all animals detected within this zone would be expected to have been exposed to actual sound levels >160 dB.

VIII. ANTICIPATED IMPACT ON SUBSISTENCE

The anticipated impact of the activity on the availability of the species or stocks of marine mammals for subsistence uses.

There is no subsistence hunting near the proposed project area, so the proposed activities would not have any impact on the availability of the species or stocks for subsistence users.

IX. ANTICIPATED IMPACT ON HABITAT

The anticipated impact of the activity upon the habitat of the marine mammal populations, and the likelihood of restoration of the affected habitat.

The proposed seismic surveys would not result in any permanent impact on habitats used by marine mammals or to the food sources they use. The main impact issue associated with the proposed activity would be temporarily elevated noise levels and the associated direct effects on marine mammals, as discussed in § VII, above. Effects of seismic sound on marine invertebrates (crustaceans and cephalopods), marine fish, and their fisheries are discussed in § 3.2.4 and § 3.3.4 and Appendix D of the PEIS. The PEIS concluded that there could be changes in behavior and other non-lethal, short-term, temporary impacts, and injurious or mortal impacts on a small number of individuals within a few meters of a high-energy acoustic source, but that there would be no significant impacts of NSF-funded marine seismic research on populations.

X. ANTICIPATED IMPACT OF LOSS OR MODIFICATION OF HABITAT ON MARINE MAMMALS

The anticipated impact of the loss or modification of the habitat on the marine mammal populations involved.

The proposed activity is not expected to have any habitat-related effects that could cause significant or long-term consequences for individual marine mammals or their populations, because operations would be limited in duration. However, a small minority of the marine mammals that are present near the proposed activity may be temporarily displaced as much as a few kilometers by the planned activity.

XI. MITIGATION MEASURES

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, their habitat, and on their availability for subsistence uses, paying particular attention to rookeries, mating grounds, and areas of similar significance.

Marine mammals are known to occur in the proposed project area. To minimize the likelihood that impacts would occur to the species and stocks, GI airgun operations would be conducted in accordance with regulations by NMFS under the MMPA and the ESA, including obtaining permission for incidental harassment or incidental 'take' of marine mammals and other endangered species. The proposed activities would take place in the U.S. EEZ.

The following subsections provide more detailed information about the mitigation measures that are an integral part of the planned activity. The procedures described here are based on protocols used during previous USGS-led or NSF-funded seismic research cruises as approved by NMFS, and on best practices recommended in Richardson et al (1995), Pierson et al. (1998), Weir and Dolman (2007), Nowacek et al. (2013), Wright (2014), and Wright and Cosentino (2015).

Planning Phase

As discussed in § 2.4.1.1 of the NSF-USGS PEIS, mitigation of potential impacts from the proposed activity begins during the planning phase. Several factors were considered during the planning phase of the proposed activity, including

***Energy Source*.—**The energy source was chosen to be the lowest practical to meet the scientific objectives. Since the dataset to be acquired during MATRIX (Proposed Action) is expected to be used for 30 years or more, the USGS also assessed how to minimize the source size while ensuring maximum penetration, highest resolution, and appropriate imaging of the hydrate stability zone and shallow natural gas distributions and to produce data of high enough quality for the results to still be considered useful in the multidecadal timeframe. The USGS settled on a range of sources and potential configurations, with the base configuration of four airguns operated at 105 in^3. The largest source that could be used is four airguns operated at 210 in^3 and towed at 3 m depth, which would be used only at water depths > 1000 m when recording data on sonobuoys. The total air volume associated with these sources is ~6 to 17% of those used for most modern 2D and 3D seismic programs (usually > 6000 in^3).

***Survey Timing*.—**When choosing the timing of the survey, the USGS took into consideration environmental conditions (e.g., the seasonal presence of marine mammals), weather, vessel availability, and optimal timing for this and other proposed research cruises on the *R/V Hugh R. Sharp* . Some marine mammal species are expected to occur in the area year-round, so altering the timing of the proposed project likely would result in no net benefits for those species.

***Mitigation Zones*----**During the planning phase, mitigation zones for the proposed marine seismic surveys were calculated based on modeling by L-DEO for both the exclusion and safety zones. Received sound levels have been predicted by L-DEO's model (Diebold et al. 2010, provided as Appendix H in the NSF-USGS PEIS), as a function of distance from the airguns, for the three potential airgun configurations: (1) Base configuration: 4 GI guns producing a total of 420 in^3 of air; (2) GG configuration: 4 GI guns producing a total of 840 in^3 of air, which will be used only to shoot to sonobuoys along certain lines at water depths greater than 1000 m; and (3) Backup configuration: 2 GI guns producing a total of 210 in^3 of air. The base and GG configuration mitigation zones are described in § 1, and the backup configuration calculations in Appendix A.

For deep water (>1000 m), we use the deep-water radii obtained from L-DEO model results (Figures 2 and 3) to determine the distance from the airguns where the received sound level is 160 dB re 1μPa_{rms}. Table 2 shows the distances at which the 160- and 175-dB re 1μPa_{rms} sound levels are expected to be received for the GI airgun configurations. The 160-dB level is the behavioral disturbance criterion that is used to estimate anticipated Level B takes for marine mammals; a 175-dB level is used by NMFS to determine behavioral disturbance for sea turtles.

NMFS guidance for assessing the effects of anthropogenic sound on marine mammal hearing (NMFS 2016a) established new thresholds for PTS onset or Level A Harassment (injury), for marine mammal species. The summary distances to the PTS thresholds for the various marine mammal hearing groups are provided in Table 3, with the detail provided in Appendix C.

The NSF-USGS PEIS defined a low-energy source as any towed acoustic source whose received level is ≤180 dB re 1 μPa_{rms} (the Level A threshold under the former NMFS acoustic guidance) at 100 m. Table 3 of Appendix F of the NSF-USGS PEIS shows that a quadrilateral (4 GI gun) array of 105 in^3 guns would meet the low-energy criteria if towed at 3 m depth and separated by 8 m. Based on the modeling in Table 1 and the fact that the quadrilateral array of guns to be used for the Proposed Action would be separated by only 2 m front to back and 8.6 m side to side (and will be operated occasionally in GG mode, which generates 210 in^3 of air per GI gun), the Proposed Action slightly exceeds the criteria of a low-energy activity according to the NSF-USGS PEIS. Note that the sources to be used for the Proposed Action at maximum generate less than 20% of the air (usually > 6000 in^3) typically used for seismic surveys by a range of research and private sector operators.

In § 2.4.2 of the NSF-USGS PEIS, Alternative B (the Preferred Alternative) conservatively applied a 100-m EZ for low-energy acoustic sources in water depths >100 m. For the Proposed Action, which does not meet the ≤180 dB re 1 μPa_{rms} Level A criterion formerly applied by NMFS and outlined in Appendix F of the NSF-USGS PEIS, the actual calculated EZ (Table 4 and Appendix C) based on the 2016 NMFS Acoustic Guidelines are substantially smaller than this prescribed 100 m EZ. Adopting the calculated EZ instead of the prescribed 100 m EZ would therefore result in a less conservative approach to protection of marine mammals (and turtles) and higher actual takes during the Proposed Action. Thus, the Proposed Action will voluntarily adopt a 100 m EZ for marine mammals. If marine mammals or sea turtles are detected in or about to enter the appropriate EZ, the airguns would be shut down immediately. Enforcement of mitigation zones via shut downs would be implemented in the Operational Phase, as noted below. A fixed 160-dB "Safety Zone" was not defined in the NSF-USGS, nor was the mitigation zone criteria changed by NMFS for marine mammals in the interim; therefore, L-DEO model results for the appropriate gun configuration are used here to determine the 160-dB radius (Table 2).

Mitigation During Operations

Mitigation measures that would be adopted include (1) vessel speed or course alteration, provided that doing so would not compromise operational safety requirements, (2) GI-gun power down to decrease the size of the EZ; (3) GI-airgun shut down when mammals or other protected species are within or about to enter EZs; and (4) ramp-up procedures.

SPEED OR COURSE ALTERATION

If a marine mammal or sea turtle is detected outside the EZ and, based on its position and the relative motion is considered likely to enter the adopted 100 m EZ, the vessel's speed and/or direct course could be changed. This would be done if operationally practicable while minimizing the effect on the planned science objectives. The activities and movements of the marine mammal or sea turtle (relative to the seismic vessel) would then be closely monitored to determine whether the animal is approaching the applicable EZ. If the animal appears likely to enter the EZ, further mitigating actions would be taken, i.e., either further course alterations or a power down or shut down of the seismic source. Typically, during seismic operations, the source vessel is unable to change speed or course and one or more alternative mitigation measures (see below) would need to be implemented.

POWER-DOWN

A power down involves decreasing the number of airguns in use such that the radius of the threshold zone is decreased to the extent that marine mammals or turtles are no longer in or about to enter the EZ. The acoustic source would also be powered down in the event an ESA-listed seabird were observed diving or foraging close to the designated EZ. During a power down, one airgun would be left operating (mitigation gun). The continued operation of one airgun is intended to alert marine mammals and turtles to the presence of the seismic vessel in the area. In contrast, a shut down, which is described below, occurs when all airgun activity is suspended.

If a marine mammal or turtle is detected outside the EZ but is likely to enter the EZ, the airguns could be powered down before the animal is within the EZ. Likewise, if a mammal or turtle is already within the EZ when first detected, the airguns would be powered down immediately to reduce the size of the EZ. During the initial power down of the airgun array, one 105 in^3 airgun would be operated. If a marine mammal or turtle is detected within or near the smaller calculated EZ around that single airgun, that airgun would also be shut down (see next subsection). While we do not access to separate modeling for a single 105 in^3 airgun, the EZ for the two 105 in^3 configuration (backup configuration; see Appendix C) provides cautionary (conservative) EZ radii. The maximum (HF) cetacean EZ calculated for two 105 in^3 is less than 43 m, so ~45 m would be conservatively adopted as the radius of the reduced EZ around a single airgun to which a power-down might occur if a protected species enters the 100 m EZ.

Following a power down, full array airgun activity could resume via ramp-up (add one gun every 5 minutes) once the marine mammal or turtle has cleared the EZ. As excerpted directly from the NSF-USGS PEIS (§ES6.1) and modified to exclude animals not relevant to the study area, the animal would be considered to have cleared the EZ if:

- is visually observed to have left the EZ;
- has not been seen within the EZ for 15 min in the case of small odontocetes; or
- has not been seen within the EZ for 30 min in the case of mysticetes and large odontocetes, including sperm, pygmy sperm, dwarf sperm, and beaked whales; or
- the vessel has moved outside the applicable EZ in which the animal in question was last seen.

When moving at 4 knots, the vessel progresses ~2 m/s. Thus, the 100 m EZ would be cleared in under 1 minute. The largest Level B zone (175 dB zone calculated for turtles is 291 m, for the base GI gun configuration at 100-1000 m water depth, per the Draft MATRIX EA (USGS, 2018); note that the GG configuration would not be used shallower than 1000 m) could be cleared in less than 2.5 minutes.

SHUT-DOWN PROCEDURES

If (a) a marine mammal or turtle is detected about to enter or is already within the EZ; (b) the vessel's movement cannot maintain the animal outside the EZ; and (c) the power down of the airguns (see above) will not be fast enough to prevent the animal from entering the EZ, the GI airguns would be shut down immediately. In consultation with NMFS, exceptions may be made for some delphinids. The operating airguns would also be shut down in the event an ESA-listed seabird were observed diving or foraging within the designated EZ and power down will not reduce the size of the EZ enough to avoid the bird's activity counting as a "take." Following a shut down, PSOs will conduct observations for at least 30 minutes. Seismic activity would not resume until the marine mammal or turtle has cleared the EZ, the ship has moved away from the last sighting of the animal for 4 minuts, or the PSO is confident that the animal has left the vicinity of the vessel. As excerpted directly from the NSF-USGS PEIS (§ES6.1) and modified to exclude animals not relevant to the study area, the animal would be considered to have cleared the EZ zone if

- is visually observed to have left the EZ;
- has not been seen within the EZ for 15 min in the case of small odontocetes; or

- has not been seen within the EZ for 30 min in the case of mysticetes and large odontocetes, including sperm, pygmy sperm, dwarf sperm, and beaked whales; or
- the vessel has moved outside the applicable EZ in which the animal in question was last seen.

As noted above, when moving at 4 knots, the vessel progresses ~2 m/s. Thus, the 100 m EZ would be cleared in under 1 minute. The largest Level B zone (175 dB zone calculated for turtles is 291 m, for the base GI gun configuration at 100-1000 m water depth, per the Draft MATRIX EA (USGS, 2018); note that the GG configuration would not be used shallower than 1000 m).

The airgun array will be shut down if a North Atlantic right whale is observed at any distance from the vessel and will remain shut down 30 minutes after the last sighting.

RAMP-UP PROCEDURES

A ramp-up procedure would be followed when the GI airguns begins operating after a specified period without GI airgun operations. PSOs will conduct observations for at least 30 minutes prior to the initiation of the ramp up. The ramp-up period to use of the full 4 airguns would be 20 min, with one gun added every 5 minutes. If one gun had been operating during a power-down (see above), ramp up to the full array would take 15 minutes, with one additional gun added every 5 minutes. Ramp up would not occur if a marine mammal or sea turtle has not cleared the 100 m EZ, as described earlier. Ramp up would begin with one (additional) GI airgun at 105 in^3, and the second (additional) GI airgun would be added after 5 min and so forth. Only after all 4 guns were firing at 105 in^3 could power be increased to run the sources in GG mode (210 in^3 each). During ramp up, the PSOs would monitor the EZ. If marine mammals or turtles are sighted, a power down or shut down would be implemented as though the full array were operational.

XII. PLAN OF COOPERATION

Where the proposed activity would take place in or near a traditional Arctic subsistence hunting area and/or may affect the availability of a species or stock of marine mammal for Arctic subsistence uses, the applicant must submit either a plan of cooperation or information that identifies what measures have been taken and/or will be taken to minimize any adverse effects on the availability of marine mammals for subsistence uses. A plan must include the following:

(i) A statement that the applicant has notified and provided the affected subsistence community with a draft plan of cooperation;

(ii) A schedule for meeting with the affected subsistence communities to discuss proposed activities and to resolve potential conflicts regarding any aspects of either the operation or the plan of cooperation;

(iii) A description of what measures the applicant has taken and/or will take to ensure that proposed activities will not interfere with subsistence whaling or sealing; and

(iv) What plans the applicant has to continue to meet with the affected communities, both prior to and while conducting activity, to resolve conflicts and to notify the communities of any changes in the operation.

Not applicable. The proposed activity would take place in the Northwest Atlantic Ocean and within the U.S. EEZ, and no activities would take place in or near a traditional Arctic subsistence hunting area.

XIII. MONITORING AND REPORTING PLAN

The suggested means of accomplishing the necessary monitoring and reporting that will result in increased knowledge of the species, the level of taking or impacts on populations of marine mammals that are expected to be present while conducting activities and suggested means of minimizing burdens by coordinating such reporting requirements with other schemes already applicable to persons conducting such activity. Monitoring plans should include a description of the survey techniques that would be used to determine the movement and activity of marine mammals near the activity site(s) including migration and other habitat uses, such as feeding...

Most of this section is taken verbatim from the Scripps IHAA application (LGL, 2017b) and adapted for the USGS circumstances outlined in this application and in the Draft MATRIX EA (USGS, 2018).

The USGS will arrange for professional marine mammal monitoring during the project, in order to implement the proposed mitigation measures that require real-time monitoring, and to satisfy the anticipated monitoring requirements of the IHA. The proposed Monitoring Plan is described below. The USGS understands that this Monitoring Plan would be subject to review by NMFS and that refinements may be required.

The monitoring work described here has been planned as a self-contained project independent of any other related monitoring projects that may be occurring simultaneously in the same regions. The USGS is prepared to discuss coordination of its monitoring program with any related work that might be done by other groups insofar as this is practical and desirable.

Vessel-based Visual Monitoring

PSO observations would take place during daytime GI airgun operations and nighttime start ups of the airguns. GI airgun operations would be suspended when marine mammals, turtles, or diving ESA-listed seabirds are observed within, or about to enter, designated EZs [see § XI above], where there is concern about potential effects on hearing or other physical effects. PSOs would also watch for marine mammals and turtles near the seismic vessel for at least 30 min prior to the planned start of airgun operations. When feasible, PSOs would also make observations during daytime periods when the seismic system is not operating for comparison of animal abundance and behavior. PSOs would also watch for any potential impacts of the acoustic sources on fish.

Three PSOs would be appointed by the USGS, with NMFS Office of Protected Resources concurrence. At least one PSO would monitor the EZ during seismic operations. PSOs would normally work in shifts of 4-hour duration or less. The vessel crew would also be instructed to assist in detecting marine mammals and turtles.

The flying bridge on the *R/V Hugh R. Sharp* is ~10.6 m above the water's surface and is a suitable platform from which PSOs would watch for marine mammals and turtles. Standard equipment for marine mammal observers would be 7 x 50 marine, anti-fog reticle binoculars and optical range finders. 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 that they can advise promptly of the need for avoidance maneuvers or seismic source shut down.

PSO Data and Documentation

The following is taken verbatim from the recent IHAA submitted by Scripps and prepared by LGL (LGL, 2017b). Since these are standard procedures, they do not require adaptation for this IHAA. PSOs would record data to estimate the numbers of marine mammals, turtles, and diving ESA-listed seabirds exposed to various received sound levels and to document apparent disturbance reactions or lack thereof. They would also record any observations of fish potentially affected by the sound sources. Data would be used to estimate numbers of marine mammals potentially 'taken' by harassment (as defined in the MMPA). They would also provide information needed to order a power down or shut down of the airguns when a marine mammal, sea turtle, or diving ESA-listed seabird is within or near the EZ.

When a sighting is made, the following information about the sighting would be recorded:

i. Species, group size, age/size/sex categories (if determinable), behavior when first sighted and after initial sighting, heading (if consistent), bearing and distance from seismic vessel, sighting cue, apparent reaction to the airguns or vessel (e.g., none, avoidance, approach, paralleling, etc.), and behavioral pace.

ii. Time, location, heading, speed, activity of the vessel, sea state, visibility, and sun glare.

The data listed under (2) would also be recorded at the start and end of each observation watch, and during a watch whenever there is a change in one or more of the variables.

All observations and shut downs would be recorded in a standardized format. Data would be entered into an electronic database. The accuracy of the data entry would be verified by computerized data validity checks as the data are entered and by subsequent manual checking of the database. These procedures would allow initial summaries of data to be prepared during and shortly after the field program, and would facilitate transfer of the data to statistical, graphical, and other programs for further processing and archiving.

Results from the vessel-based observations would provide

1. The basis for real-time mitigation (GI airgun shut down).
2. Information needed to estimate the number of marine mammals potentially taken by harassment, which must be reported to NMFS.
3. Data on the occurrence, distribution, and activities of marine mammals, turtles, and diving ESA-listed seabirds in the area where the seismic study is conducted.
4. Information to compare the distance and distribution of marine mammals, turtles, and diving ESA-listed seabirds relative to the source vessel at times with and without seismic activity.
5. Data on the behavior and movement patterns of marine mammals and turtles seen at times with and without seismic activity.
6. Any observations of fish potentially affected by the sound sources.

A report would be submitted to NMFS within 90 days after the end of the cruise. The report would describe the operations that were conducted and sightings of marine mammals and turtles near the operations. The report would provide full documentation of methods, results, and interpretation pertaining to all monitoring. The 90-day report would summarize the dates and locations of seismic operations, all marine mammal, turtle, and diving ESA-listed seabird sightings (dates, times, locations, activities, associated seismic survey activities), and any observations of fish potentially affected by the sound sources. The report would also include estimates of the number and nature of exposures that could result in "takes" of marine mammals by harassment or in other ways.

XIV. COORDINATING RESEARCH TO REDUCE AND EVALUATE INCIDENTAL TAKE

Suggested means of learning of, encouraging, and coordinating research opportunities, plans, and activities relating to reducing such incidental taking and evaluating its effects.

The USGS would coordinate the planned marine mammal monitoring program associated with the seismic survey with other parties that may have interest in this area. The USGS would coordinate with applicable U.S. agencies (e.g., NMFS), and would comply with their requirements.

XV. LITERATURE CITED

Many of the biological references are taken directly from the Draft Scripps EA (LGL, 2017a), as incorporated in the Draft MATRIX EA (USGS, 2018) by reference. Some references taken from the Scripps IHAA (LGL, 2017b). Updates have been made where necessary to reflect additional or alternate information used by or accessed by the U.S. Geological Survey. All access dates for online information refer to LGL's activities in preparation of the Draft Scripps EA (LGL, 2017a) when these dates are in 2017.

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APPENDICES

Appendix A: Backup Configuration Information and Calculations

In the case of compressor failure or other equipment problems, the airguns could be operated in the backup, 2 GI gun, configuration. The exclusion/mitigation zones for this configuration are significantly smaller than those for the configurations (Base and GG) targeted for the Optimal and Base Surveys. Thus, takes calculated for the other configurations are larger and therefore more conservative than applicable to the Backup Configuration. For the sake of completeness, information about the backup configuration is provided here and calculations of the sound source levels are given in Appendix C. **Backup Configuration** (Configuration 3) is 2 GI guns producing 210 in^3 total volume, as shown in Figure A1. If a compressor were offline, this lowest-energy configuration would be used to sustain data acquisition. Guns 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.

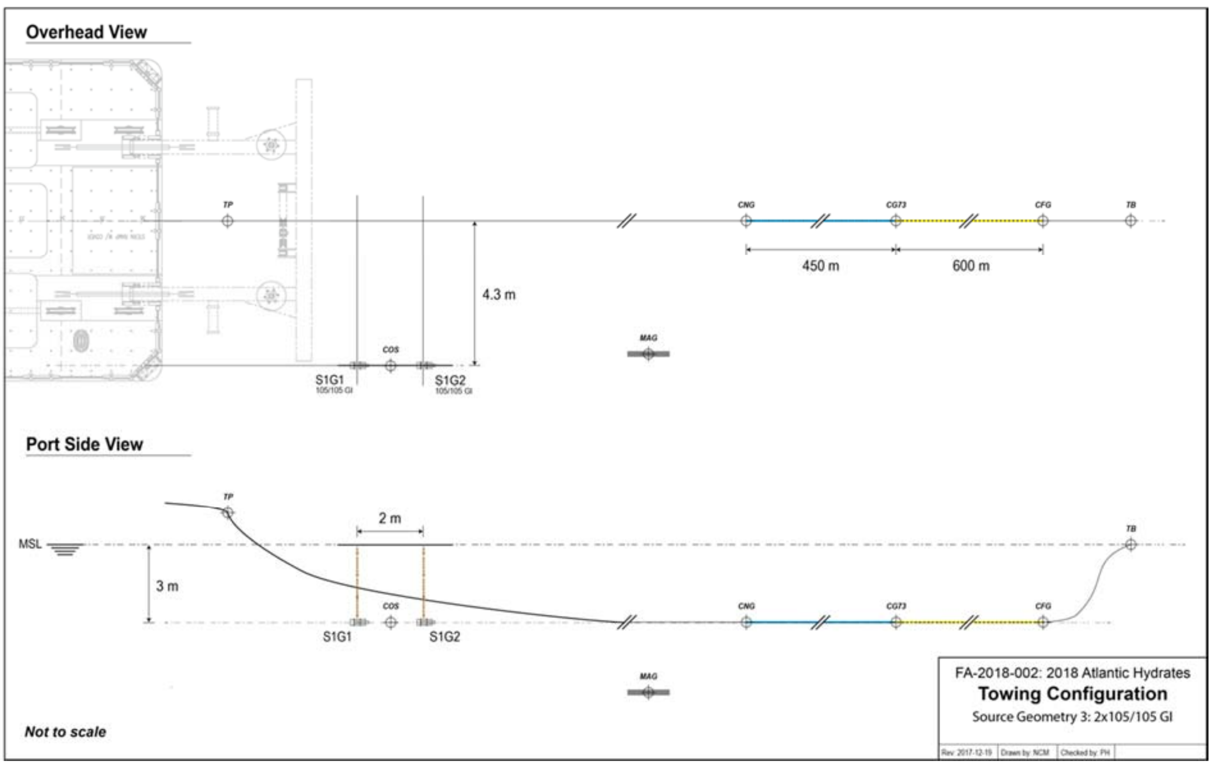

Figure A1. **Backup configuration** (Source configuration 3): 210 in^3 total volume consisting of 2x105/105in^3 GI guns firing in standard GI mode. Guns are labelled as S#G*, where # is the side and * is the gun number.

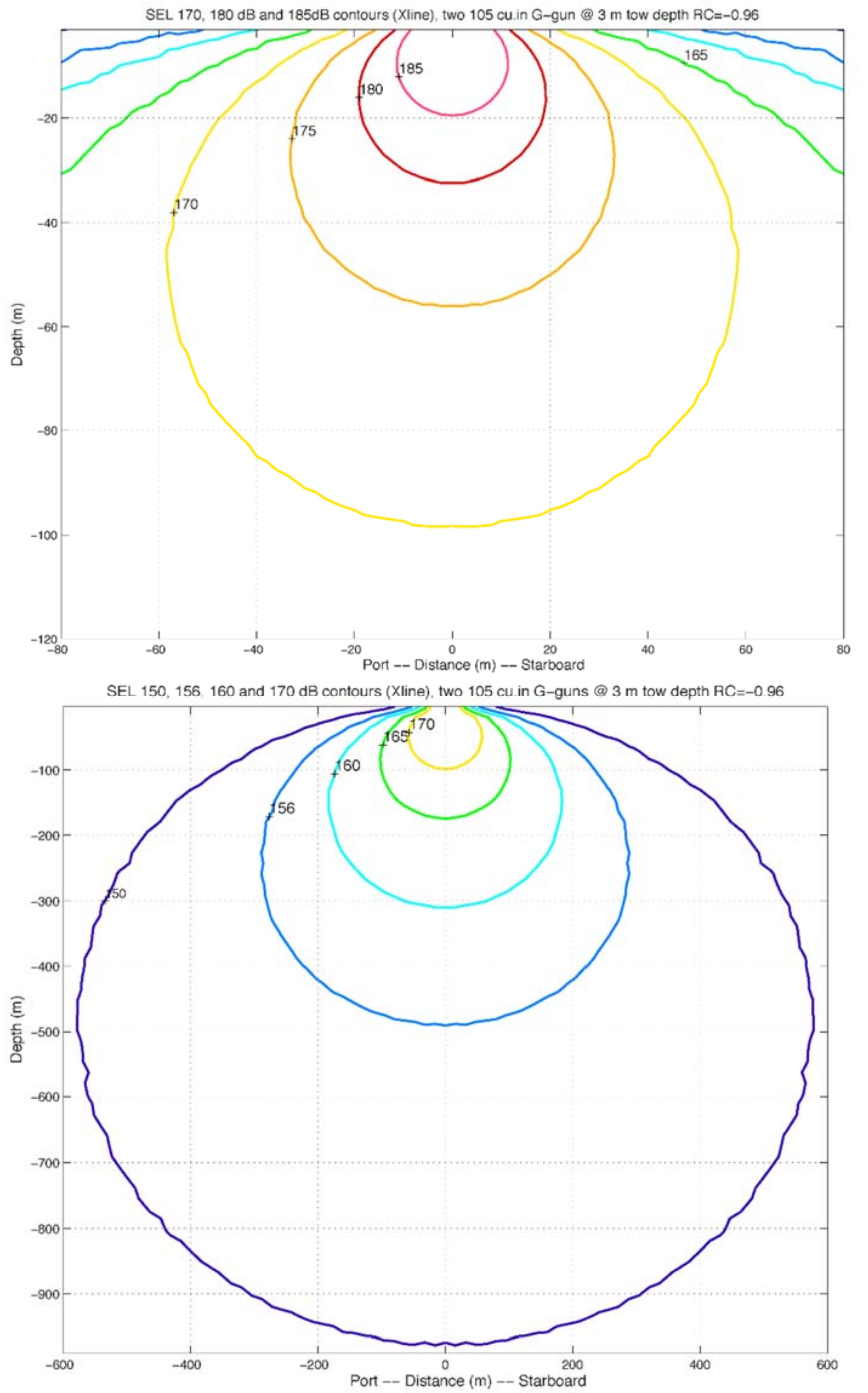

FIGURE A2. Modeled deep-water received sound exposure levels (SELs) from the backup configuration (Configuration 3; two 105 in^3 GI-guns) at a 3-m tow depth. Received rms levels (SPLs) are expected to be ~10 dB higher. The plot at the top provides the radius to the 170-dB SEL isopleth as a proxy for the 180-dB rms isopleth, and the plot at the bottom provides the radius to the 150 and 165-dB SEL isopleths as a proxy for the 160 and 175-dB rms isopleths, respectively. The upper plot is a blow-up of the lower plot.

Appendix B: Sound Exposure Levels (SEL): Scaling Analyses and All Results

SEL (dB) associated with airgun arrays tested in the Gulf of Mexico as part of Tolstoy et al. (2009). These values are used to scale calculations conducted by L-DEO for the Proposed Action.

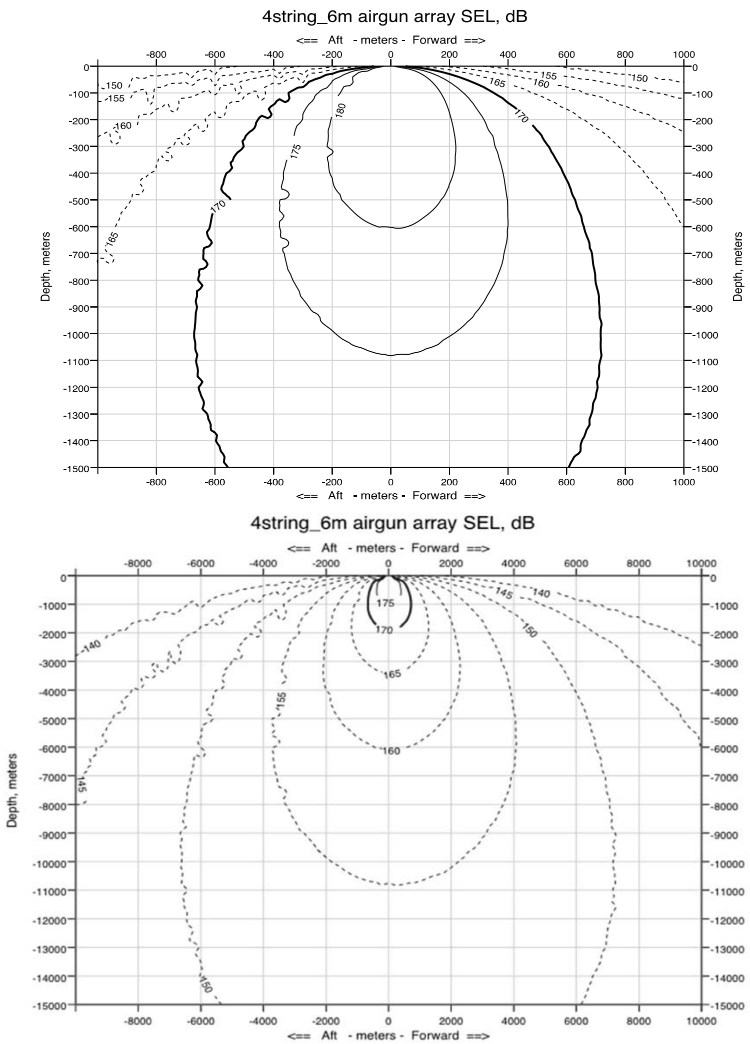

FIGURE B1. Modeled deep-water received sound exposure levels (SELs) from the 36-airgun array at a 6-m tow depth used during the GoM calibration survey. These values are used along with a scaling factor to determine SELs for shallow-water deployments with the three proposed configurations. Received rms levels (SPLs) are expected to be ~10 dB higher. The plot at the top provides the radius to the 170 dB SEL isopleth as a proxy for the 180-dB rms isopleth, and the plot at the bottom provides the radius to the 150-dB SEL isopleth as a proxy for the 160-dB rms isopleth.

For the **Base Configuration** (Configuration 1):

- the <u>150-decibel (dB)</u> Sound Exposure Level (SEL)[1] corresponds to deep-water maximum radii of

[1] SEL (measured in dB re 1 µPa^2 · s) is a measure of the received energy in the pulse and represents the SPL that would be measured if the pulse energy were spread evenly across a 1-s period. Because actual seismic pulses are less than

1090.6 m for the four 105 in^3 airguns at 3 m tow depth (Fig. 5), and 7,244 m for the 6600 in^3 at 6-m tow depth, yielding scaling factors of 0.151 to be applied to the shallow-water 6-m tow depth results.

- the 165-decibel (dB) Sound Exposure Level (SEL) corresponds to deep-water maximum radii of 193.94 m for the four 105 in^3 airguns at 3 m tow depth, and 1,284 m for a 6-m tow depth, yielding a scaling factor of 0.151 to be applied to the shallow-water 6-m tow depth results.

- Similarly, the 170 dB SEL corresponds to deep-water maximum radii of 109.72 for the four 105 in^3 airguns at 3 m tow depth (Fig. 2) and 719 m for the 6600 in^3 at 6-m tow depth (Fig. 4), yielding the same 0.152 scaling factor.
- the 185-decibel (dB) Sound Exposure Level (SEL) corresponds to deep-water maximum radii of 19.89 m for the four 105 in^3 at 3-m tow depth, and 126.3 m for a 6-m tow depth, yielding a scaling factor of 0.157 to be applied to the shallow-water 6-m tow depth results.

Measured 160-, 175-, 180-, 190- and 195-dB re 1µPa_{rms} distances in shallow water for the 36-airgun *R/V Langseth* array towed at 6 m depth were 17.5 km, 2.84 km, 1.6 km, 458 m and 240 m, respectively, based on a 95th percentile fit (Tolstoy et al. 2009). Multiplying by the scaling factors to account for the tow depth and discharge volume differences between the 6600 cu.in airgun array at 6 m tow depth and the USGS Proposed Action Base Configuration, the 420 cu.in airgun array at 3 m tow depth yields distances of 2.642 km, 429 m, 243 m, 71 m and 38 m, respectively.

For the **GG Configuration** (Configuration 2):

- the 150-decibel (dB) Sound Exposure Level (SEL) corresponds to deep-water maximum radii of 1,244 m for the four 210 in^3 airguns at 3 m tow depth (Fig. 6), and 7,244 m for the L-DEO 6600 in^3 at 6-m tow depth (Fig. 8), yielding scaling factors of 0.172 to be applied to the shallow-water 6-m tow depth results.

- the 165-decibel (dB) Sound Exposure Level (SEL) corresponds to deep-water maximum radii of 219.54 m for the four 210 in^3 airguns at 3 m tow depth, and 1,284 m for a 6-m tow depth, yielding a scaling factor of 0.171 to be applied to the shallow-water 6-m tow depth results.

- Similarly, the 170 dB SEL corresponds to deep-water maximum radii of 124.72 for the four 210 in^3 airguns at 3 m tow depth (Fig. 2) and 719 m for the 6600 in^3 at 6-m tow depth (Fig. 4), yielding the same 0.173 scaling factor.
- the 185-decibel (dB) Sound Exposure Level (SEL) corresponds to deep-water maximum radii of 22.69 m for the four 210 in^3 at 3-m tow depth, and 126.3 m for a 6-m tow depth, yielding a scaling factor of 0.179 to be applied to the shallow-water 6-m tow depth results.

Measured 160-, 175-, 180-, 190- and 195-dB re 1µPa_{rms} distances in shallow water for the 36-airgun *R/V Langseth* array towed at 6 m depth were 17.5 km, 2.84 km, 1.6 km, 458 m and 240 m, respectively, based on a 95th percentile fit (Tolstoy et al. 2009). Multiplying by the scaling factors to account for the tow depth and discharge volume differences between the 6600 cu.in airgun array at 6 m tow depth and the 840 cu.in airgun array at 3 m tow depth yields distances of 3.01 km, 485 m, 277 m, 80 m and 43 m, respectively.

For the **Backup Configuration** (Configuration 3):

- the 150-decibel (dB) Sound Exposure Level (SEL) corresponds to deep-water maximum radii of 578.152 m for the two 105 in^3 airguns at 3 m tow depth (Fig. 7), and 7,244 m for the 6600 in^3 at 6-m tow depth (Fig. 8), yielding scaling factors of 0.080 to be applied to the shallow-water 6-m tow depth results.

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1 s in duration in most situations, this means that the SEL value for a given pulse is usually lower than the SPL calculated for the actual duration of the pulse. In this EA, we assume that rms pressure levels of received seismic pulses would be 10 dB higher than the SEL values predicted by L-DEO's model.

- the 165-decibel (dB) Sound Exposure Level (SEL) corresponds to deep-water maximum radii of 102.37 m for the two 105 in^3 airguns at 3 m tow depth, and 1,284 m for a 6-m tow depth, yielding a scaling factor of 0.080 to be applied to the shallow-water 6-m tow depth results.

- Similarly, the 170 dB SEL corresponds to deep-water maximum radii of 58.395 for the two 105 in^3 airguns at 3 m tow depth (Fig. 2) and 719 m for the 6600 in^3 at 6-m tow depth (Fig. 4), yielding the same 0.081 scaling factor.
- the 185-decibel (dB) Sound Exposure Level (SEL) corresponds to deep-water maximum radii of 11.343 m for the two 105 in^3 at 3-m tow depth, and 126.3 m for a 6-m tow depth, yielding a scaling factor of 0.089 to be applied to the shallow-water 6-m tow depth results.

Measured 160-, 175-, 180-, 190- and 195-dB re 1µPa_{rms} distances in shallow water for the 36-airgun *R/V Langseth* array towed at 6 m depth were 17.5 km, 2.84 km, 1.6 km, 458 m and 240 m, respectively, based on a 95th percentile fit (Tolstoy et al. 2009). Multiplying by the scaling factors to account for the tow depth and discharge volume differences between the 6600 cu.in airgun array at 6 m tow depth and the 110 cu.in airgun array at 3 m tow depth yields distances of 1.4 km, 227 m, 130 m, 38 m and 21 m, respectively.

Table B1. Predicted distances to which sound levels ≥ 195, 190-, 180-, 175-, and 160-dB re 1 μPa_{rms} are expected to be received during the proposed surveys in the Northwest Atlantic Ocean. The Proposed Action will not involve ensonifying the seafloor at water depths shallower than 100 m.

Source and Volume	Tow Depth (m)	Water Depth (m)	Predicted rms Radii (m)				
			195 dB	190dB	180 dB	175 dB	160 dB
Base Configuration (Configuration 1) Four 105 in^3 G-guns	3	>1000 m	100[4]	100[4]	110[4]	194[1]	1091[1]
		100–1000 m	100[4]	100[4]	165[4]	291[2]	1637[2]
GG Configuration (Configuration 2) Four 210 in^3 G-guns	3	>1000 m	100[4]	100[4]	125[1]	220[1]	1244[1]
		100–1000 m	100[4]	100[4]	188[2]	330[2]	1866[2]
Backup Configuration (Configuration 3) Two 105 in^3 G-guns	3	>1000 m	100[4]	100[4]	100[4]	102[1]	578[1]
		100–1000 m	100[4]	100[4]	100[4]	153[2]	867[2]

[1] Distance is based on L-DEO model results.
[2] Distance is based on L-DEO model results with a 1.5 x correction factor between deep and intermediate water depths.
[3] Distance is based on empirically derived measurements in the GoM with scaling applied to account for differences in tow depth.
[4] Modeled distances based on empirically derived measurements in the GoM are smaller than 100 m. Therefore, we use 100 m for these mitigation zone according to accepted practice.

Appendix C. Supporting Documentation for Level A Acoustic Modeling

The following information was provided by Dr. Anne Bécel at Lamont-Doherty Earth Observatory based on modeling methodology previously applied in EAs for NSF-funded programs. The documentation is provided verbatim, with modifications only to eliminate redundancies, to clarify how the different components relate to the Proposed Action, and to ensure consistency in terminology across this Draft EA.

BASE CONFIGURATION:

4 x 105 cu.in – 2 m separation aft-fore direction and 8.6 m separation in the port-starboard direction @ a 3 m tow depth

SELcum methodology (spreadsheet – Sivle et al., 2014)

Source Velocity (meters/second)	2.05778*
1/Repetition rate^ (seconds)	12.149**

† Methodology assumes propagation of 20 log R; Activity duration (time) independent
^ Time between onset of successive pulses.
* 4 kts

Table C1: Table showing the results for one single SEL SL modeling without and with applying weighting function to the 5 hearing groups. The modified farfield signature is estimated using the distance from the source array geometrical center to where the SELcum threshold is the largest. A propagation is of 20 $\log_{10}$ (Radial distance) is used to estimate the modified farfield SEL.

SEL_{cum} Threshold	183 dB	185 dB	155 dB	185 dB	203 dB
Distance(m) (no weighting function)	34.3541	28.0537	907.6353	28.0537	N/A (<1m)
Modified Farfield SEL*	213.7196	213.9598	214.1582	213.9598	203
Distance (m) (with weighting function)	15.6980	N/A	N/A	N/A	N/A
Adjustment (dB)	-6.80	N/A	N/A	N/A	N/A

* Propagation of 20 log R

For the Low Frequency Cetaceans, we estimated a new adjustment value by computing the distance from the geometrical center of the source to where the 183dB SEL cum isopleth is the largest. We first run the modeling for one single shot without applying any weighting function. The maximum 183dB SEL cum isopleth is located at 34.35 m from the source. We then run the modeling for one single shot with the low frequency Cetaceans weighting function applied to the full spectrum. The maximum 183 dB SEL cum isopleth is located at 15.69 m from the source. Difference between 34.35 m and 15.69 m gives an adjustment factor of -6.80 dB assuming a propagation of 20log10(R).

TABLE C2. Results for single shot SEL source level modeling for the four 105 in^3 airguns with weighting function calculations for SEL_{cum} criteria.

F: MOBILE SOURCE: Impulsive, Intermittent (SAFE DISTANCE METHODOLOGY)

VERSION 1.1: Aug-16

KEY

(green)	Action Proponent Provided Information
(pink)	NMFS Provided Information (Acoustic Guidance)
(blue)	Resultant Isopleth

STEP 1: GENERAL PROJECT INFORMATION

PROJECT TITLE	Carolyn Ruppel -
PROJECT/SOURCE INFORMATION	source : SIO portable system = 4 x 105 cu.in GI-gun at a 3m towed depth - (2 m separation in the fore-aft direction, 8.6 m in the port- starboard direction)
Please include any assumptions	
PROJECT CONTACT	

STEP 2: WEIGHTING FACTOR ADJUSTMENT

Specify if relying on source-specific WFA, alternative weighting/dB adjustment, or if using default value

Weighting Factor Adjustment (kHz)[¥]	User defined	Override WFA: Using LDEO modeling

[¥] Broadband: 95% frequency contour percentile (kHz) OR Narrowband: frequency (kHz); For appropriate default WFA: See INTRODUCTION tab

† If a user relies on alternative weighting/dB adjustment rather than relying upon the WFA (source-specific or default), they may override the Adjustment (dB) (row 62), and enter the new value directly. However, they must provide additional support and documentation supporting this modification.

* BROADBAND Sources: Cannot use WFA higher than maximum applicable frequency (See GRAY tab for more information on WFA applicable frequencies)

STEP 3: SOURCE-SPECIFIC INFORMATION

NOTE: Choose either F1 OR F2 method to calculate isopleths (not required to fill in sage boxes for both)

NOTE: LDEO modeling relies on Method F2

F2: ALTERNATIVE METHOD† TO CALCULATE PK and SEL_{cum} (SINGLE STRIKE/SHOT/PULSE EQUIVALENT)

SEL_{cum}

Source Velocity (meters/second)	2.05778
1/Repetition rate^ (seconds)	12.149

†Methodology assumes propagation of 20 log R; Activity duration (time) independent

^Time between onset of successive pulses.

Modified farfield SEL	213.7196	213.9598	214.1582	213.9598	203
Source Factor	1.93829E+20	2.04852E+20	2.14427E+20	2.04852E+20	1.64233E+19

RESULTANT ISOPLETHS*

*Impulsive sounds have dual metric thresholds (SELcum & PK). Metric producing largest isopleth should be used.

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
SEL_{cum} Threshold	183	185	155	185	203
PTS SEL_{cum} Isopleth to threshold (meters)	31.0	0.0	0.0	0.4	0.0

WEIGHTING FUNCTION CALCULATIONS

Weighting Function Parameters	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds	
a	1	1.6	1.8	1	2	
b	2	2	2	2	2	
f_1	0.2	8.8	12	1.9	0.94	
f_2	19	110	140	30	25	
C	0.13	1.2	1.36	0.75	0.64	
Adjustment (dB)†	-6.80	-54.02	-63.18	-23.74	-29.86	OVERIDE Using LDEO Modeling

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
SEL_{cum} Threshold	183	185	155	185	203
PTS SEL_{cum} Isopleth to threshold (meters)	31.0	0.0	0.0	0.4	0.0

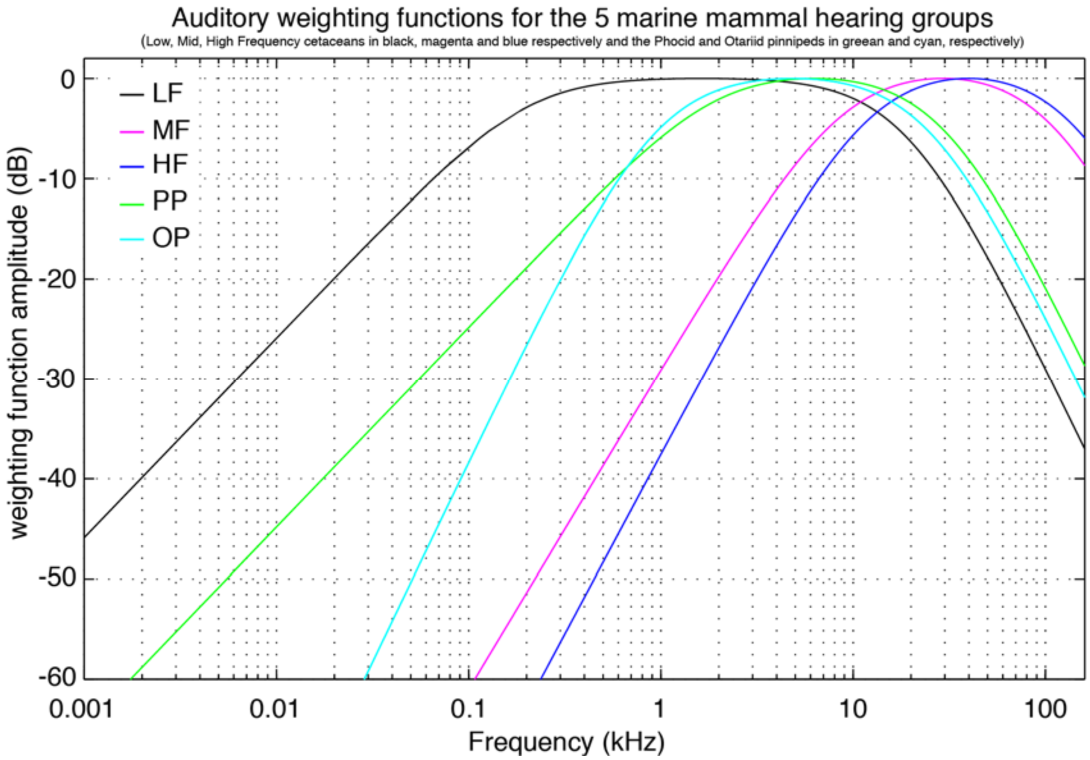

FIGURE C1: Auditory weighting functions for the 5 marine mammal hearing groups defined by NOAA's Acoustic Guidelines.

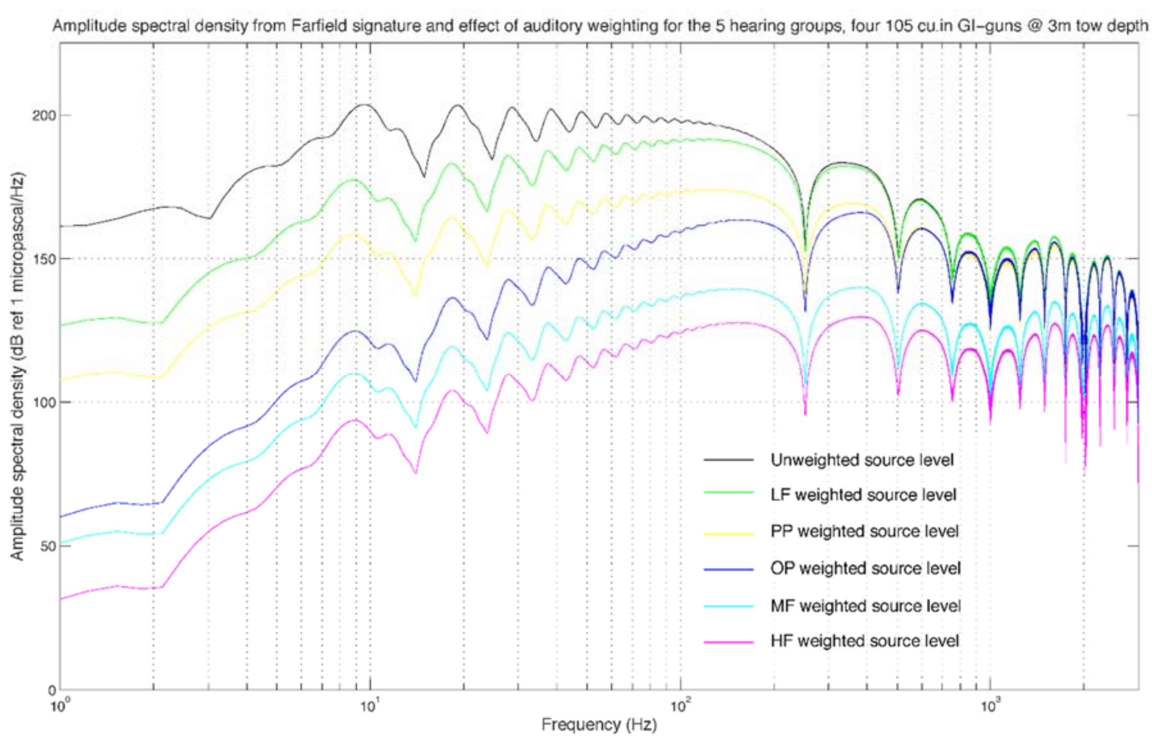

FIGURE C2: Modeled amplitude spectral density of the four 105 cu.in airgun farfield signature. Amplitude spectral density before (black) and after (green, yellow, blue, cyan, magenta) applying the auditory weighting function for the Low Frequency Cetaceans, Phocid Pinnipeds, Otariid Pinnipeds, Mid Frequency Cetaceans, High Frequency

Cetaceans, respectively. Modeled spectral levels in micropascals are used to calculate the difference between the un-weighted and weighted source level at each frequency and to derive the adjustment factors for the Phocid Pinnipeds, Otariid Pinnipeds, Mid Frequency Cetaceans, and High Frequency Cetaceans as inputs into the NMFS user spreadhseet. Note that pinnipeds will not be encountered during the Proposed Action, but modeling is done here for the sake of completeness.

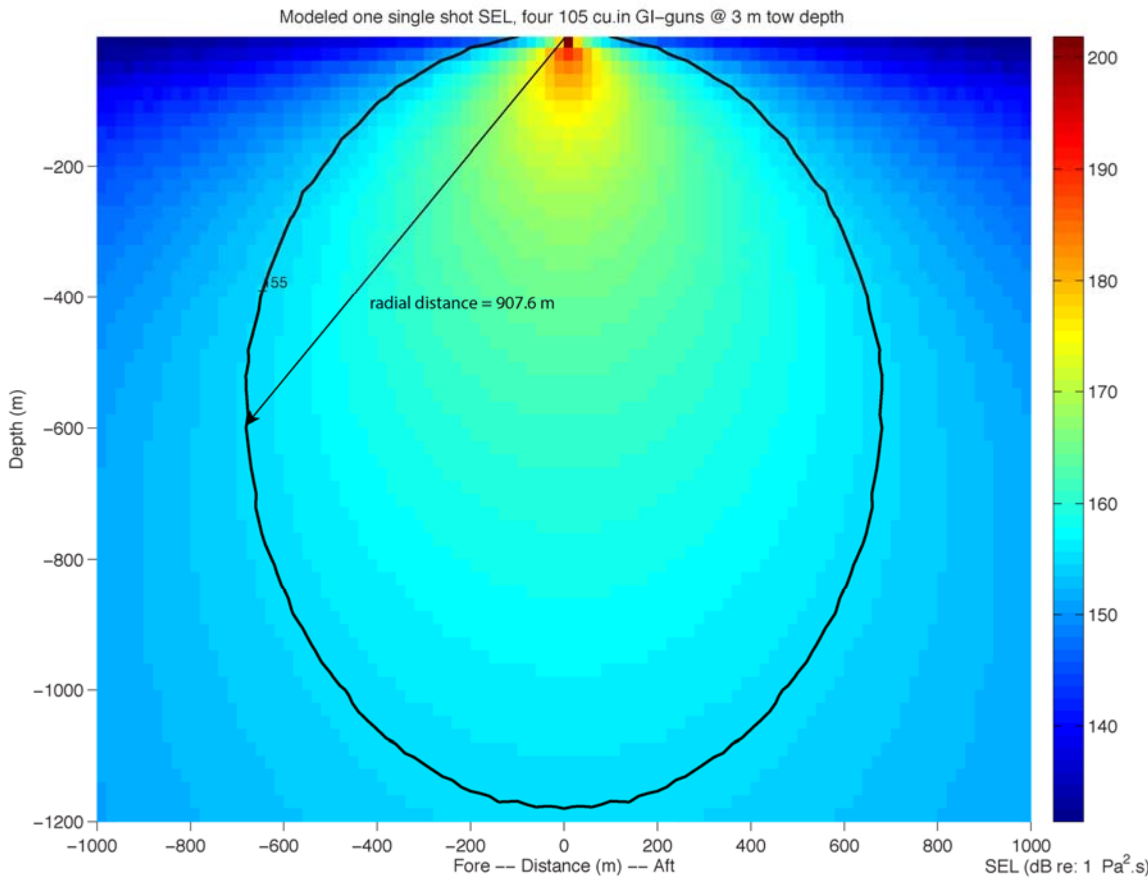

FIGURE C3: Modeled received sound levels (SELs) in deep water from the four 105 cu.in GI-guns at a 3-m tow depth. The plot provides the distance from the geometrical center of the source array to the 155-dB SEL isopleth (907.6 m).

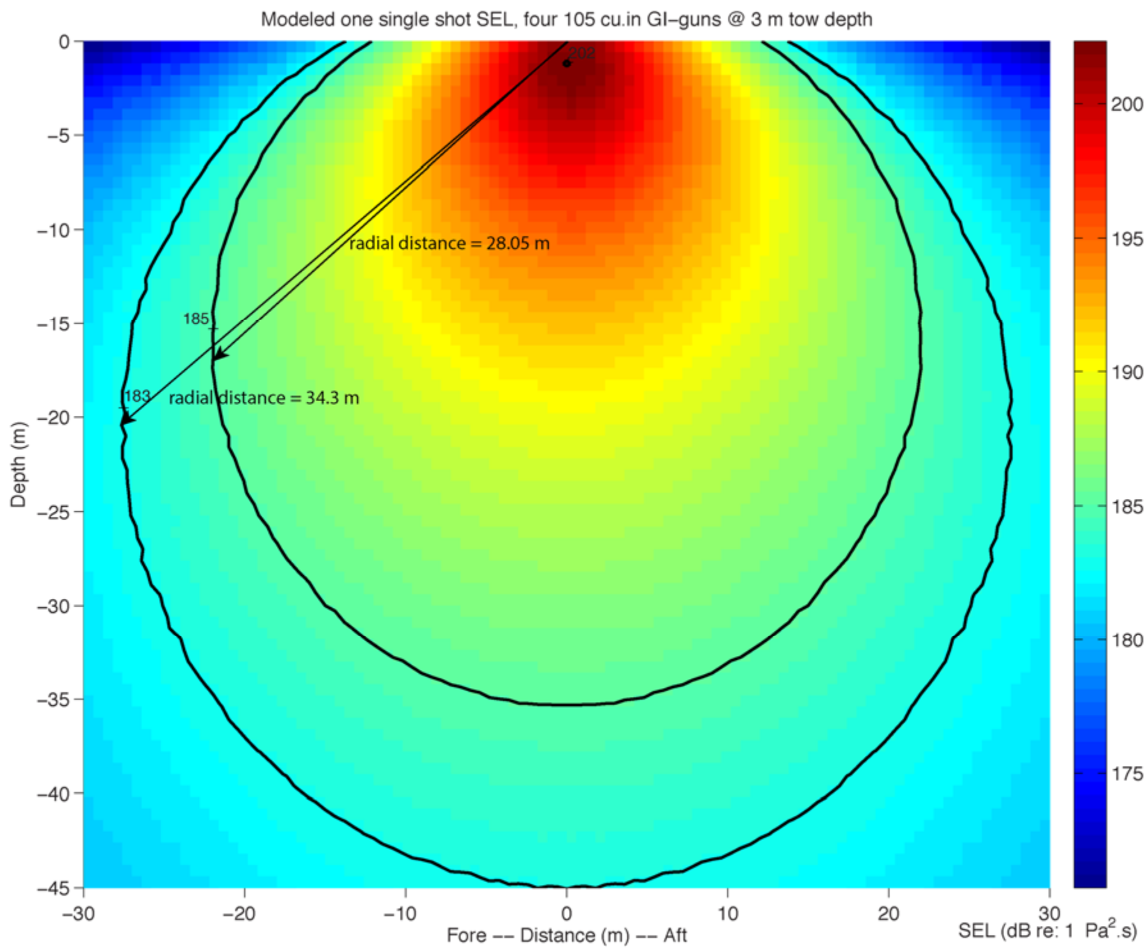

FIGURE C4 : Modeled received sound levels (SELs) in deep water from the four 105 cu.in GI-guns at a 3-m tow depth. The plot provides the distance from the geometrical center of the source array to the 183 and 185 dB SEL isopleths

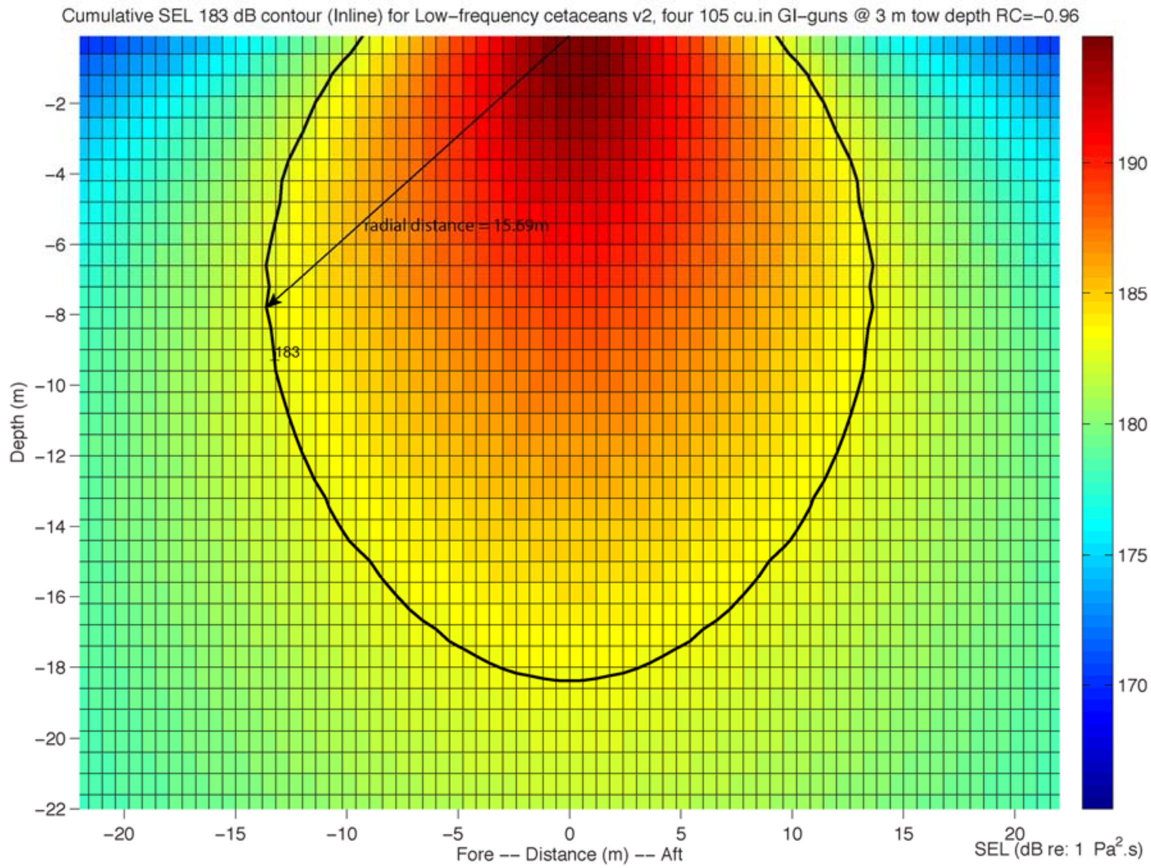

FIGURE C5: Modeled received sound exposure levels (SELs) from the four 105 cu.in GI-guns at a 3-m tow depth, after applying the auditory weighting function for the Low Frequency Cetaceans hearing group following to the new technical guidance. The plot provides the radial distance to the 183-dB SELcum isopleth for one shot. The difference in radial distances between Fig. 4 (34.35 m) and this figure (15.69 m) allows us to estimate the adjustment in dB.

Peak Sound Pressure Level :

TABLE C3. LEVEL A. NMFS Level A acoustic thresholds (Peak SPL_{flat}) for impulsive sources for marine mammals and predicted radial distances to Level A thresholds for various marine mammal hearing groups that could be received from the four 105 cu.in airguns at a 3 m tow depth during the proposed seismic survey in the north western Atlantic Ocean. While the modified PK farfield value (calculated as PK threshold $+20\log_{10}$(radius)) is reported here, it is irrelevant since the calculations no longer rely on applying band pass filters.

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
PK Threshold (dB)	219	230	202	218	232
Modified PK farfield (dB)	239.0	N/A	239.0	239.1	N/A
Radius to threshold (meters)	10.03	N/A (0)	70.426	11.35	N/A (0)

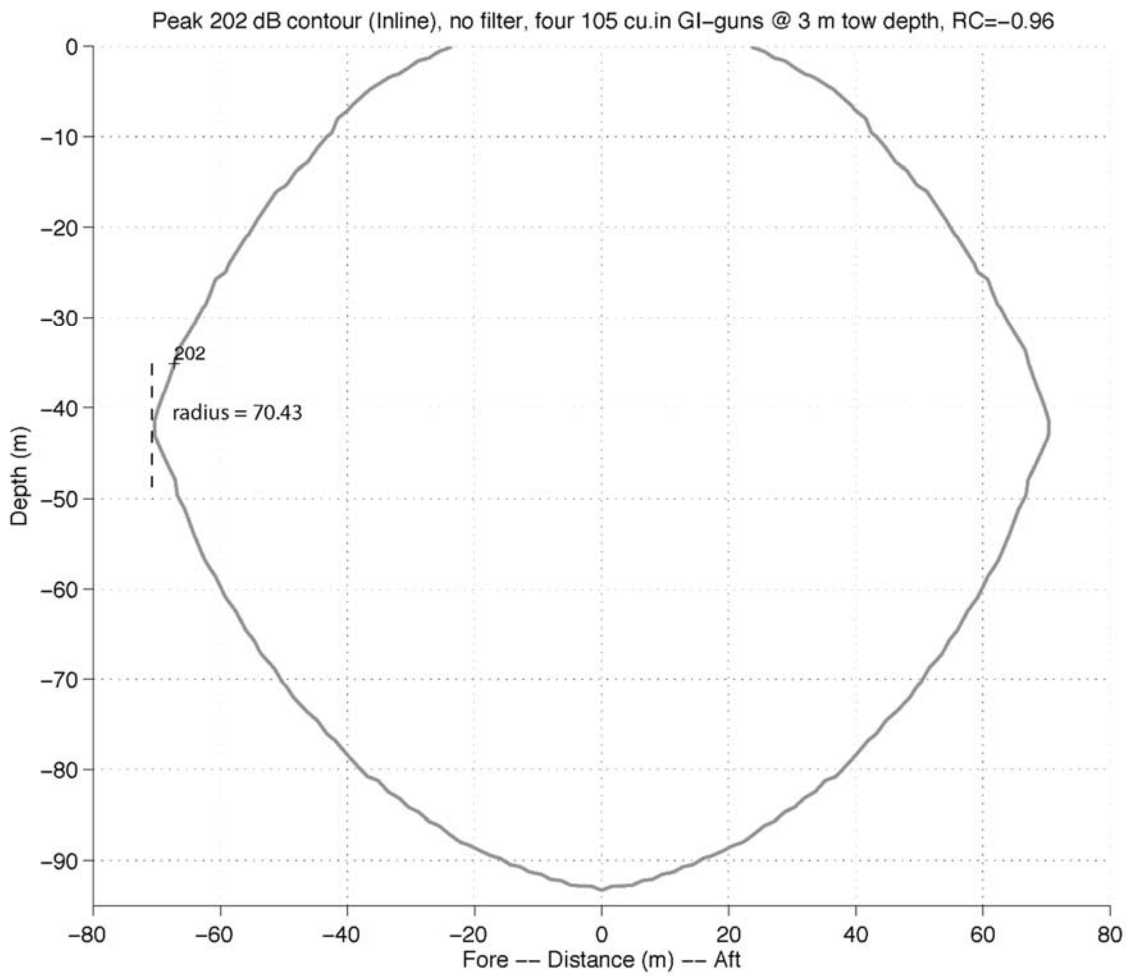

FIGURE C6: Modeled deep-water received Peak SPL from the four 105 cu.in GI-guns at a 3-m tow depth. The plot provides the radius of the 202-dB peak isopleth (70.43 m).

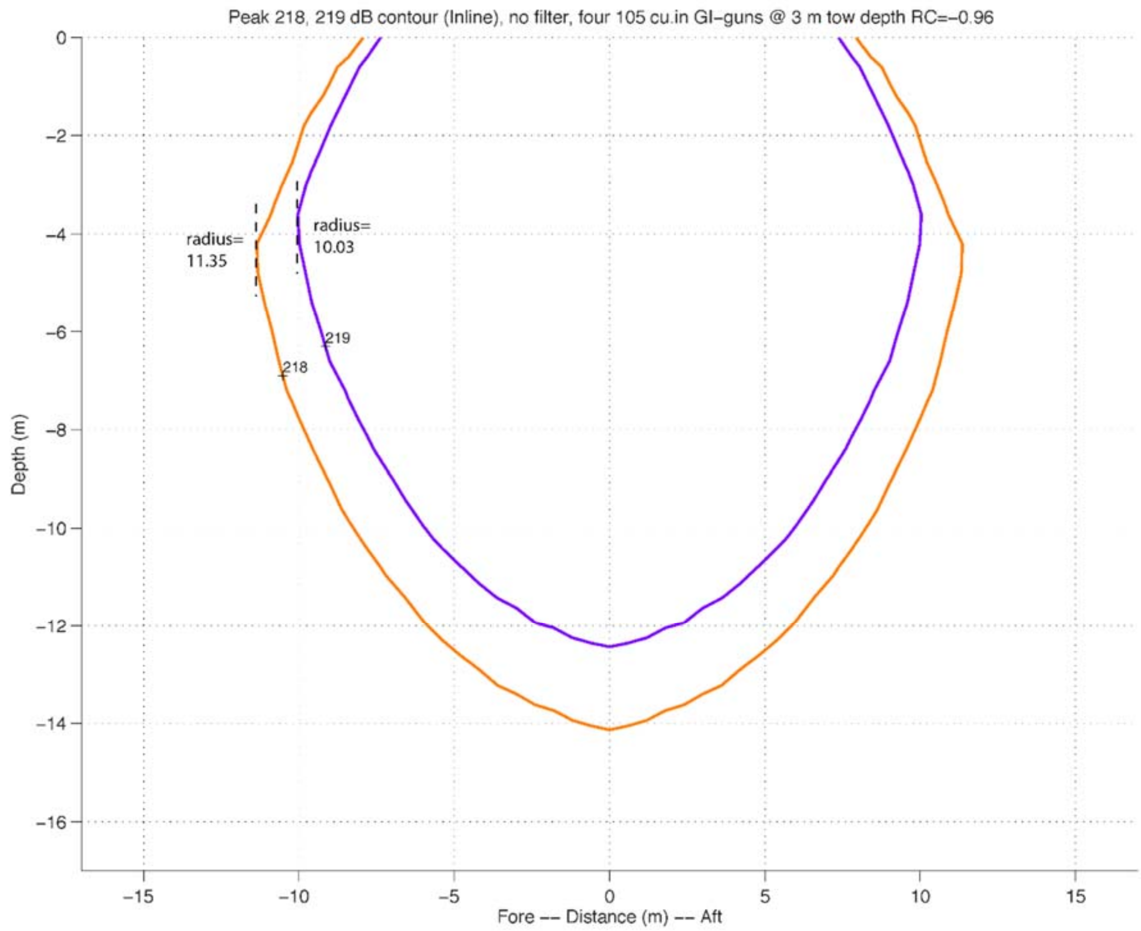

FIGURE C7: Modeled deep-water received Peak SPL from four 105 cu.in GI-guns at a 3-m tow depth. The plot provides the radius of the 218 and 219 dB peak isopleths.

GG CONFIGURATION
4 x 210 cu.in – 2 m separation aft-fore direction and 8.6 m separation in the port-starboard direction @ a 3 m tow depth

Table C4: Table showing the results for one single SEL SL modeling without and with applying weighting function to the 5 hearing groups. The modified farfield signature is estimated using the distance from the source array geometrical center to where the SELcum threshold is the largest. A propagation is of 20 $\log_{10}$ (Radial distance) is used to estimate the modified farfield SEL.

SEL_{cum} Threshold	183	185	155	185	203
Distance(m) (no weighting function)	39.4216	30.8975	1029.1	30.8975	1.8439
Modified Farfield SEL*	214.9147	214.7985	215.2492	214.7985	208.3147
Distance (m) (with weighting function)	17.7149	N/A	N/A	N/A	N/A
Adjustment (dB)	-6.9479	N/A	N/A	N/A	N/A

* Propagation of 20 log R

For the Low Frequency Cetaceans, we estimated a new adjustment value by computing the distance from the geometrical center of the source to where the 183dB SEL cum isopleth is the largest. We first run the modeling for one single shot without applying any weighting function. The maximum 183dB SEL cum isopleth is located at 39.42 m from the source. We then run the modeling for one single shot with the low frequency Cetaceans weighting function applied to the full spectrum. The maximum 183 dB SEL cum isopleth is located at 17.71 m from the source. Difference between 17.71 m and 39.42 m gives an adjustment factor of -6.95 dB assuming a propagation of 20log10(R).

TABLE C5. Results for single shot SEL source level modeling for the four 210 in^3 airguns with weighting function calculations for SEL_{cum} criteria.

F: MOBILE SOURCE: Impulsive, Intermittent (SAFE DISTANCE METHODOLOGY)

VERSION 1.1: Aug-16

KEY	
	Action Proponent Provided Information
	NMFS Provided Information (Acoustic Guidance)
	Resultant Isopleth

STEP 1: GENERAL PROJECT INFORMATION

PROJECT TITLE	Carolyn Ruppel -
PROJECT/SOURCE INFORMATION Please include any assumptions	source : SIO portable system = 4 x 210 cu.in GI-gun at a 3m towed depth - (2 m separation in the fore-aft direction, 8.6 m separation in the port-starboard direction)
PROJECT CONTACT	

STEP 2: WEIGHTING FACTOR ADJUSTMENT — Specify if relying on source-specific WFA, alternative weighting/dB adjustment, or if using default value

Weighting Factor Adjustment (kHz)[¥]	User defined	Override WFA: Using LDEO modeling

[¥] Broadband: 95% frequency contour percentile (kHz) OR Narrowband: frequency (kHz); For appropriate default WFA: See INTRODUCTION tab

† If a user relies on alternative weighting/dB adjustment rather than relying upon the WFA (source-specific or default), they may override the Adjustment (dB) (row 62), and enter the new value directly. However, they must provide additional support and documentation supporting this modification.

*** BROADBAND Sources: Cannot use WFA higher than maximum applicable frequency (See GRAY tab for more information on WFA applicable frequencies)**

STEP 3: SOURCE-SPECIFIC INFORMATION

NOTE: Choose either F1 OR F2 method to calculate isopleths (not required to fill in sage boxes for both)

NOTE: LDEO modeling relies on Method F2

F2: ALTERNATIVE METHOD† TO CALCULATE PK and SEL_{cum} (SINGLE STRIKE/SHOT/PULSE EQUIVALENT)

SEL_{cum}

Source Velocity (meters/second)	2.05778
1/Repetition rate^ (seconds)	12.149

†Methodology assumes propagation of 20 log R; Activity duration (time) independent

^Time between onset of successive pulses.

Modified farfield SEL	214.9147	214.7985	215.2492	214.7985	208.3147
Source Factor	2.55229E+20	2.4849E+20	2.75664E+20	2.4849E+20	5.5838E+19

RESULTANT ISOPLETHS*

*Impulsive sounds have dual metric thresholds (SELcum & PK). Metric producing largest isopleth should be used.

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
SEL_{cum} Threshold	183	185	155	185	203
PTS SEL_{cum} Isopleth to threshold (meters)	39.5	0.0	0.1	0.5	0.0

WEIGHTING FUNCTION CALCULATIONS

Weighting Function Parameters	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds	
a	1	1.6	1.8	1	2	
b	2	2	2	2	2	
f_1	0.2	8.8	12	1.9	0.94	
f_2	19	110	140	30	25	
C	0.13	1.2	1.36	0.75	0.64	
Adjustment (dB)†	-6.94	-54.84	-64.11	-24.04	-30.75	OVERIDE Using LDEO Modeling

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
SEL_{cum} Threshold	183	185	155	185	203
PTS SEL_{cum} Isopleth to threshold (meters)	39.5	0.0	0.1	0.5	0.0

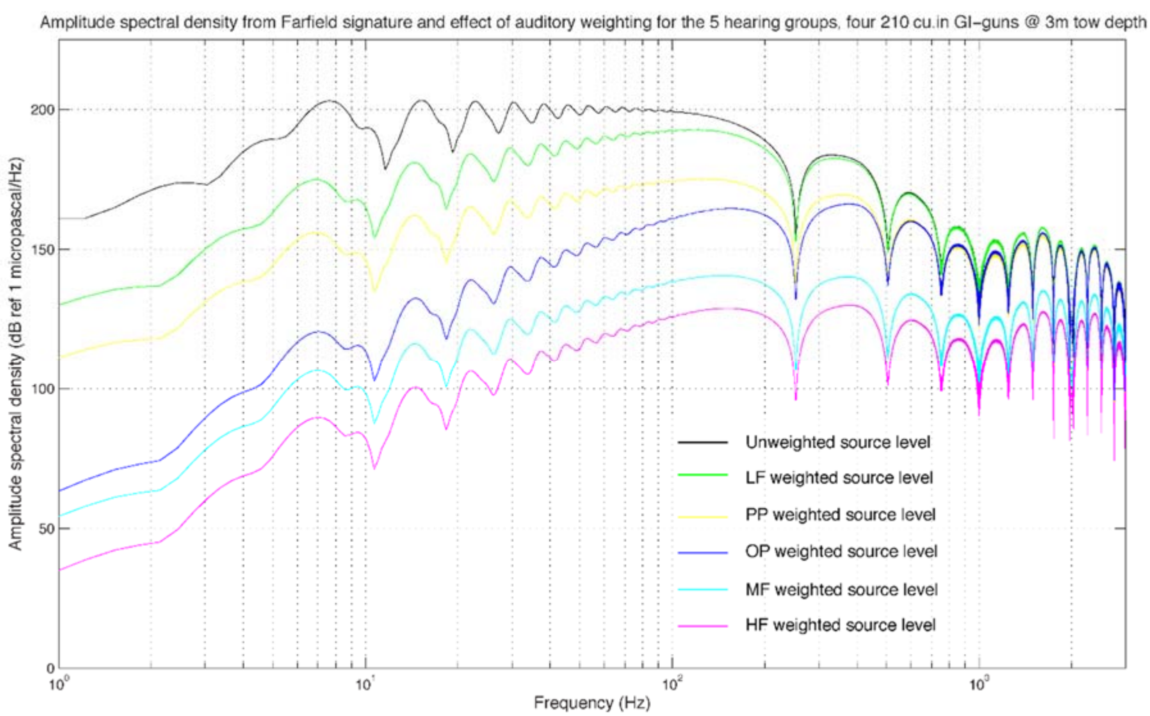

FIGURE C8: Modeled amplitude spectral density of the four 210 cu.in airgun farfield signature. Amplitude spectral density before (black) and after (green, yellow, blue, cyan, magenta) applying the auditory weighting function for the Low Frequency Cetaceans, Phocid Pinnipeds, Otariid Pinnipeds, Mid Frequency Cetaceans, High Frequency Cetaceans, respectively. Modeled spectral levels in micropascals are used to calculate the difference between the unweighted and weighted source level at each frequency and to derive the adjustment factors for the Phocid Pinnipeds, Otariid Pinnipeds, Mid Frequency Cetaceans, and High Frequency Cetaceans as inputs into the NMFS user spreadhseet.

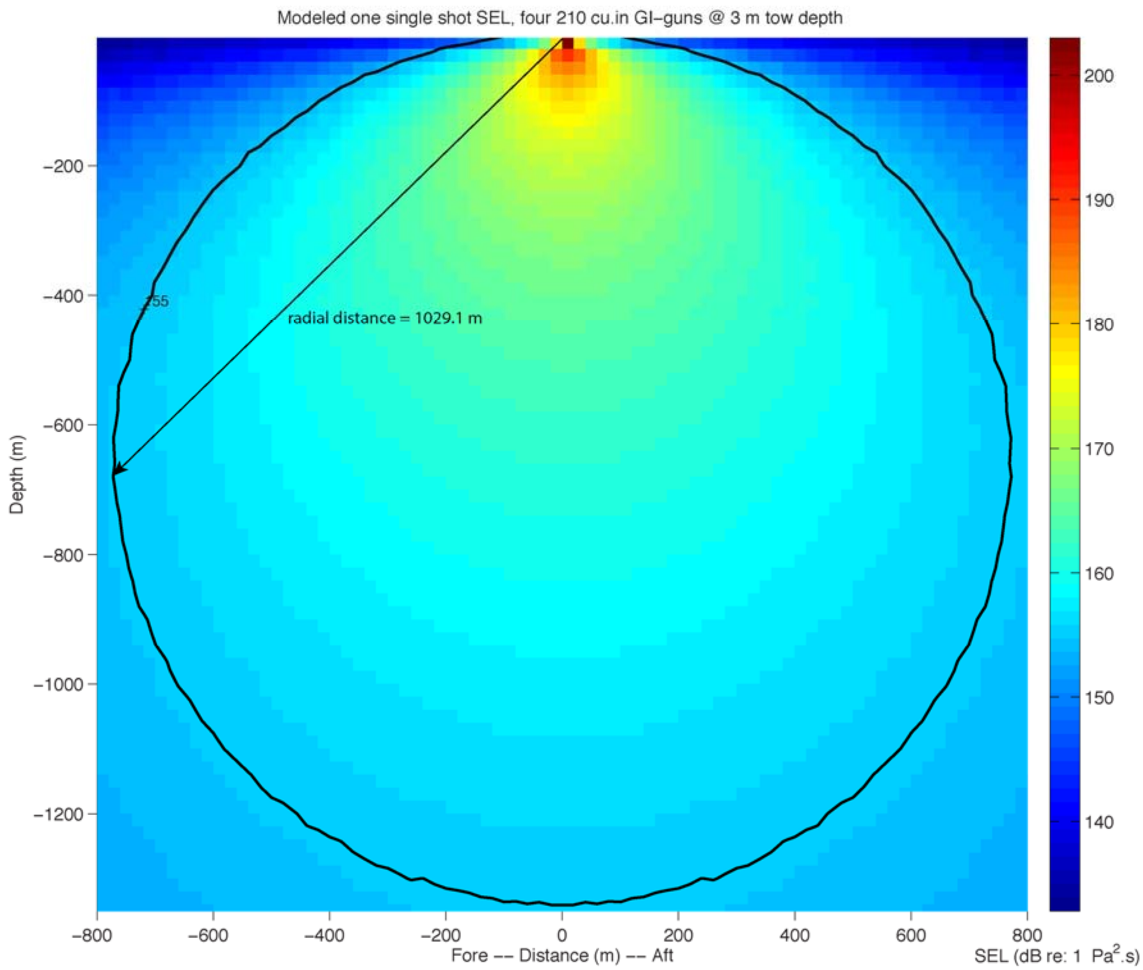

FIGURE C9: Modeled received sound levels (SELs) in deep water from the four 210 cu.in GI-guns at a 3-m tow depth. The plot provides the distance from the geometrical center of the source array to the 155-dB SEL isopleth (1029.1 m).

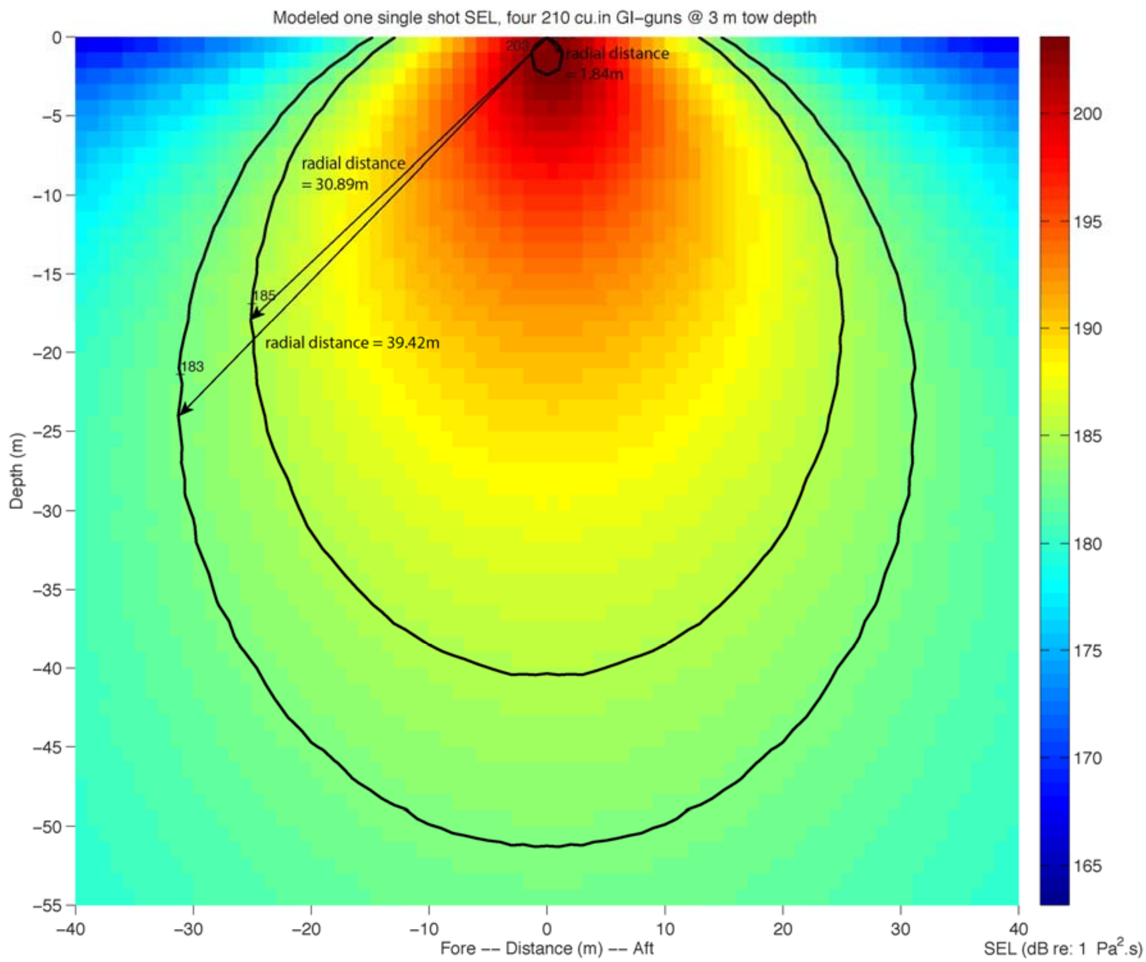

FIGURE C10 : Modeled received sound levels (SELs) in deep water from the four 210 cu.in GI-guns at a 3-m tow depth. The plot provides the distance from the geometrical center of the source array to the 183, 185 and 203 dB SEL isopleths

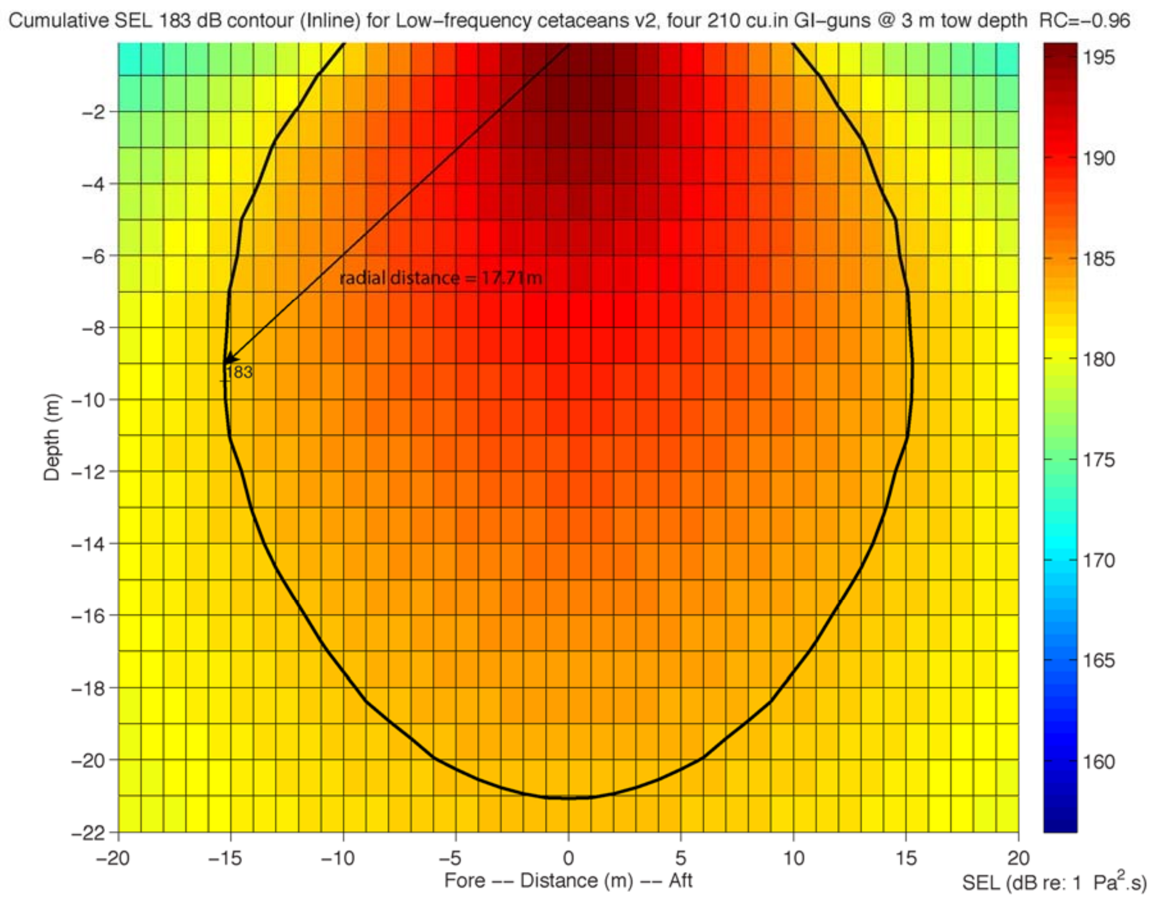

FIGURE C11: Modeled received sound exposure levels (SELs) from the four 210 cu.in GI-guns at a 3-m tow depth, after applying the auditory weighting function for the Low Frequency Cetaceans hearing group following to the new technical guidance. The plot provides the radial distance to the 183-dB SELcum isopleth for one shot. The difference in radial distances between Fig. 4 (39.42 m) and this figure (17.71 m) allows us to estimate the adjustment in dB.

Peak Sound Pressure Level :

TABLE C6. LEVEL A. NMFS Level A acoustic thresholds (Peak SPL_{flat}) for impulsive sources for marine mammals and predicted radial distances to Level A thresholds for various marine mammal hearing groups that could be received from the four 210 cu.in airguns at a 3 m tow depth during the proposed seismic survey in the north western Atlantic Ocean. While the modified PK farfield value (calculated as PK threshold $+20\log_{10}$(radius)) is reported here, it is irrelevant since the calculations no longer rely on applying band pass filters.

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
PK Threshold	219	230	202	218	232
Modified PK farfield (dB)	240.2	N/A	240.1	240.3	N/A
Radius to threshold (meters)	11.56	N/A (0)	80.50	13.04	N/A (0)

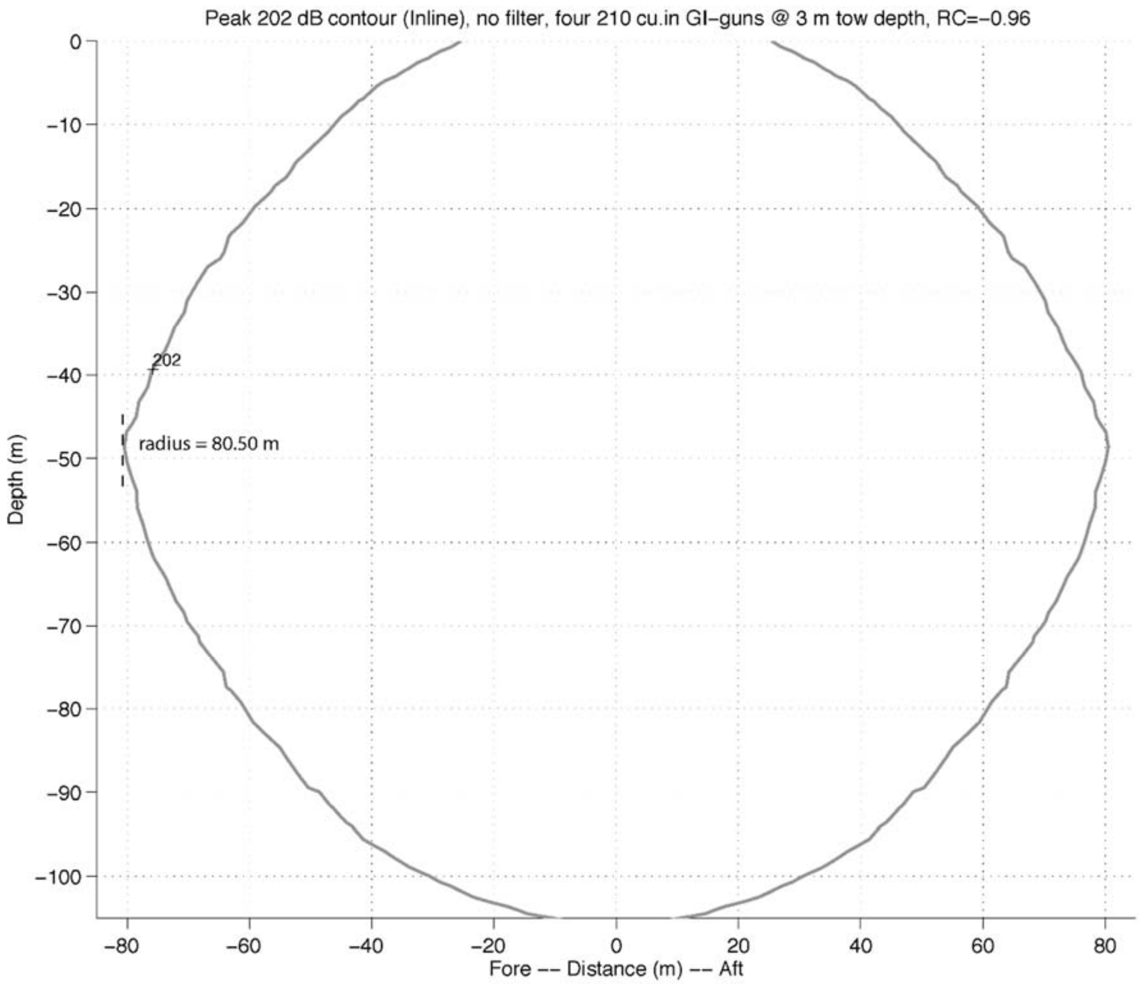

FIGURE C12: Modeled deep-water received Peak SPL from four 210 cu.in airguns at a 3-m tow depth. The plot provides the radius of the 202-dB peak isopleth (80.50 m).

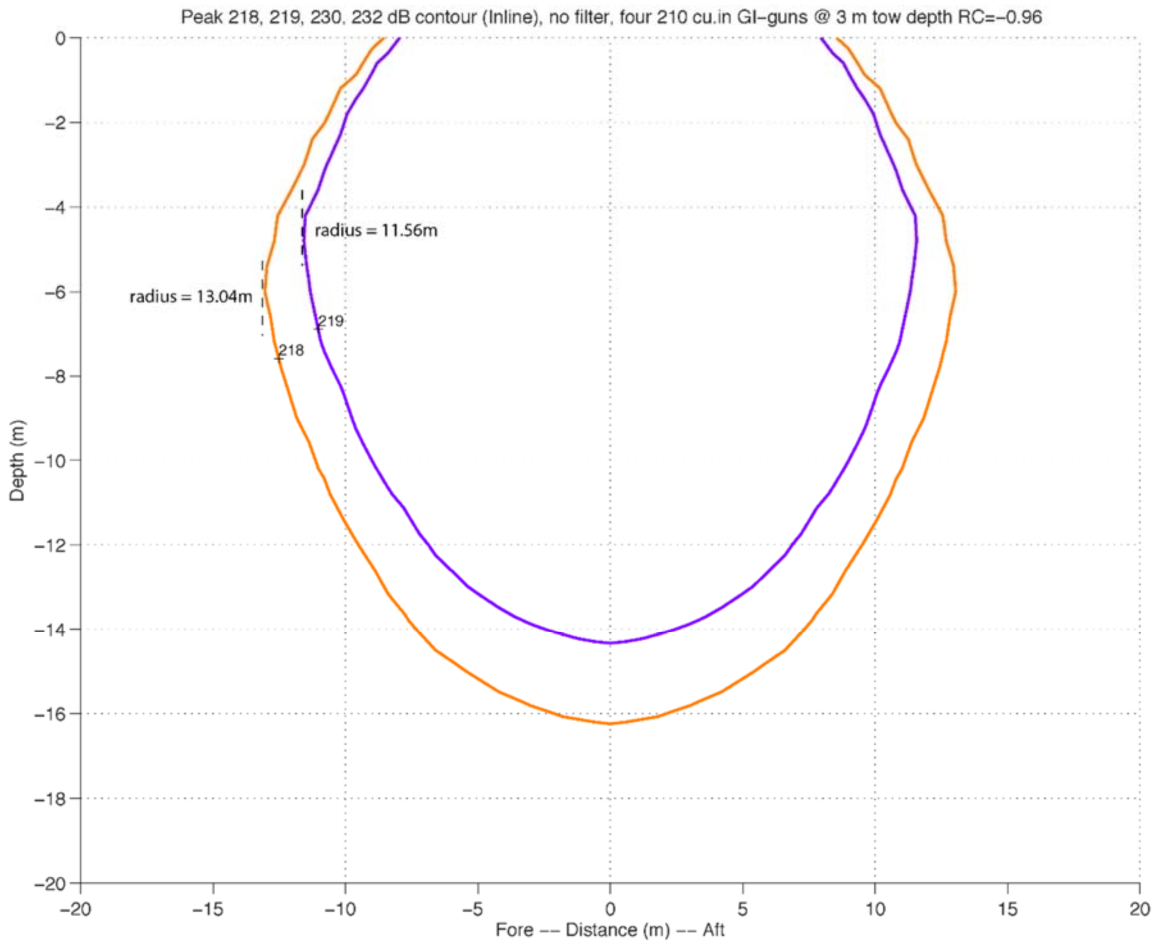

FIGURE C13: Modeled deep-water received Peak SPL from two 210 cu.in airguns at a 3-m tow depth. The plot provides the radius of the 218 and 219 dB peak isopleths.

BACKUP CONFIGURATION

2 x 105 cu.in – 2 m separation aft-fore direction @ 3 m depth

SELcum methodology (spreadsheet – Sivle et al., 2014)

Table C7: Table showing the results for one single SEL SL modeling without and with applying weighting function to the 5 hearing groups. The modified farfield signature is estimated using the distance from the source array geometrical center to where the SELcum threshold is the largest. A propagation of 20 $\log_{10}$ (Radial distance) is used to estimate the modified farfield SEL.

SEL_{cum} Threshold	183	185	155	185	203
Distance(m) (no weighting function)	17.9821	14.5253	459.5354	14.5352	2.2227
Modified Farfield SEL*	208.0968	208.2425	208.2464	208.2425	209.9376
Distance (m) (with weighting function)	9.1754	N/A	N/A	N/A	N/A
Adjustment (dB)	- 5.84	N/A	N/A	N/A	N/A

* Propagation of 20 log R

For the Low Frequency Cetaceans, we estimated a new adjustment value by computing the distance from the geometrical center of the source to where the 183dB SEL cum isopleth is the largest. We first run the modeling for one single shot without applying any weighting function. The maximum 183dB SEL cum isopleth is located at 17.98 m from the source. We then run the modeling for one single shot with the low frequency Cetaceans weighting function applied to the full spectrum. The maximum 183 dB SEL cum isopleth is located at 9.17 m from the source. Difference between 17.98 m and 9.17 m gives an adjustment factor of -5.84 dB assuming a propagation of 20log10(R).

TABLE C8. Results for single shot SEL source level modeling for the two 105 in^3 airguns with weighting function calculations for SEL_{cum} criteria.

F: MOBILE SOURCE: Impulsive, Intermittent (SAFE DISTANCE METHODOLOGY)

VERSION 1.1: Aug-16

KEY

(green)	**Action Proponent Provided Information**
(pink)	**NMFS Provided Information (Acoustic Guidance)**
(blue)	**Resultant Isopleth**

STEP 1: GENERAL PROJECT INFORMATION

PROJECT TITLE	Carolyn Ruppel -
PROJECT/SOURCE INFORMATION	source : SIO portable system = 2 x 105 cu.in GI-gun at a 3m towed depth - (2 m separation in the fore-aft direction)
Please include any assumptions	
PROJECT CONTACT	

STEP 2: WEIGHTING FACTOR ADJUSTMENT

Specify if relying on source-specific WFA, alternative weighting/dB adjustment, or if using default value

Weighting Factor Adjustment (kHz)[¥]	User defined	Default used

[¥] Broadband: 95% frequency contour percentile (kHz) OR Narrowband: frequency (kHz); For appropriate default WFA: See INTRODUCTION tab

† If a user relies on alternative weighting/dB adjustment rather than relying upon the WFA (source-specific or default), they may override the Adjustment (dB) (row 62), and enter the new value directly. However, they must provide additional support and documentation supporting this modification.

*** BROADBAND Sources: Cannot use WFA higher than maximum applicable frequency (See GRAY tab for more information on WFA applicable frequencies)**

STEP 3: SOURCE-SPECIFIC INFORMATION

NOTE: Choose either F1 OR F2 method to calculate isopleths (not required to fill in sage boxes for both)

NOTE: LDEO modeling relies on Method F2

F2: ALTERNATIVE METHOD† TO CALCULATE PK and SEL_{cum} (SINGLE STRIKE/SHOT/PULSE EQUIVALENT)

SEL_{cum}

Source Velocity (meters/second)	2.05778
1/Repetition rate^ (seconds)	12.149

†Methodology assumes propagation of 20 log R; Activity duration (time) independent

^Time between onset of successive pulses.

Modified farfield SEL	**208.0968**	**208.2425**	**208.2464**	**208.2425**	**209.9376**
Source Factor	**5.31055E+19**	**5.49173E+19**	**5.49667E+19**	**5.49173E+19**	**8.11371E+19**

RESULTANT ISOPLETHS*

*Impulsive sounds have dual metric thresholds (SELcum & PK). Metric producing largest isopleth should be used.

Hearing Group	**Low-Frequency Cetaceans**	**Mid-Frequency Cetaceans**	**High-Frequency Cetaceans**	**Phocid Pinnipeds**	**Otariid Pinnipeds**
SEL_{cum} Threshold	183	185	155	185	203
PTS SEL_{cum} Isopleth to threshold (meters)	**10.6**	**0.0**	**0.0**	**0.1**	**0.0**

WEIGHTING FUNCTION CALCULATIONS

Weighting Function Parameters	**Low-Frequency Cetaceans**	**Mid-Frequency Cetaceans**	**High-Frequency Cetaceans**	**Phocid Pinnipeds**	**Otariid Pinnipeds**	
a	1	1.6	1.8	1	2	
b	2	2	2	2	2	
f_1	0.2	8.8	12	1.9	0.94	
f_2	19	110	140	30	25	
C	0.13	1.2	1.36	0.75	0.64	
Adjustment (dB)†	-5.84	-53.99	-63.14	-23.74	-29.82	**OVERIDE Using LDEO Modeling**

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
SEL_{cum} Threshold	183	185	155	185	203
PTS SEL_{cum} Isopleth to threshold (meters)	10.6	0.0	0.0	0.1	0.0

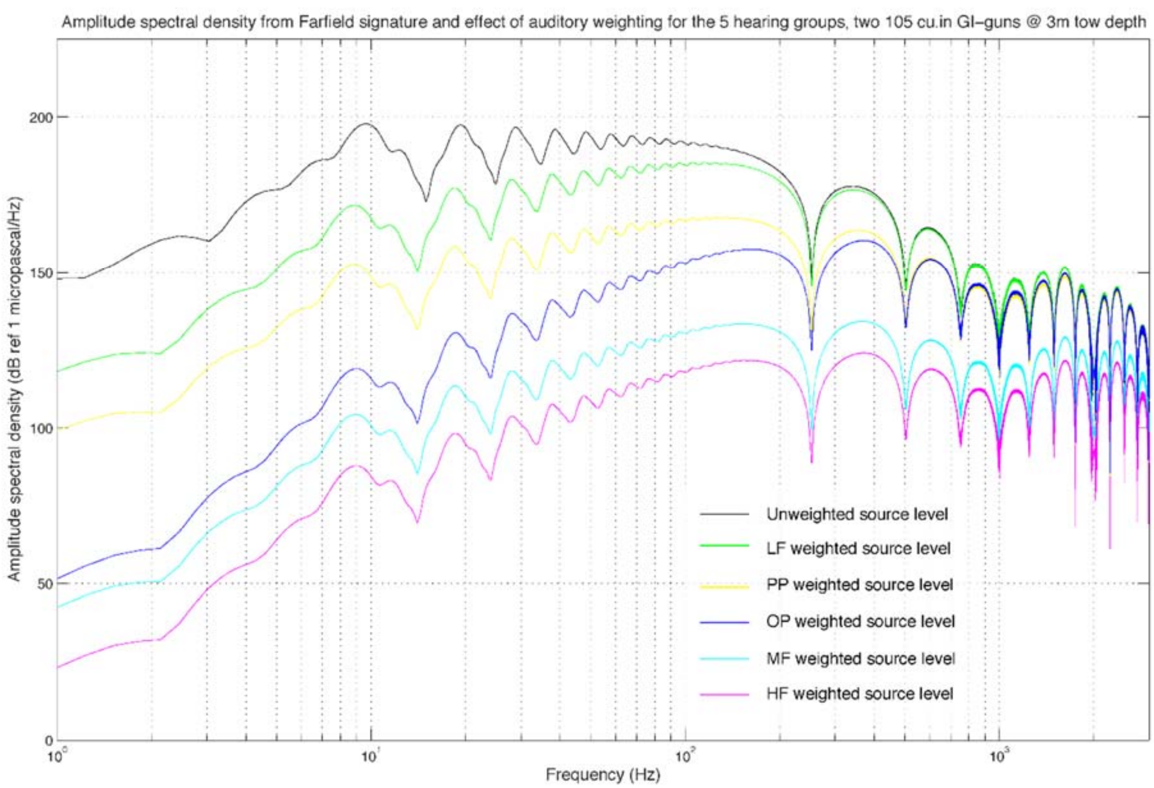

FIGURE C14: Modeled amplitude spectral density of the two 105 cu.in airgun farfield signature. Amplitude spectral density before (black) and after (green, yellow, blue, cyan, magenta) applying the auditory weighting function for the Low Frequency Cetaceans, Phocid Pinnipeds, Otariid Pinnipeds, Mid Frequency Cetaceans, High Frequency Cetaceans, respectively. Modeled spectral levels in micropascals are used to calculate the difference between the un-weighted and weighted source level at each frequency and to derive the adjustment factors for the Phocid Pinnipeds, Otariid Pinnipeds, Mid Frequency Cetaceans, and High Frequency Cetaceans as inputs into the NMFS user spreadhseet.

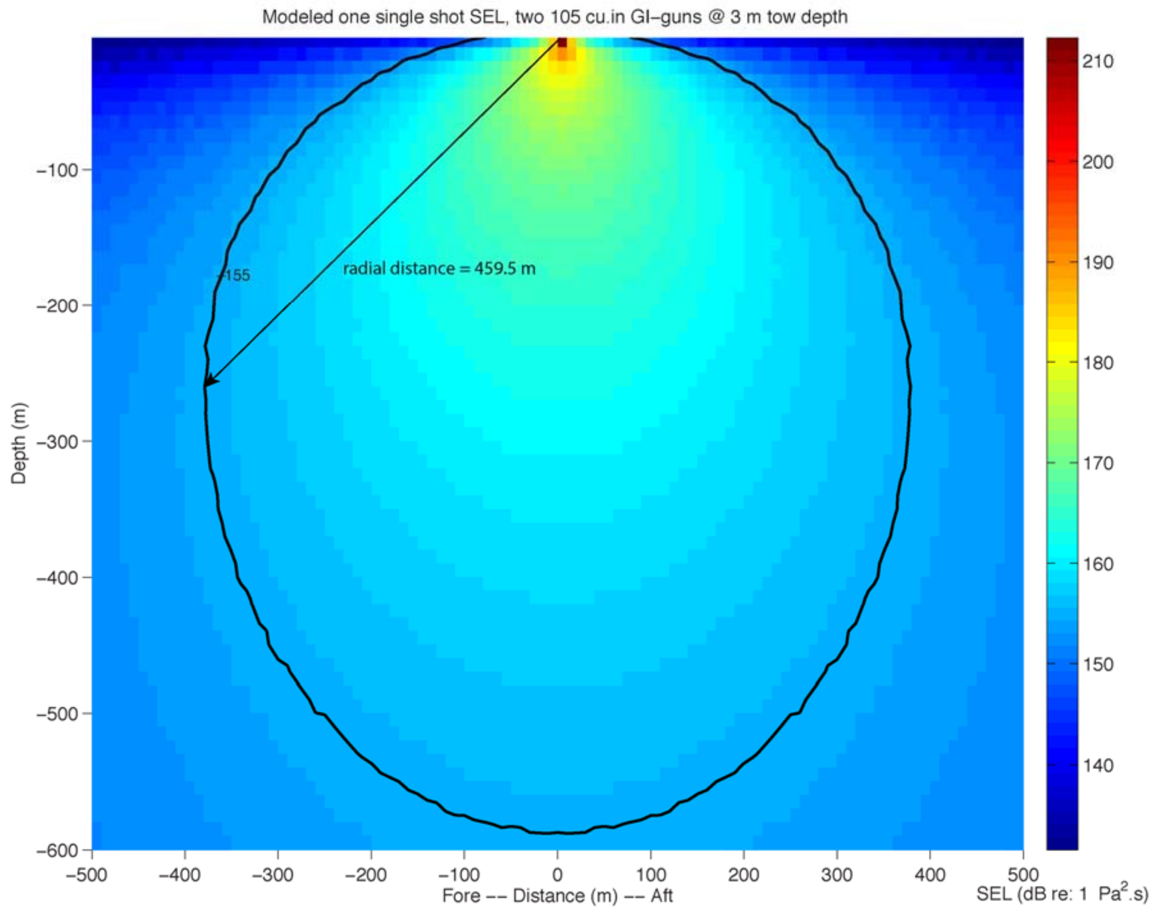

FIGURE C15: Modeled received sound levels (SELs) in deep water from the two 105 cu.in GI-guns at a 3-m tow depth. The plot provides the distance from the geometrical center of the source array to the 155-dB SEL isopleth (459.5 m).

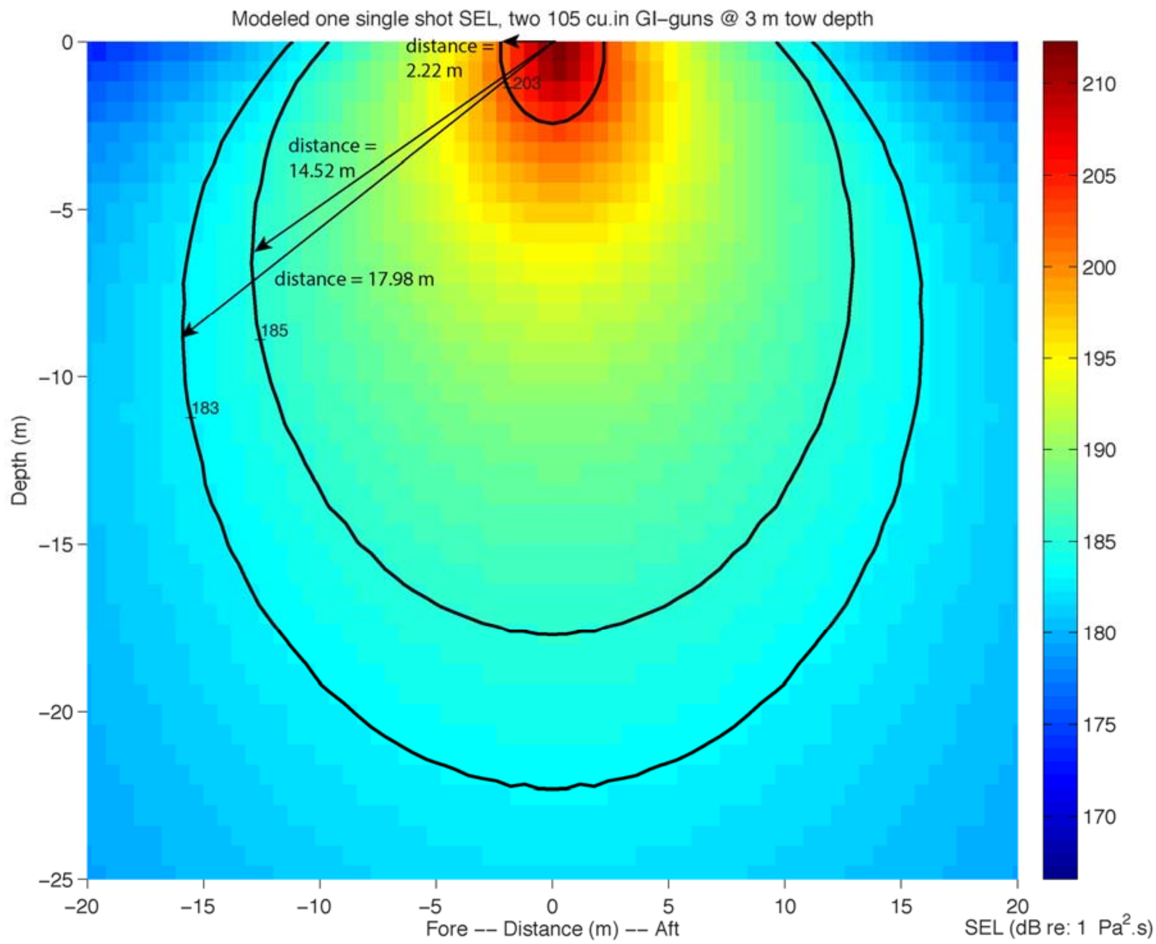

FIGURE C16: Modeled received sound levels (SELs) in deep water from the two 105 cu.in GI-guns at a 3-m tow depth. The plot provides the distance from the geometrical center of the source array to the 183 and 185 dB SEL isopleths

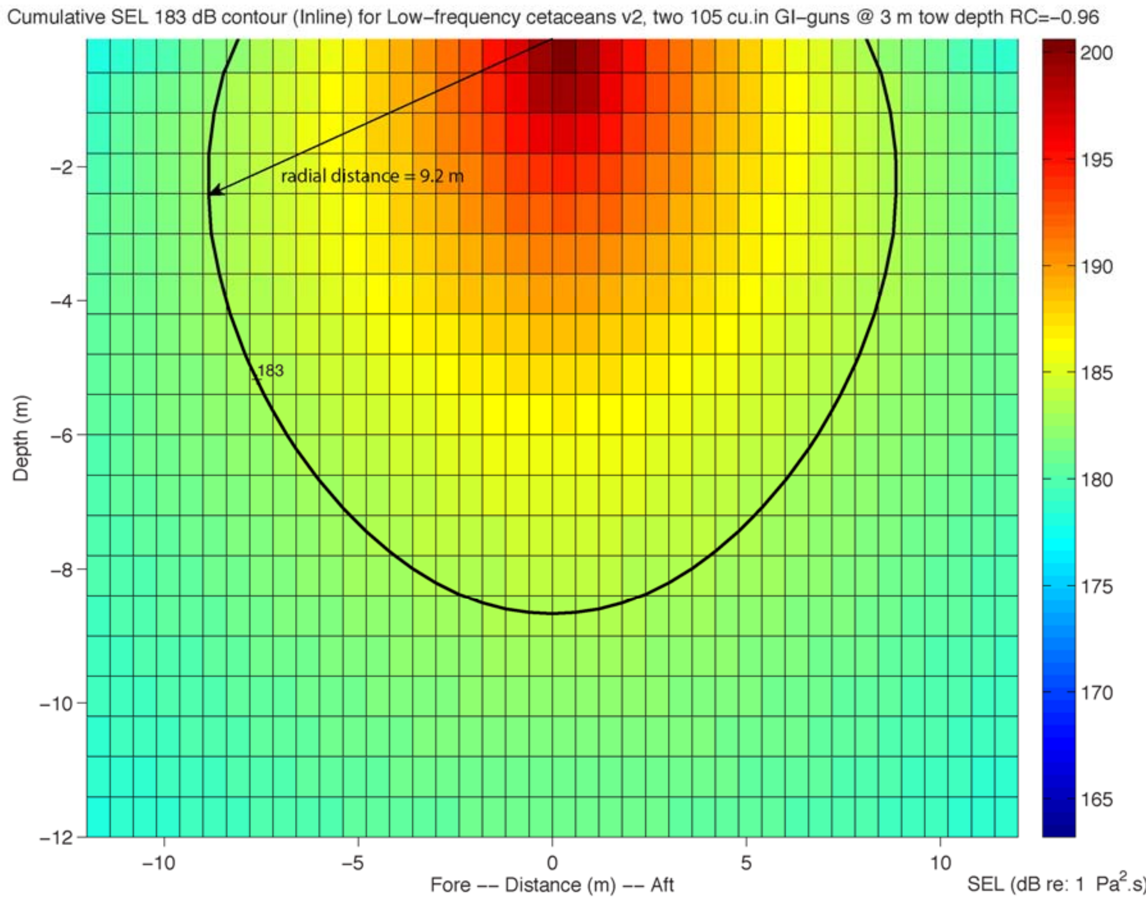

FIGURE C17: Modeled received sound exposure levels (SELs) from the two 105 cu.in GI-guns at a 3-m tow depth, after applying the auditory weighting function for the Low Frequency Cetaceans hearing group following to the new technical guidance. The plot provides the radial distance to the 183-dB SELcum isopleth for one shot. The difference in radial distances between Fig. 4 (17.98 m) and this figure (9.17 m) allows us to estimate the adjustment in dB.

Peak Sound Pressure Level :

TABLE C9. LEVEL A. NMFS Level A acoustic thresholds (Peak SPL_{flat}) for impulsive sources for marine mammals and predicted radial distances to Level A thresholds for various marine mammal hearing groups that could be received from the two 105 cu.in airguns at a 3 m tow depth during the proposed seismic survey in the north western Atlantic Ocean. While the modified PK farfield value (calculated as PK threshold $+20\log_{10}(\text{radius})$) is reported here, it is irrelevant since the calculations no longer rely on applying band pass filters.

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
PK Threshold	219	230	202	218	232
Modified PK farfield (dB)	235.3	234.0	234.5	235.3	232.7
Radius to threshold (meters)	6.52	1.58	42.32	7.31	1.08

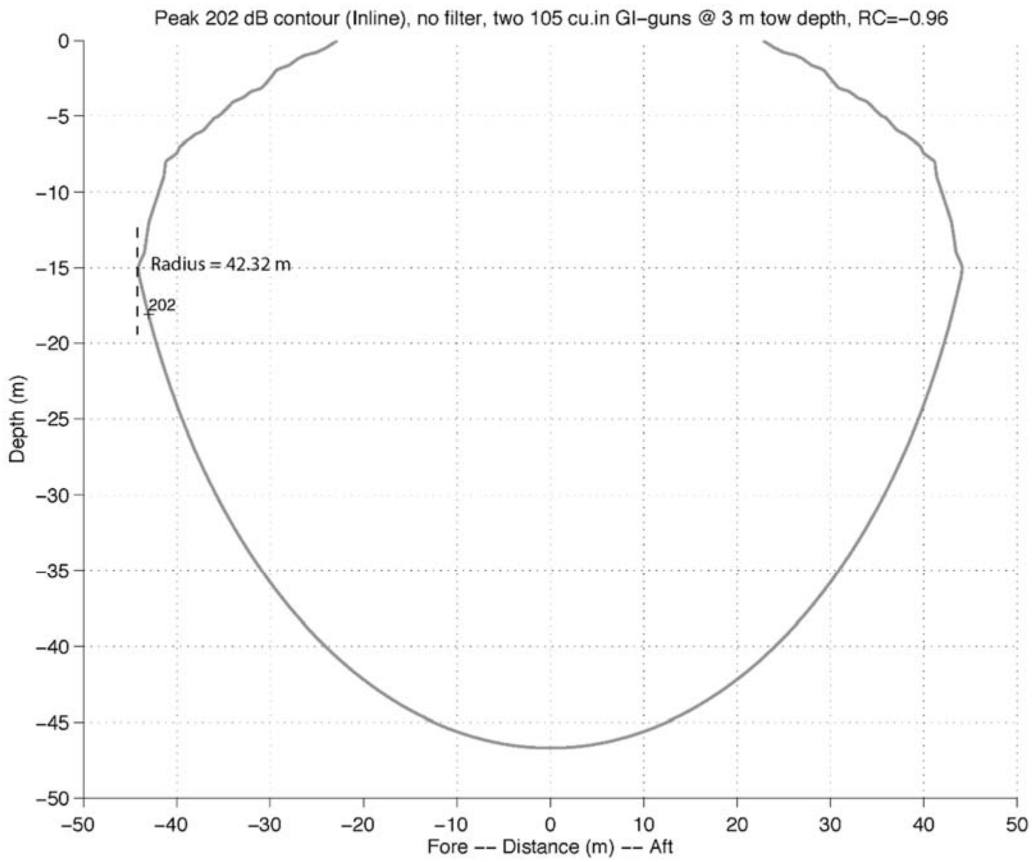

FIGURE C18: Modeled deep-water received Peak SPL from two 105 cu.in airguns at a 3-m tow depth. The plot provides the radius of the 202-dB peak isopleth (42.32 m).

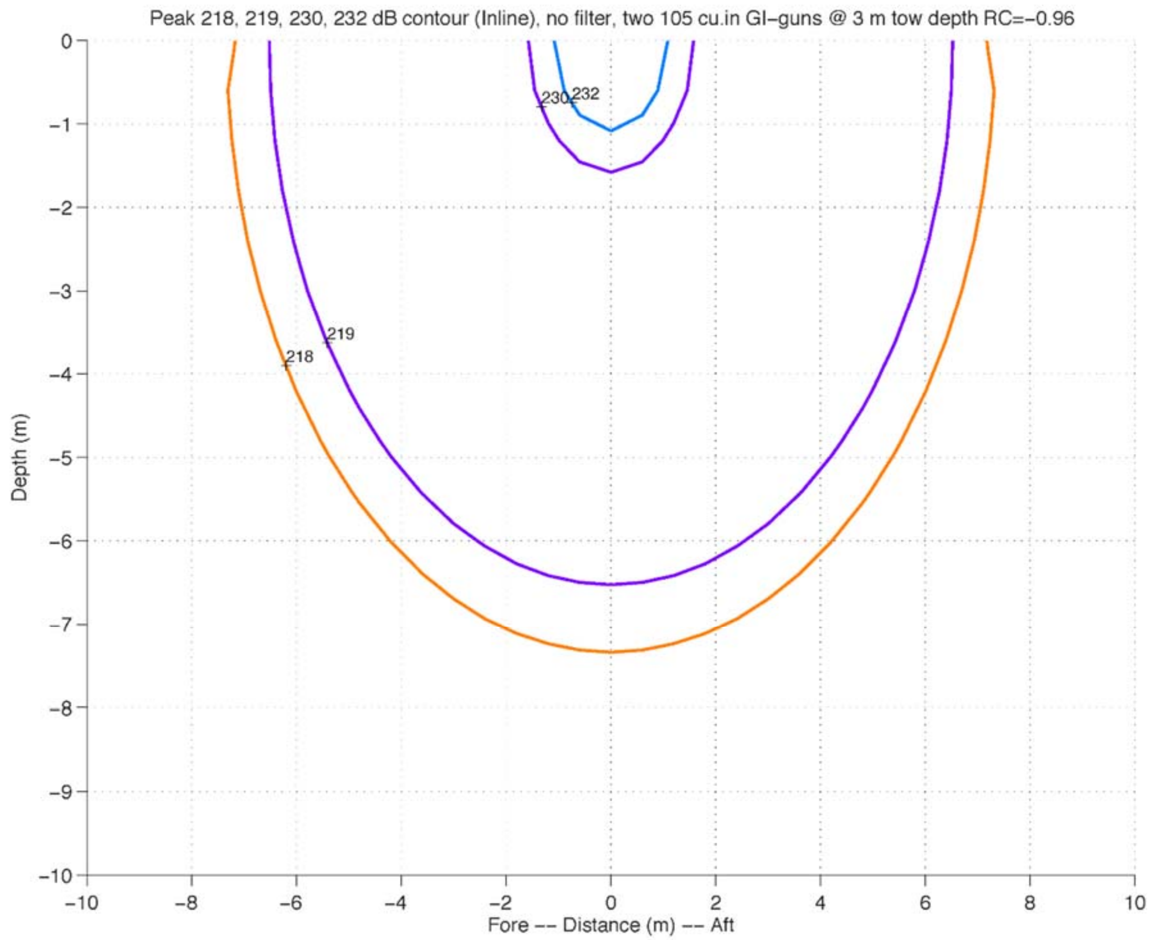

FIGURE C19: Modeled deep-water received Peak SPL from two 105 cu.in airguns at a 3-m tow depth. The plot provides the radius of the 218-219-230 and 232 dB peak isopleths.

Summary Tables for PTS SEL_{cum} and Peak SPL_{flat}.

Table C10. PTS SEL_{cum} isopleth to threshold in meters (*italics*) for each source configuration and hearing group, as calculated using the NMFS spreadsheet.

	Hearing Group		
	Low-Frequency Cetaceans	**Mid-Frequency Cetaceans**	**High-Frequency Cetaceans**
SEL_{cum} Threshold	183 dB	185 dB	155 dB
Base Configuration	*31.0 m*	*0.0*	*0.0*
GG Configuration	*39.5 m*	*0.0*	*0.1 m*

Backup Configuration	*10.6 m*	*0.0*	*0.0*

TABLE C11. SUMMARY LEVEL A. NMFS Level A acoustic thresholds (Peak SPL_{flat}) for impulsive sources and predicted radial distances to Level A thresholds in meters for the three source configurations.

	Hearing Group		
	Low-Frequency Cetaceans	**Mid-Frequency Cetaceans**	**High-Frequency Cetaceans**
PK Threshold	219 dB	230 dB	202 dB
Base configuration	*10.03 m*	*N/A (0)*	*70.426 m*
GG configuration	*11.56 m*	*N/A (0)*	*80.50 m*
Backup configuration	*6.52 m*	*1.58 m*	*42.32 m*

Appendix I. USFWS Consultation (Endangered Species Act)

Re: ESA: Proposed USGS lower energy marine seismic survey on U.S. Mid-Atlantic Margin, August 2018

Inbox x

Smith, Glenn <glenn_s_smith@fws.gov> Jun 7

to me, Ben, John, Rachel, Jerry

Hi Carolyn-

I was able to review the documents along with our lead biologist for the roseate tern. Since these are mid-Atlantic transects, not New England coastal transects, we would only have potential migratory roseate terns in the action area during project implemenation. However, most of the terns migrate in September. Even though some adults may leave in late August, there would be little overlap of tern migration with the project. Since the chance of the terns being in the area during these tests would be discountable and the impact by the noise from 80 m or more below them should be insignificant, the action is not likely to adversely affect roseate terns.

We would appreciate any information on roseate tern encounters that are documented during implementation of the survey.
Thanks,

Glenn S. Smith
Assistant Regional TE Coordinator, Northeast Region

Southeast Region Concurrence on Effects Determination for Proposed USGS MATRIX Activities

Inbox x

Tawes, Robert <robert_tawes@fws.gov> Jun 22

to me, Glenn, Ben, John, Michelle, Marelisa, Tom, Jerry, Jack, mleeper, ncmiller

Dr. Ruppel,

Ben Thatcher in our Headquarters Office forwarded to us your letter dated May 21, 2018, that requested concurrence with endangered species effects determinations for the proposed Mid-Atlantic Resource Imaging Experiment (MATRIX), which is planned for August, 2018 (the Action). Glenn Smith in our Northeast Region has already provided concurrence for the USGS determination that the Action is not likely to adversely affect the roseate tern. I am responding for the Southeast Region to the USGS determinations for the Bermuda petrel and the black-capped petrel.

We appreciate your consideration of the black-capped petrel, which is a species that the Service is reviewing for classification as endangered or threatened. Because this species is not yet classified or proposed for listing as endangered or threatened, Service concurrence with your determination for the black-capped petrel is not required under section 7 of the Endangered Species Act (ESA). However, we reviewed the draft Environmental Assessment for the Action and conferred with the lead biologists in our Field Offices for each petrel species.

We agree with the USGS assessment that the probability of encountering individuals of these two species at sea in the proposed survey area is low, but not discountable. If the ship should happen upon individuals along the survey transects, we agree with your findings that any disturbance associated with the surveys, including the seismic operations, would most likely cause an avoidance response that is not biologically meaningful. The proposed mitigation measures, including dedicated observers and airgun shutdowns when protected species are detected, further ensure that any petrel responses to the operations are insignificant. Therefore, the Service concurs that the Action may affect, but is not likely to adversely affect the Bermuda petrel and the black-capped petrel.

This concurrence fulfills USGS responsibilities under section 7 of the ESA for the Bermuda petrel. Reinitiating this consultation is required if USGS retains discretionary involvement or control over the Action (or is authorized by law) when:

(a) new information reveals that the Action may affect listed species or designated critical habitat in a manner or to an extent not considered;
(b) the Action is modified in a manner that causes effects to listed species or designated critical habitat not considered; or
(c) a new species is listed or critical habitat designated that the Action may affect.

Thank you for your careful consideration of ESA-protected and at-risk species in planning this Action. If you have any questions about this response, please contact Jerry Ziewitz of my staff at 850-877-6513 or by email at jerry_ziewitz@fws.gov.

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Appendix J. Federal Register Notice from NMFS on IHA Application (May 31, 2018)

DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration

RIN 0648–XF986

Takes of Marine Mammals Incidental to Specified Activities; Taking Marine Mammals Incidental to a Low-Energy Geophysical Survey in the Northwest Atlantic Ocean

AGENCY: National Marine Fisheries Service (NMFS), National Oceanic and Atmospheric Administration (NOAA), Commerce.

ACTION: Notice; proposed incidental harassment authorization; request for comments.

SUMMARY: NMFS has received a request from the Scripps Institution of Oceanography (SIO) for authorization to take marine mammals incidental to a low-energy marine geophysical survey in the Northwest Atlantic Ocean. Pursuant to the Marine Mammal Protection Act (MMPA), NMFS is requesting comments on its proposal to issue an incidental harassment authorization (IHA) to incidentally take marine mammals during the specified activities. NMFS will consider public comments prior to making any final decision on the issuance of the requested MMPA authorization and agency responses will be summarized in the final notice of our decision.

DATES: Comments and information must be received no later than May 29, 2018.

ADDRESSES: Comments should be addressed to Jolie Harrison, Chief, Permits and Conservation Division, Office of Protected Resources, National Marine Fisheries Service. Physical comments should be sent to 1315 East-West Highway, Silver Spring, MD 20910 and electronic comments should be sent to *ITP.Carduner@noaa.gov.*

Instructions: NMFS is not responsible for comments sent by any other method, to any other address or individual, or received after the end of the comment period. Comments received electronically, including all attachments, must not exceed a 25-megabyte file size. Attachments to electronic comments will be accepted in Microsoft Word or Excel or Adobe PDF file formats only. All comments received are a part of the public record and will generally be posted online at *www.fisheries.noaa.gov/national/marine-mammal-protection/incidental-take-authorizations-research-and-other-activities* without change. All personal identifying information (*e.g.,* name, address) voluntarily submitted by the commenter may be publicly accessible. Do not submit confidential business information or otherwise sensitive or protected information.

FOR FURTHER INFORMATION CONTACT: Jordan Carduner, Office of Protected Resources, NMFS, (301) 427–8401. Electronic copies of the application and supporting documents, as well as a list of the references cited in this document, may be obtained online at: *www.fisheries.noaa.gov/national/marine-mammal-protection/incidental-take-authorizations-research-and-other-activities.* In case of problems accessing these documents, please call the contact listed above.

SUPPLEMENTARY INFORMATION:

Background

Sections 101(a)(5)(A) and (D) of the MMPA (16 U.S.C. 1361 *et seq.*) direct the Secretary of Commerce (as delegated to NMFS) to allow, upon request, the incidental, but not intentional, taking of small numbers of marine mammals by U.S. citizens who engage in a specified activity (other than commercial fishing) within a specified geographical region if certain findings are made and either regulations are issued or, if the taking is limited to harassment, a notice of a proposed authorization is provided to the public for review.

An authorization for incidental takings shall be granted if NMFS finds that the taking will have a negligible impact on the species or stock(s), will not have an unmitigable adverse impact on the availability of the species or stock(s) for subsistence uses (where relevant), and if the permissible methods of taking and requirements pertaining to the mitigation, monitoring and reporting of such takings are set forth.

NMFS has defined ''negligible impact'' in 50 CFR 216.103 as an impact resulting from the specified activity that cannot be reasonably expected to, and is not reasonably likely to, adversely affect the species or stock through effects on annual rates of recruitment or survival.

The MMPA states that the term ''take'' means to harass, hunt, capture, kill or attempt to harass, hunt, capture, or kill any marine mammal.

Except with respect to certain activities not pertinent here, the MMPA defines ''harassment'' as any act of pursuit, torment, or annoyance which (i) has the potential to injure a marine mammal or marine mammal stock in the wild (Level A harassment); or (ii) has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering (Level B harassment).

National Environmental Policy Act

To comply with the National Environmental Policy Act of 1969 (NEPA; 42 U.S.C. 4321 *et seq.*) and NOAA Administrative Order (NAO) 216–6A, NMFS must review our proposed action (*i.e.,* the issuance of an incidental harassment authorization) with respect to potential impacts on the human environment. This action is consistent with categories of activities identified in Categorical Exclusion B4 (incidental harassment authorizations with no anticipated serious injury or mortality) of the Companion Manual for NOAA Administrative Order 216–6A, which do not individually or cumulatively have the potential for significant impacts on the quality of the human environment and for which we have not identified any extraordinary circumstances that would preclude this categorical exclusion. Accordingly, NMFS has preliminarily determined that the issuance of the proposed IHA qualifies to be categorically excluded from further NEPA review.

Summary of Request

On November 20, 2017, NMFS received a request from SIO for an IHA to take marine mammals incidental to conducting a low-energy marine geophysical survey in the Northwest Atlantic Ocean. On February 8, 2018, we deemed SIO's application for authorization to be adequate and complete. SIO's request is for take of a small number of 35 species of marine mammals by Level B harassment and Level A harassment. Neither SIO nor NMFS expects mortality to result from this activity, and, therefore, an IHA is appropriate. The planned activity is not expected to exceed one year, hence, we do not expect subsequent MMPA incidental harassment authorizations would be issued for this particular activity.

Description of Proposed Activity

Overview

SIO proposes to conduct low-energy marine seismic surveys in the Northwest Atlantic Ocean during June–July 2018. The surveys would take place in International Waters in water deeper than 1,000 meters (m) (See Figure 1 in the IHA application). The proposed surveys would involve one source vessel, the R/V *Atlantis.* The *Atlantis* would tow a pair of 45 cubic inch (in^3) GI airguns at a depth of 2–4 m with a total discharge volume of approximately

90 in^3 as an energy source along predetermined lines.

Dates and Duration

The seismic survey would be carried out for approximately 25 days. The *Atlantis* would likely depart from St. George's, Bermuda, on or about June 14, 2018 and would return to Woods Hole, Massachusetts, on or about July 17, 2018. Some deviation in timing could result from unforeseen events such as weather, logistical issues, or mechanical issues with the research vessel and/or equipment. Seismic activities would occur 24 hours per day during the proposed survey.

Specific Geographic Region

The proposed surveys would take place in International Waters of the Northwest Atlantic Ocean, between ~33.5° and 53.5° N, and 37° and 49° W. Representative survey track lines for the survey area is shown in Figure 1 of the IHA application. The *Atlantis* would depart from St. George's, Bermuda, and would return to Woods Hole, Massachusetts.

Detailed Description of Specific Activity

SIO proposes to conduct low-energy seismic surveys low-energy seismic surveys in the Northwest Atlantic Ocean in International Waters between ~33.5° and 53.5° N, and 37° and 49° W, in water deeper than 1,000 m. The survey area and representative survey tracklines are shown in Figure 1 in the IHA application. As described above, some deviation in actual tracklines and timing could be necessary. The proposed surveys would be in support of a potential future International Ocean Discovery Program (IODP) project and would examine regional seismic stratigraphy and provide seismic images of changing sediment distributions from deepwater production changes. The proposed surveys would thus take place in an area that is of interest to the IODP and that has older Deep Sea Drilling Project (DSDP) sites. To achieve the program's goals, the Principal Investigators propose to collect low-energy, high-resolution multi-channel seismic (MCS) profiles.

The procedures to be used for the seismic surveys would be similar to those used during previous seismic surveys by SIO and would use conventional seismic methodology. The surveys would involve one source vessel, R/V *Atlantis,* which is operated by Woods Hole Oceanographic Institution (WHOI). R/V *Atlantis* would deploy a pair of 45-in^3 GI airguns as an energy source with a total volume of 90 in^3. The receiving system would consist of one hydrophone streamer, either 200 or 600 m in length, as described below. As the airguns are towed along the survey lines, the hydrophone streamer would receive the returning acoustic signals and transfer the data to the on-board processing system.

The proposed surveys would consist of: (1) Digital bathymetric, echosounding and MCS surveys at six locations to enable the selection and analysis of potential future IODP drill sites (see Survey Areas 1–6 in Figure 1 in the IHA application); and (2) digital bathymetric, echo-sounding and MCS reflection profiles that tie the proposed drill sites to existing DSDP drill sites and replace poor-quality analog seismic data. Each of the six site surveys would consist of grids of ship tracks that would be acquired using two different types of airgun array configurations. The first would be a reconnaissance grid designed to identify the optimum orientation and length of seismic lines needed for a second, higher-data quality survey designed to locate exactly the most suitable potential future drill site suggested by results of the reconnaissance survey. This two-step effort is needed for two reasons. First, most of the proposed survey sites have been crossed by low-resolution, single-channel, analog seismic data collected 30–40 years ago, and as such are only marginally suitable for proper drill site selection. Second, basement ridges are typically spaced closer than the 10–20 kilometer (km) resolution of satellite bathymetry that currently provides constraints on seafloor features in this region, making it necessary to conduct ship-borne bathymetric surveys as a first indicator of potential future drill locations.

Each reconnaissance grid would be collected using a pair of 45-in^3 airguns, with airguns spaced 8 m apart at a water depth of 2–4 m, with a 200 m hydrophone streamer and with the vessel traveling at 8 knots (kt). Each high-quality site-selection grid, embedded entirely within the boundaries of the reconnaissance grid, would be collected using a pair of 45-in^3 airguns, with airguns spaced 2 m apart at a depth of 2–4 m, with a 600 m hydrophone streamer and with the vessel traveling at to 5 kt to achieve especially high-quality seismic reflection data.

A reconnaissance grid and an embedded high-quality survey grid would be centered at each of the six Survey Areas, as shown in Figure 1 of the IHA application. Figure 1 of the IHA application also shows representative tracklines for a potential reconnaissance grid consisting of four 30 nautical mile (nm) long main lines, three 20 nm cross lines, and ~60 nm of turns, for a total of ~240 nm data per reconnaissance grid. All data, including turns, would be collected inside the boundaries of a 40 x 40 nm box. The location, orientation, and size of the embedded high-quality survey grid would depend on the information obtained during the reconnaissance survey. A potential high-quality grid could have 10 intersecting tracklines. A site appropriate for potential future drilling by the IODP would be identified with each of these high-quality digital data grids. These latter grids would comprise at least 120 nm of data. In addition to the six site surveys, MCS profiles would be acquired at a speed of 8 kt, with a pair of 45-in^3 airguns towed 8 m apart at a water depth of 2–4 m, using a 200-m streamer.

The six proposed site surveys would collect up to 4,334 km of data; survey lines connecting several grids and existing DSDP drill sites, as shown in Figure 1, comprise another 3,577 km, for a total of 7,911 km of seismic acquisition. All data would be collected in water depths of more than 1,000 m. There could be additional seismic operations in the project area associated with equipment testing, re-acquisition due to equipment malfunction, data degradation during poor weather, or interruption due to shutdown or track deviation in compliance with IHA requirements. To account for these additional seismic operations, 25 percent has been added in the form of operational days, which is equivalent to adding 25 percent to the proposed line km to be surveyed.

In addition to the operations of the airgun array, a multibeam echosounder (MBES) and a sub-bottom profiler (SBP) would also be operated continuously throughout the survey, but not during transits to and from the project area. All planned geophysical data acquisition activities would be conducted by SIO with on-board assistance by the scientists who have proposed the study. The vessel would be self-contained, and the crew would live aboard the vessel for the entire cruise.

The *Atlantis* has a length of 84 m, a beam of 16 m, and a maximum draft of 5.8 m. The ship is powered by diesel electric motors and 1,180 SHP azimuthing stern thrusters. An operation speed of approximately 5–8 kt (9–15 km/hr) would be used during seismic acquisition. When not towing seismic survey gear, the *Atlantis* cruises at approximately 11 kt (20 km/hr). It has a normal operating range of approximately 32,000 km. The *Atlantis* would also serve as the platform from which vessel-based protected species visual observers (PSO) would watch for marine mammals during airgun operations.

During the survey, the *Atlantis* would tow a pair of 45-in^3 GI airguns and a 200- or 600-m long streamer containing hydrophones along predetermined lines. The generator chamber of each GI airgun, the one responsible for introducing the sound pulse into the ocean, is 45 in^3. The larger (105 in^3) injector chamber injects air into the previously generated bubble to maintain its shape, and does not introduce more sound into the water. The two 45-in^3 GI airguns would be towed 21 m behind R/V *Atlantis,* 2 m (during 5-kt grid surveys) or 8 m (8-kt reconnaissance and seismic transect surveys) apart side by side, at a depth of 2–4 m. Surveys with the 2-m airgun separation configuration would use a 600-m hydrophone streamer, whereas surveys with the 8-m airgun separation configuration would use a 200-m hydrophone streamer. Seismic pulses would be emitted at intervals of 25 m for the 5 kt surveys using the 2-m GI airgun separation and at intervals of 50 m for the 8 kt surveys using the 8-m airgun separation.

TABLE 1—SPECIFICATIONS OF THE R/V ATLANTIS AIRGUN ARRAY

Number of airguns	2.
Gun positions used	Two inline airguns 2- or 8-m apart.
Tow depth of energy source.	2–4 m.
Dominant frequency components.	0–188 Hz.
Air discharge volume	Approximately 90 in^3.
Shot interval	7.8 seconds.

Proposed mitigation, monitoring, and reporting measures are described in detail later in this document (please see ''Proposed Mitigation'' and ''Proposed Monitoring and Reporting'').

Description of Marine Mammals in the Area of Specified Activities

Section 4 of the application summarizes available information regarding status and trends, distribution and habitat preferences, and behavior and life history, of the potentially affected species. Additional information about these species (*e.g.,* physical and behavioral descriptions) may be found on NMFS' website (*www.fisheries.noaa.gov/find-species*).

The populations of marine mammals considered in this document do not occur within the U.S. EEZ and are therefore not assigned to stocks and are not assessed in NMFS' Stock Assessment Reports (SAR). As such, information on potential biological removal (PBR; defined by the MMPA as the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population) and on annual levels of serious injury and mortality from anthropogenic sources are not available for these marine mammal populations. Abundance estimates for marine mammals in the survey location are lacking; therefore the abundance estimates presented here are based on the U.S. Atlantic SARs (Hayes *et al.,* 2017), as this is considered the best available information on potential abundance of marine mammals in the area. However, as described above, the marine mammals encountered by the proposed survey are not assigned to stocks. All abundance estimate values presented in Table 2 are the most recent available at the time of publication and are available in the 2017 U.S. Atlantic draft SARs (*e.g.,* Hayes *et al.* 2017) available online at: *www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-stock-assessments,* except where noted otherwise.

Table 2 lists all species with expected potential for occurrence in the survey area and with the potential to be taken as a result of the proposed survey, and summarizes information related to the population, including regulatory status under the MMPA and ESA. For taxonomy, we follow Committee on Taxonomy (2016).

TABLE 2—MARINE MAMMAL SPECIES POTENTIALLY PRESENT IN THE PROJECT AREA EXPECTED TO BE AFFECTED BY THE SPECIFIED ACTIVITIES

Species	Stock	ESA/MMPA status; Strategic (Y/N) [1]	Abundance [2]	Relative occurrence in project area
Order Cetartiodactyla—Cetacea—Superfamily Mysticeti (baleen whales)				
Family: Balaenopteridae:				
Humpback whale [3] (*Megaptera novaeangliae*)	n/a	-/-; N	12,312	Uncommon.
Minke whale [4] (*Balaenoptera acutorostrata*)	n/a	-/-; N	20,741	Uncommon.
Bryde's whale (*Balaenoptera brydei*)	n/a	-/-; N	unknown	Uncommon.
Sei whale (*Balaenoptera borealis*)	n/a	E/D; Y	357	Uncommon.
Fin whale [4] (*Balaenoptera physalus*)	n/a	E/D; Y	3,522	Uncommon.
Blue whale (*Balaenoptera musculus*)	n/a	E/D; Y	440	Uncommon.
Order Cetartiodactyla—Cetacea—Superfamily Odontoceti (toothed whales, dolphins, and porpoises)				
Family: Physeteridae:				
Sperm whale (*Physeter macrocephalus*)	n/a	E/D; Y	2,288	Uncommon.
Order Cetartiodactyla—Cetacea—Superfamily Odontoceti (toothed whales, dolphins, and porpoises)				
Family: Kogiidae:				
Pygmy sperm whale [5] (*Kogia breviceps*)	n/a	-/-; N	3,785	Rare.
Dwarf sperm whale [5] (*Kogia sima*)	n/a	-/-; N	3,785	Rare.

TABLE 2—MARINE MAMMAL SPECIES POTENTIALLY PRESENT IN THE PROJECT AREA EXPECTED TO BE AFFECTED BY THE SPECIFIED ACTIVITIES—Continued

Species	Stock	ESA/ MMPA status; Strategic (Y/N)[1]	Abundance[2]	Relative occurrence in project area
Order Cetartiodactyla—Cetacea—Superfamily Odontoceti (toothed whales, dolphins, and porpoises)				
Family: Delphinidae:				
Killer whale (*Orcinus orca*)	n/a	-/-; N	unknown	Uncommon.
False killer whale (*Pseudorca crassidens*)	n/a	-/-; N	442	Uncommon.
Pygmy killer whale (*Feresa attenuata*)	n/a	-/-; N	unknown	Rare.
Short-finned pilot whale (*Globicephala macrorhynchus*)	n/a	-/-; N	21,515	Uncommon.
Long-finned pilot whale (*Globicephala melas*)	n/a	-/-; N	5,636	Uncommon.
Harbor porpoise (*Phocoena phocoena*)	n/a	-/-; N	79,833	Uncommon.
Bottlenose dolphin (*Tursiops truncatus*)	n/a	-/-; N	77,532	Uncommon.
Striped dolphin (*Stenella coeruleoala*)	n/a	-/-; N	54,807	Uncommon.
Risso's dolphin (*Grampus griseus*)	n/a	-/-; N	18,250	Uncommon.
Common dolphin[4] (*Delphinus delphis*)	n/a	-; N	173,486	Uncommon.
Atlantic white-sided dolphin (*Lagenorhynchus obliquidens*)	n/a	-; N	48,819	Uncommon.
Atlantic spotted dolphin (*Stenella frontalis*)	n/a	-; N	44,715	Uncommon.
Pantropical spotted dolphin (*Stenella attenuate*)	n/a	-; N	3,333	Uncommon.
White beaked dolphin (*Lagenorhynchus albirostris*)	n/a	-; N	2,003	Uncommon.
Rough-toothed dolphin (*Steno bredanensis*)	n/a	-; N	271	Rare.
Order Cetartiodactyla—Cetacea—Superfamily Odontoceti (toothed whales, dolphins, and porpoises)				
Family: Ziphiidae:				
Cuvier's beaked whale (*Ziphius cavirostris*)	n/a	-/-; N	6,532	Uncommon.
Blainville's beaked whale[6] (*Mesoplodon densirostris*)	n/a	-; N	7,092	Uncommon.
True's beaked whale[6] (*Mesoplodon mirus*)	n/a	-/-; N	7,092	Rare.
Gervais beaked whale[6] (*Mesoplodon europaeus*)	n/a	-; N	7,092	Uncommon.
Sowerby's beaked whale[6] (*Mesoplodon bidens*)	n/a	-; N	7,092	Uncommon.
Northern bottlenose whale (*Hyperoodon ampullatus*)	n/a	-; N	unknown	Uncommon.
Order Carnivora—Superfamily Pinnipedia				
Family: Phocidae (earless seals):				
Hooded seal (*Cystophora cristata*)	n/a	-; N	592,100	Rare.
Harp seal (*Pagophilus groenlandicus*)	n/a	-; N	7,100,000	Rare.
Ringed seal (*Pusa hispida*)[7]	n/a	-; N	unknown	Rare.

[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] Abundance estimates are from the NMFS 2017 draft Atlantic SAR (Hayes *et al.,* 2017) unless otherwise noted. We note that marine mammals in the survey area would not belong to NMFS stocks, as the survey area is outside the geographic boundaries for stock assessments, thus stock abundance estimates are provided for comparison purposes only.

[3] NMFS defines a stock of humpback whales only on the basis of the Gulf of Maine feeding population; however, multiple feeding populations originate from the Distinct Population Segment (DPS) that is expected to occur in the proposed survey area (the West Indies DPS). As West Indies DPS whales from multiple feeding populations may be encountered in the proposed survey area, the total abundance of the West Indies DPS best reflects the abundance of the population that may encountered by the proposed survey. The West Indies DPS abundance estimate shown here reflects the latest estimate as described in the NMFS Status Review of the Humpback Whale under the Endangered Species Act (Bettridge *et al.,* 2015).

[4] Abundance for these species is from the 2007 Canadian Trans-North Atlantic Sighting Survey (TNASS), which provided full coverage of the Atlantic Canadian coast (Lawson and Gosselin, 2009). Abundance estimates from TNASS were corrected for perception and availability bias, when possible. In general, where the TNASS survey effort provided superior coverage of a stock's range (as compared with NOAA shipboard survey effort), we elect to use the resulting abundance estimate over the current NMFS abundance estimate (derived from survey effort with inferior coverage of the stock range).

[5] Abundance estimate represents pygmy and dwarf sperm whales combined.

[6] Abundance estimate represents all species of *Mesoplodon* in the Atlantic.

[7] NMFS does not have a defined stock of ringed seals in the Atlantic Ocean.

Four marine mammal species that are listed under the Endangered Species Act (ESA) may be present in the survey area and are included in the take request: The fin whale, sei whale, blue whale and sperm whale.

Below is a description of the species that are both common in the survey area and that have the highest likelihood of occurring in the survey area and thus are expected to have the potential to be taken by the proposed activities. Though other marine mammal species are known to occur in the North Atlantic Ocean, the temporal and/or spatial occurrence of several of these species is such that take of these species is not expected to occur, and they are therefore not discussed further beyond the explanation provided here. Four cetacean species, although present in the wider North Atlantic Ocean, likely would not be found near the proposed project area because their ranges generally do not extend as far north: Clymene dolphin, Fraser's dolphin, spinner dolphin, and melon-headed whale. Another cetacean species, the North Atlantic right whale, occurs in nearshore waters off the U.S. coast, and its range does not extend as far offshore as the proposed project area. Another three cetacean species occur in arctic waters, and their ranges generally do not extend as far south as the proposed project area: The bowhead whale, narwhal, and beluga. Two additional cetacean species, the Atlantic humpback dolphin (which occurs in coastal waters of western Africa) and the long-beaked common dolphin (which occurs in coastal waters of South America and western Africa) do not occur in deep offshore waters. Several pinniped species also are known to occur in North Atlantic waters, but are not expected to occur in deep offshore waters of the proposed project area, including the gray seal, harbor seal, and bearded seal.

We have reviewed SIO's species descriptions, including life history information, distribution, regional distribution, diving behavior, and acoustics and hearing, for accuracy and completeness. We refer the reader to Section 4 of SIO's IHA application, rather than reprinting the information here.

Humpback Whale

Humpback whales are found worldwide in all ocean basins. In winter, most humpback whales occur in the subtropical and tropical waters of the Northern and Southern Hemispheres (Muto *et al.,* 2015). These wintering grounds are used for mating, giving birth, and nursing new calves. Humpback whales were listed as endangered under the Endangered Species Conservation Act (ESCA) in June 1970. In 1973, the ESA replaced the ESCA, and humpbacks continued to be listed as endangered. NMFS recently evaluated the status of the species, and on September 8, 2016, NMFS divided the species into 14 distinct population segments (DPS), removed the current species-level listing, and in its place listed four DPSs as endangered and one DPS as threatened (81 FR 62259; September 8, 2016). The remaining nine DPSs were not listed. The West Indies DPS, which is not listed under the ESA, is the only DPS of humpback whale that is expected to occur in the survey area.

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. Several sightings have been made in water >2,000 m deep during the summer to the west of SIO's proposed Survey Areas 4, 5, and 6, and northwest of Survey Area 6 (Figure 1 in the IHA application) (DFO Sightings Database 2017; OBIS, 2017). Two humpback whales outfitted with satellite transmitters near the Dominican Republic during winter and spring of 2008 to 2012 were later reported off the east coast of Canada, as well as near the proposed project area between Survey Sites 4 and 5 (Kennedy *et al.* 2014). Humpback whales were sighted during a summer survey along the Mid-Atlantic Ridge from Iceland to north of the Azores, including east of the survey area (Waring *et al.* 2008) and they have also been sighted near the Mid-Atlantic Ridge near the Azores (Silva *et al.* 2014; OBIS, 2017). Humpback whales could be encountered in the proposed project area during June–July, especially north of 40° N.

Minke Whale

The minke whale has a cosmopolitan distribution ranging from the tropics and subtropics to the ice edge in both hemispheres (Jefferson *et al.* 2008). Some populations migrate from high latitude summering grounds to lower latitude wintering grounds (Jefferson *et al.* 2015). In the Northern Hemisphere, the minke whale is usually seen in coastal areas, but can also occur in pelagic waters during northward migrations in spring and summer, and southward migration in autumn (Stewart and Leatherwood, 1985; Perrin and Brownell, 2009). 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. One minke whale was sighted during a summer survey along the Mid-Atlantic Ridge from Iceland to north of the Azores, east of SIO's proposed Survey Area 5 (Figure 1 in the IHA application) (Waring et al., 2008), and one sighting was made during June 2006 to the east of SIO's proposed Survey Area 6 at 53.3° N, 40.9° W (OBIS 2017). Other minke whale sightings have also been reported between the proposed project area and the Mid-Atlantic Ridge (OBIS 2017), and sightings have been made to the west of SIO's proposed Survey Areas 2 to 6 during summer and other seasons (DFO Sightings Database 2017; OBIS 2017).

Bryde's Whale

Bryde's whales are distributed worldwide in tropical and sub-tropical waters, but the taxonomy and number of species and/or subspecies of Bryde's whales in the world is currently a topic of debate (Kato and Perrin 2009; Rosel and Wilcox 2014). In the western Atlantic Ocean, Bryde's whales are reported from the southeastern United States including the Gulf of Mexico and the southern West Indies to Cabo Frio, Brazil (Leatherwood and Reeves, 1983). Bryde's whales have been observed feeding in the Azores during their northward spring migration (Villa *et al.* 2011), but the distribution of Bryde's whale elsewhere in the North Atlantic is not well known, though there are records from Virginia south to Brazil in the west, and from Morocco south to Cape of Good Hope in the east (Kato and Perrin, 2009). There was one Bryde's whale sighting reported at ~40° N during a survey along the Mid-Atlantic Ridge north of the Azores (Waring *et al.* 2008). Bryde's whales could be encountered in the proposed project area during June–July.

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. Sei whales are regularly sighted near the Azores during spring (Víkingsson et al. 2010; Ryan et al. 2013; Silva et al. 2014), and numerous sightings have also been made there during summer (Silva et al. 2014; OBIS 2017). One sei whale that was tagged in the Azores during 2005 (Olsen *et al.* 2009) and seven individuals that were tagged in the Azores during May–June 2008 and 2009 travelled to the Labrador Sea, where they spent extended periods of time on the northern shelf, presumably to feed (Prieto *et al.* 2010, 2014), then travelled northbound from the Azores just to the east of SIO's proposed Survey Areas 3 and 4, and between Survey Areas 5 and 6, during May and June, en route to the Labrador Sea (Olsen et al. 2009; Prieto et al. 2010, 2014). Sei whales could be encountered in the proposed project area during June–July, especially north of 40° N.

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° N; very low densities are expected south of 40° N. Fin whales are commonly sighted off Newfoundland and Labrador, with most records for June through November (DFO Sightings Database 2017). Several fin whale sightings have been made to the west of SIO's proposed Survey Areas 3 to 6 (see Figure 1 in IHA application) (DFO Sightings Database 2017; OBIS 2017). One sighting was made near SIO's proposed Survey Area 5 at 53° N, 40° W (OBIS 2017). Fin whales were sighted during a summer survey along the Mid-Atlantic Ridge from Iceland to north of the Azores, including east of SIO's proposed Survey Area 5 and between 40 and 45° N (Waring et al. 2008). Several sightings have also been made between the proposed project area and the Mid-Atlantic Ridge (OBIS 2017) and fin whales were seen near the Mid-Atlantic Ridge at ~60° N in July 2012 (Ryan et al. 2013). Fin whales could be encountered in the proposed project area during June–July, especially north of 40° N.

Blue Whale

The blue whale has a cosmopolitan distribution and tends to be pelagic, only coming nearshore to feed and possibly to breed (Jefferson *et al.* 2008). Blue whale migration is less well defined than for some other rorquals, and their movements tend to be more closely linked to areas of high primary productivity, and hence prey, to meet their high energetic demands (Branch *et al.* 2007). Generally, blue whales are seasonal migrants between high latitudes in the summer, where they feed, and low latitudes in the winter, where they mate and give birth (Lockyer and Brown 1981). Some individuals may stay in low or high latitudes throughout the year (Reilly and Thayer 1990; Watkins *et al.* 2000).

Blue whales are uncommon in the waters of Newfoundland, but are seen from spring through fall, with most sightings reported for July and August (DFO Sightings Database 2017). Blue whales have also been observed off Newfoundland to the west of SIO's proposed Survey Areas 2 and 3 (DFO Sightings Database 2017; OBIS 2017), as well as northwest of SIO's proposed Survey Area 6 (OBIS 2017). Blue whales were seen during a summer survey along the Mid-Atlantic Ridge from Iceland to north of the Azores, between 40 and 45° N (Waring *et al.* 2008). Additionally, blue whales outfitted with satellite tags were tracked from the Azores northward along the Mid-Atlantic Ridge during spring 2009 and 2011 (Silva et al. 2013). They have also been sighted in the Azores during late spring and summer (Ryan et al. 2013; OBIS 2017). Blue whales could be encountered within the proposed project area during June–July, but are considered to be uncommon in the area.

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. Sightings of sperm whales were also made on and east of the Flemish Cap, along the Mid-Atlantic Ridge from at least 32 to 57° N, and near SIO's proposed Survey Areas 1–4 and the seismic transects south of 45.5° N (OBIS 2017). Sperm whales were the second most commonly sighted cetacean species (n = 48) during a summer survey along the Mid-Atlantic Ridge from Iceland to north of the Azores; sightings were more abundant at and north of ~52° N, including to the east of SIO's proposed Survey Site 5 (Waring et al. 2008). Sperm whales were also sighted ~500 km north of Survey Area 1 during the summer 2004 seismic survey by L–DEO (Haley and Koski, 2004). There are also numerous sightings of sperm whales in the Azores (Morato et al. 2008; Ryan et al. 2013; Silva et al. 2014; OBIS 2017). Sperm whales could be encountered in the proposed project area during June–July.

Pygmy and 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). Based on density modeling by Mannocci et al. (2017) for the western North Atlantic, slightly higher densities are expected to occur south of 40° N compared to northern regions. Pygmy and dwarf sperm whales likely would 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). There is one record of a Cuvier's beaked whale from June 2006 between the proposed seismic transects at 51.4° N, 43.1° W, as well as numerous sightings from the Azores (Silva *et al.* 2014; OBIS 2017). 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). Relatively few records exist of Mesoplodont beaked whale observations in the proposed survey area. There are 16 records of Sowerby's beaked whale near the Azores (OBIS 2017) and 10 records of stranded Sowerby's beaked whales were recorded in the central group of islands in the Azores from 2002 through 2009 (Pereira et al. 2011). Mesoplodont beaked whales, including True's, Gervais', Sowerby's, and Blainville's beaked whale, may be encountered in the proposed project area.

Northern Bottlenose Whale

Northern bottlenose whales are distributed in the North Atlantic from Nova Scotia to about 70° N in the Davis Strait, along the east coast of Greenland to 77° 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). There are two records just west of SIO's proposed Survey Area 4, four records for the Mid-Atlantic Ridge between 52.8 and 54.3° N, and one record northeast of the beginning of the southwestern-most seismic transect (OBIS 2017). Northern bottlenose whales were also sighted ~520 km north of Survey Area 1 during the summer 2004 seismic survey by L–DEO (Haley and Koski 2004). Sightings have also been made in the Azores, including during summer (Silva et al. 2014; OBIS 2017). Northern bottlenose whales could be encountered in the proposed project area.

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). There is one record near SIO's proposed Survey Area 6, one near the end of the proposed seismic transect heading southwest of Survey Area 6, east of the Flemish Cap, and northwest of Survey Area 1 (OBIS 2017). One record was made on the Mid-Atlantic Ridge at ~56° N, and there are numerous records for the Azores (OBIS 2017). Killer whales could be encountered within the proposed project area during June–July.

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). There is one record just to the west of Survey Areas 3 and 4, two records on the Mid-Atlantic Ridge between 51° and 52° N, and numerous records in and around the Azores (OBIS 2017). Silva et al. (2014) also reported records for the Azores. False killer whales could be encountered in the proposed project area.

Pygmy Killer Whale

The pygmy sperm 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). There are no records of this species near the proposed project area in the OBIS database (OBIS 2017). Pygmy killer whales are expected to be rare within and near the proposed project 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). Although there are no records near the proposed project area, sightings have been reported for the Azores (OBIS 2017). Short-finned pilot whales could be encountered in the proposed project area.

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. Long-finned pilot whales are commonly sighted off Newfoundland and Labrador (DFO Sightings Database 2017; OIBS 2017); although sightings have been reported year-round, most have occurred during July and August (DFO Sightings Database 2017). There are numerous records near the deep waters of the proposed project area, including sightings near SIO's proposed Survey Area 5 and near the end of the seismic transect heading south of Area 5, and on and east of the Flemish Cap (OBIS 2017). Long-finned pilot whales were also sighted ~520 km north of Survey Area 1 during the summer 2004 seismic survey by L–DEO (Haley and Koski 2004). The long-finned pilot whale could be encountered in the proposed study area.

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. Based on modeling by Mannocci et al. (2017), densities are expected to be low throughout the deep offshore waters of the western North Atlantic. However, in the OBIS database, there are records throughout the North Atlantic, including in offshore waters near the proposed project area between SIO's proposed survey transects at 49.3° N, 42.7° W; near Survey Areas 2, 3, and 4; near Sites 558 and 563; and west of Survey Area 1 near the seismic transect (OBIS 2017). Bottlenose dolphins were sighted ~500 km north of Survey Area 1 during the summer 2004 seismic survey by L–DEO (Haley and Koski 2004). They have also been reported in the Azores (Morato et al. 2008; Silva et al. 2014; OBIS 2017). Bottlenose dolphins could 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). One sighting was made in May 2012 in the proposed project area at 36.3° N, 53.3° W north of the southern-most seismic transect (OBIS 2017). Pantropical spotted dolphins could be encountered in the proposed project area.

Atlantic Spotted Dolphin

Atlantic spotted dolphins are distributed in tropical and warm temperate waters of the western North Atlantic (Leatherwood et al., 1976). Based on density modeling by Mannocci et al. (2017), Atlantic spotted dolphins occur throughout the western North Atlantic up to ~45° N, with slightly higher densities along 40° N and ~32° N. There are sighting records near SIO's proposed Survey Area 2, and between the Grand Banks and the southern-most seismic transect (OBIS 2017). One sighting was made at 34.0° N, 51.7° W just to the northwest of Survey Area 1 during the spring 2013 L–DEO seismic survey in the Mid-Atlantic (Milne et al. 2013). Atlantic spotted dolphins were also sighted ~520 km north of Survey Area 1 during the summer 2004 seismic survey by L–DEO (Haley and Koski 2004). Sightings have also been made near the Azores, including during spring and summer (Morato et al. 2008; Ryan et al. 2013; Silva et al. 2014; OBIS 2017). Atlantic spotted dolphins could be encountered in the proposed project area.

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). Based on density modeling by Mannocci et al. (2017) for the western North Atlantic, higher densities are expected in offshore waters north of ~38° N, with the lowest densities south of ~30° N. There are sighting records for the deep offshore waters between the coast of Canada and the Mid-Atlantic Ridge for May through August, including near SIO's proposed Survey Areas 2 and 3 (OBIS 2017). Sightings were also made in June 2004 along the Mid-Atlantic Ridge between 41° and 49° N (Doksæter et al. 2008). Striped dolphins also occur in the Azores (Ryan et al. 2013; Silva et al. 2014; OBIS 2017). Striped dolphins could be encountered in the proposed project area.

Common Dolphin

The common dolphin may be one of the most widely distributed species of cetaceans, as it is found world-wide in temperate and subtropical seas. 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 ~35° N (Jefferson et al. 2015). Based on density modeling by Mannocci et al. (2017) for the western North Atlantic, higher densities occur in offshore areas north of ~40° N; very low densities are expected south of 40° N. There are records throughout the North Atlantic, including sightings on the shelf and offshore of Newfoundland and the deep waters of the proposed project area (OBIS 2017). There are sighting records just south of SIO's proposed Survey Area 5 along the seismic transect and near Survey Areas 1–4 (OBIS 2017). There are numerous records along the Mid-Atlantic Ridge between 35° and 52° N (Doksæter et al. 2008; OBIS 2017). Common dolphins also occur in the Azores (Morato et al. 2008; Ryan et al. 2013; Silva et al. 2014; OBIS 2017). Common dolphins could be encountered in the proposed project area.

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. Sighting records exist within or near the proposed project area, including near SIO's proposed Survey Areas 5 and 6, along the seismic transect heading southwest of Survey Area 6, near Survey Areas 3 and 4, Site 563, and north of Survey Area 1 (OBIS 2017). There are also several records along the Mid-Atlantic Ridge between 35° and 60° N (Doksæter et al. 2008; OBIS 2017). Atlantic white-sided dolphins are likely to be encountered in the proposed project area during June–July.

White-Beaked Dolphin

The white-beaked dolphin is found in waters from southern New England to southern Greenland and Davis Straits (Leatherwood et al. 1976; CETAP 1982), across the Atlantic to the Barents Sea and south to at least Portugal (Reeves et al. 1999). It appears to prefer deep waters along the outer shelf and slope, but can also occur in shallow areas and far offshore (Jefferson et al. 2015). One sighting of white-beaked dolphin was made in the deep waters off Newfoundland, southwest of SIO's proposed Survey Area 6 near the proposed seismic transect, during July 2012 (Ryan et al. 2013). Another sighting was made near the proposed seismic transect southwest of Survey Area 5 at 50.1° N, 40.8° W during March 2011 (OBIS 2017). White-beaked dolphins were observed on the Mid-Atlantic Ridge at 56.4° N during June 2004 (Skov et al. 2004). White-beaked dolphins could be encountered in the proposed project area during June–July.

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 60° N and 60° S where surface water temperatures are at least 10 °C (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 is one sighting record near SIO's proposed Survey Area 4, just north of the end of the proposed seismic transect; and one sighting has been reported near Survey Area 2 (OBIS 2017). There are numerous records for the Azores (Silva et al. 2014; OBIS 2017). Risso's dolphin could be encountered in the proposed project area during June–July.

Harbor Porpoise

The harbor porpoise inhabits temperate, subarctic, and arctic waters. It is typically found in shallow water (<100 m) nearshore, but it is occasionally sighted in deeper offshore water (Jefferson et al. 2015). In the western North Atlantic, it occurs from the southeastern United States to Baffin Island; in the eastern North Atlantic (Jefferson et al. 2015). The harbor porpoise is generally considered uncommon in the offshore regions of the proposed project area, although sightings have been made along the outer shelf of Newfoundland and the Flemish Cap (DFO Sightings Database 2017; OBIS 2017). Mannocci et al. (2017) reported relatively high densities in offshore waters north of ~40° N; very low densities are expected to occur south of ~38° N. Harbor porpoises have been sighted in the Azores from May through September (OBIS 2017). Given their preference for coastal waters, harbor porpoises are expected to be uncommon near the proposed survey area.

Ringed Seal

Ringed seals have a circumpolar distribution and are found in all seasonally ice-covered seas of the Northern Hemisphere as well as in certain freshwater lakes (King 1983). The subspecies *P.h. hispida* (Arctic ringed seal) occurs in the Northwest Atlantic Ocean. The southern range of the ringed seal extends to the coasts of Labrador and northern Newfoundland, where it most commonly occurs from November to January (Stenson 1994). As the range of this species includes the waters off southern Greenland and the Labrador Sea, it could be encountered in the proposed project area, but ringed seals are likely to be rare within and near the proposed project area.

Harp Seal

The harp seal occurs throughout much of the North Atlantic and Arctic Oceans (Ronald and Healey 1981; Lavigne and Kovacs 1988). Harp seals are highly migratory (Sergeant 1965; Stenson and Sjare 1997). Breeding occurs at different times for each stock between late February and April. Adults then assemble on suitable pack ice to undergo the annual molt. The migration then continues north to Arctic summer feeding grounds. Harp seals have mainly been sighted on the shelf off Newfoundland, but there are no sightings in the OBIS database for the proposed project area (OBIS 2017). Harp seals are likely to be rare within and near the proposed project area during June–July.

Hooded Seal

The hooded seal occurs throughout much of the North Atlantic and Arctic Oceans (King 1983) preferring deeper water and occurring farther offshore than harp seals (Sergeant 1976a; Campbell 1987; Lavigne and Kovacs 1988; Stenson et al. 1996). Hooded seals remain on the Newfoundland continental shelf during winter/spring (Stenson et al. 1996) and breeding occurs in March. Hooded seals have been reported in shelf and offshore waters of Newfoundland throughout the year, including west of Survey Area 6 and near the seismic transect southwest of SIO's proposed Survey Area 6, during summer (Stenson and Kavanagh 1994; Andersen et al. 2009, 2012). Vagrants, especially juveniles, have been reported in the Azores and off northwestern Africa (Jefferson et al. 2015). However, there are no sightings in the OBIS database for the proposed project area (OBIS 2017). Hooded seals are likely to be rare within and near the proposed project area during June–July.

Marine Mammal Hearing

Hearing is the most important sensory modality for marine mammals underwater, and exposure to anthropogenic sound can have deleterious effects. To appropriately assess the potential effects of exposure to sound, it is necessary to understand the frequency ranges marine mammals are able to hear. Current data indicate that not all marine mammal species have equal hearing capabilities (*e.g.,* Richardson *et al.,* 1995; Wartzok and Ketten, 1999; Au and Hastings, 2008). To reflect this, Southall *et al.* (2007) recommended that marine mammals be divided into functional hearing groups based on directly measured or estimated hearing ranges on the basis of available behavioral response data, audiograms derived using auditory evoked potential techniques, anatomical modeling, and other data. Note that no direct measurements of hearing ability have been successfully completed for mysticetes (*i.e.,* low-frequency cetaceans). Subsequently, NMFS (2016) described generalized hearing ranges for these marine mammal hearing groups. Generalized hearing ranges were chosen based on the approximately 65 dB threshold from the normalized composite audiograms, with the exception for lower limits for low-frequency cetaceans where the lower bound was deemed to be biologically implausible and the lower bound from Southall *et al.* (2007) retained. The functional groups and the associated frequencies are indicated below (note that these frequency ranges correspond to the range for the composite group, with the entire range not necessarily reflecting the capabilities of every species within that group):

- Low-frequency cetaceans (mysticetes): Generalized hearing is estimated to occur between approximately 7 Hertz (Hz) and 35 kilohertz (kHz);
- Mid-frequency cetaceans (larger toothed whales, beaked whales, and most delphinids): Generalized hearing is estimated to occur between approximately 150 Hz and 160 kHz;
- High-frequency cetaceans (porpoises, river dolphins, and members of the genera Kogia and Cephalorhynchus; including two members of the genus Lagenorhynchus, on the basis of recent echolocation data and genetic data): Generalized hearing is estimated to occur between approximately 275 Hz and 160 kHz; and
- Pinnipeds in water; Phocidae (true seals): Generalized hearing is estimated to occur between approximately 50 Hz to 86 kH.

The pinniped functional hearing group was modified from Southall *et al.* (2007) on the basis of data indicating that phocid species have consistently demonstrated an extended frequency range of hearing compared to otariids, especially in the higher frequency range (Hemilä *et al.,* 2006; Kastelein *et al.,* 2009; Reichmuth and Holt, 2013).

For more detail concerning these groups and associated frequency ranges, please see NMFS (2016) for a review of available information. Thirty-three marine mammal species (thirty cetacean and three pinniped (all phocid) species) have the reasonable potential to co-occur with the proposed survey activities. Please refer to Table 2. Of the cetacean species that may be present, six are classified as low-frequency cetaceans (*i.e.,* all mysticete species), twenty-two are classified as mid-frequency cetaceans (*i.e.,* all delphinid species, beaked whales, and the sperm whale), and three are classified as a high-frequency cetaceans (*i.e.,* harbor porpoise, pygmy and dwarf sperm whales).

Potential Effects of Specified Activities on Marine Mammals and Their Habitat

This section includes a summary and discussion of the ways that components of the specified activity may impact marine mammals and their habitat. The ''Estimated Take by Incidental Harassment'' section later in this document includes a quantitative analysis of the number of individuals that are expected to be taken by this activity. The ''Negligible Impact Analysis and Determination'' section considers the content of this section, the ''Estimated Take by Incidental Harassment'' section, and the ''Proposed Mitigation'' section, to draw conclusions regarding the likely impacts of these activities on the reproductive success or survivorship of individuals and how those impacts on individuals are likely to impact marine mammal species or stocks.

Description of Active Acoustic Sound Sources

This section contains a brief technical background on sound, the characteristics of certain sound types, and on metrics used in this proposal inasmuch as the information is relevant to the specified activity and to a discussion of the potential effects of the specified activity on marine mammals found later in this document.

Sound travels in waves, the basic components of which are frequency, wavelength, velocity, and amplitude. Frequency is the number of pressure waves that pass by a reference point per unit of time and is measured in Hz or cycles per second. Wavelength is the distance between two peaks or corresponding points of a sound wave (length of one cycle). Higher frequency sounds have shorter wavelengths than lower frequency sounds, and typically attenuate (decrease) more rapidly, except in certain cases in shallower water. Amplitude is the height of the sound pressure wave or the ''loudness'' of a sound and is typically described using the relative unit of the decibel (dB). A sound pressure level (SPL) in dB is described as the ratio between a measured pressure and a reference pressure (for underwater sound, this is 1 microPascal (μPa)) and is a logarithmic unit that accounts for large variations in amplitude; therefore, a relatively small change in dB corresponds to large changes in sound pressure. The source level (SL) represents the SPL referenced at a distance of 1 m from the source (referenced to 1 μPa) while the received level is the SPL at the listener's position (referenced to 1 μPa).

Root mean square (rms) is the quadratic mean sound pressure over the duration of an impulse. Root mean square is calculated by squaring all of the sound amplitudes, averaging the squares, and then taking the square root of the average (Urick, 1983). Root mean square accounts for both positive and negative values; squaring the pressures makes all values positive so that they may be accounted for in the summation of pressure levels (Hastings and Popper, 2005). This measurement is often used in the context of discussing behavioral effects, in part because behavioral effects, which often result from auditory cues, may be better expressed through averaged units than by peak pressures.

Sound exposure level (SEL; represented as dB re 1 μPa^2-s) represents the total energy contained within a pulse and considers both intensity and duration of exposure. Peak sound pressure (also referred to as zero-to-peak sound pressure or 0-p) is the maximum instantaneous sound pressure measurable in the water at a specified distance from the source and is represented in the same units as the rms sound pressure. Another common metric is peak-to-peak sound pressure (pk-pk), which is the algebraic difference between the peak positive and peak negative sound pressures. Peak-to-peak pressure is typically approximately 6 dB higher than peak pressure (Southall *et al.,* 2007).

When underwater objects vibrate or activity occurs, sound-pressure waves are created. These waves alternately compress and decompress the water as the sound wave travels. Underwater sound waves radiate in a manner similar to ripples on the surface of a pond and may be either directed in a beam or beams or may radiate in all directions (omnidirectional sources), as is the case for pulses produced by the airgun arrays considered here. The compressions and decompressions associated with sound waves are detected as changes in pressure by aquatic life and man-made sound receptors such as hydrophones.

Even in the absence of sound from the specified activity, the underwater environment is typically loud due to ambient sound. Ambient sound is defined as environmental background sound levels lacking a single source or point (Richardson *et al.,* 1995), and the sound level of a region is defined by the total acoustical energy being generated by known and unknown sources. These sources may include physical (*e.g.,* wind and waves, earthquakes, ice, atmospheric sound), biological (*e.g.,* sounds produced by marine mammals, fish, and invertebrates), and anthropogenic (*e.g.,* vessels, dredging, construction) sound. A number of sources contribute to ambient sound, including the following (Richardson *et al.,* 1995):

- *Wind and waves:* The complex interactions between wind and water surface, including processes such as breaking waves and wave-induced bubble oscillations and cavitation, are a main source of naturally occurring ambient sound for frequencies between 200 Hz and 50 kilohertz (kHz) (Mitson, 1995). In general, ambient sound levels tend to increase with increasing wind speed and wave height. Surf sound becomes important near shore, with measurements collected at a distance of 8.5 km from shore showing an increase of 10 dB in the 100 to 700 Hz band during heavy surf conditions;
- *Precipitation:* Sound from rain and hail impacting the water surface can become an important component of total sound at frequencies above 500 Hz, and possibly down to 100 Hz during quiet times;
- *Biological:* Marine mammals can contribute significantly to ambient sound levels, as can some fish and snapping shrimp. The frequency band for biological contributions is from approximately 12 Hz to over 100 kHz; and
- *Anthropogenic:* Sources of ambient sound related to human activity include transportation (surface vessels), dredging and construction, oil and gas drilling and production, seismic surveys, sonar, explosions, and ocean acoustic studies. Vessel noise typically dominates the total ambient sound for frequencies between 20 and 300 Hz. In general, the frequencies of anthropogenic sounds are below 1 kHz and, if higher frequency sound levels are created, they attenuate rapidly. Sound from identifiable anthropogenic sources other than the activity of interest (*e.g.,* a passing vessel) is sometimes termed background sound, as opposed to ambient sound.

The sum of the various natural and anthropogenic sound sources at any given location and time—which comprise ''ambient'' or ''background'' sound—depends not only on the source levels (as determined by current weather conditions and levels of biological and human activity) but also on the ability of sound to propagate through the environment. In turn, sound propagation is dependent on the spatially and temporally varying properties of the water column and sea floor, and is frequency-dependent. As a result of the dependence on a large number of varying factors, ambient sound levels can be expected to vary widely over both coarse and fine spatial and temporal scales. Sound levels at a given frequency and location can vary by 10–20 dB from day to day (Richardson *et al.,* 1995). The result is that, depending on the source type and its intensity, sound from a given activity may be a negligible addition to the local environment or could form a distinctive signal that may affect marine mammals. Details of source types are described in the following text.

Sounds are often considered to fall into one of two general types: Pulsed and non-pulsed (defined in the following). The distinction between these two sound types is important because they have differing potential to cause physical effects, particularly with regard to hearing (*e.g.,* Ward, 1997 in Southall *et al.,* 2007). Please see Southall *et al.* (2007) for an in-depth discussion of these concepts.

Pulsed sound sources (*e.g.,* airguns, explosions, gunshots, sonic booms, impact pile driving) produce signals that are brief (typically considered to be less than one second), broadband, atonal transients (ANSI, 1986, 2005; Harris, 1998; NIOSH, 1998; ISO, 2003) and occur either as isolated events or repeated in some succession. Pulsed sounds are all characterized by a relatively rapid rise from ambient pressure to a maximal pressure value followed by a rapid decay period that may include a period of diminishing, oscillating maximal and minimal pressures, and generally have an increased capacity to induce physical injury as compared with sounds that lack these features.

Non-pulsed sounds can be tonal, narrowband, or broadband, brief or prolonged, and may be either continuous or non-continuous (ANSI, 1995; NIOSH, 1998). Some of these non-pulsed sounds can be transient signals of short duration but without the essential properties of pulses (*e.g.,* rapid rise time). Examples of non-pulsed sounds include those produced by vessels, aircraft, machinery operations such as drilling or dredging, vibratory pile driving, and active sonar systems (such as those used by the U.S. Navy). The duration of such sounds, as received at a distance, can be greatly extended in a highly reverberant environment.

Airgun arrays produce pulsed signals with energy in a frequency range from about 10–2,000 Hz, with most energy radiated at frequencies below 200 Hz. The amplitude of the acoustic wave emitted from the source is equal in all directions (*i.e.,* omnidirectional), but airgun arrays do possess some directionality due to different phase delays between guns in different directions. Airgun arrays are typically tuned to maximize functionality for data acquisition purposes, meaning that sound transmitted in horizontal directions and at higher frequencies is minimized to the extent possible.

As described above, a MBES and a SBP would also be operated from the *Atlantis* continuously throughout the survey, but not during transits to and from the project area. Due to the lower source level of the SBP relative to the *Atlantis's* airgun array, the sounds from the SBP are expected to be effectively subsumed by the sounds from the airgun array. Thus, any marine mammal that was exposed to sounds from the SBP would already have been exposed to sounds from the airgun array, which are expected to propagate further in the water. As such, the SBP is not expected to result in the take of any marine mammal that has not already been taken by the sounds from the airgun array, and therefore we do not consider noise from the SBP further in this analysis. Each ping emitted by the MBES consists of four successive fan-shaped transmissions, each ensonifying a sector that extends 1° fore–aft. Given the movement and speed of the vessel, the intermittent and narrow downward-directed nature of the sounds emitted by the MBES would result in no more than one or two brief ping exposures of any individual marine mammal, if any exposure were to occur. Thus, we conclude that the likelihood of marine mammal take resulting from MBES exposure is discountable and therefore we do not consider noise from the MBES further in this analysis.

Acoustic Impacts

Potential Effects of Underwater Sound—Please refer to the information given previously (''Description of Active Acoustic Sound Sources'') regarding sound, characteristics of sound types, and metrics used in this document. Note that, in the following discussion, we refer in many cases to a recent review article concerning studies of noise-induced hearing loss conducted from 1996–2015 (*i.e.,* Finneran, 2015). For study-specific citations, please see that work. 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 as we do not expect that use of airgun arrays are reasonably likely to result in such effects (see below for further discussion). 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.

1. *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 threshold shift 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).

2. *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, let alone 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; Goold, 1996; 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.

3. *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).

4. *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 kt. The chances of a lethal injury decline from approximately 80 percent at 15 kt to approximately 20 percent at 8.6 kt. At speeds below 11.8 kt, the chances of lethal injury drop below 50 percent, while the probability asymptotically increases toward one hundred percent above 15 kt.

The *Atlantis* would travel at a speed of either 5 kt (9.3 km/hour) or 8 kt (14.8 km/hour) 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 kt) 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 = $0–5.5 \times 10^{-6}$; 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. We anticipate that vessel collisions involving a seismic data acquisition vessel towing gear, while not impossible, represent unlikely, unpredictable events for which there are no preventive measures. 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 (25 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, 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-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 operators 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 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.

Anticipated Effects on Marine Mammal Habitat

Effects to Prey—Marine mammal prey varies by species, season, and location and, for some, 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 survey activities at the project area would be temporary avoidance of the area. The duration of fish avoidance of a given area after survey effort 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 air gun 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 survey and any areas used by marine mammal prey species. The proposed survey would occur over a relatively short time period (25 days) and would occur over a very small area relative to the area available as marine mammal habitat in the Northwest Atlantic Ocean. We do not have any information to suggest the proposed survey area represents a significant feeding area for any marine mammal, and 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—which 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 previous discussion on masking under ''Acoustic Effects''), 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 communications 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. As described previously, exploratory surveys such as these cover a large area but 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.

Estimated Take

This section provides an estimate of the number of incidental takes proposed for authorization through this IHA, which will inform both NMFS' consideration of ''small numbers'' and the negligible impact determination.

Harassment is the only type of take expected to result from these activities. Except with respect to certain activities not pertinent here, section 3(18) of the MMPA defines ''harassment'' as any act of pursuit, torment, or annoyance which (i) has the potential to injure a marine mammal or marine mammal stock in the wild (Level A harassment); or (ii) has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering (Level B harassment).

Authorized takes would primarily be by Level B harassment, as use of the seismic airguns have the potential to result in disruption of behavioral patterns for individual marine mammals. There is also some potential for auditory injury (Level A harassment) to result, primarily for high frequency cetaceans. Auditory injury is unlikely to occur for low- and mid-frequency cetaceans given very small modeled zones of injury for those species. The proposed mitigation and monitoring measures are expected to minimize the severity of such taking to the extent practicable. As described previously, no mortality is anticipated or proposed to be authorized for this activity. Below we describe how the take is estimated.

Described in the most basic way, we estimate take by considering: (1) Acoustic thresholds above which NMFS believes the best available science indicates marine mammals will be behaviorally harassed or incur some degree of permanent hearing impairment; (2) the area or volume of water that will be ensonified above these levels in a day; (3) the density or occurrence of marine mammals within these ensonified areas; and (4) and the number of days of activities. Below, we describe these components in more detail and present the exposure estimate and associated numbers of take proposed for authorization.

Acoustic Thresholds

Using the best available science, NMFS has developed acoustic thresholds that identify the received level of underwater sound above which exposed marine mammals would be reasonably expected to be behaviorally harassed (equated to Level B harassment) or to incur PTS of some degree (equated to Level A harassment).

Level B Harassment for non-explosive sources—Though significantly driven by received level, the onset of behavioral disturbance from anthropogenic noise exposure is also informed to varying degrees by other factors related to the source (*e.g.,* frequency, predictability, duty cycle), the environment (*e.g.,* bathymetry), and the receiving animals (hearing, motivation, experience, demography, behavioral context) and can be difficult to predict (Southall *et al.,* 2007, Ellison *et al.* 2011). Based on the best available science and the practical need to use a threshold based on a factor that is both predictable and measurable for most activities, NMFS uses a generalized acoustic threshold based on received level to estimate the onset of behavioral harassment. NMFS predicts that marine mammals are likely to be behaviorally harassed in a manner we consider to fall under Level B harassment when exposed to underwater anthropogenic noise above received levels of 120 dB re 1 μPa (rms) for continuous (*e.g.* vibratory pile-driving, drilling) and above 160 dB re 1 μPa (rms) for non-explosive impulsive (*e.g.,* seismic airguns) or intermittent (*e.g.,* scientific sonar) sources. SIO's proposed activity includes the use of impulsive seismic sources. Therefore, the 160 dB re 1 μPa (rms) criteria is applicable for analysis of level B harassment.

Level A harassment for non-explosive sources—NMFS' Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (NMFS, 2016) identifies dual criteria to assess auditory injury (Level A harassment) to five different marine mammal groups (based on hearing sensitivity) as a result of exposure to noise from two different types of sources (impulsive or non-impulsive). As described above, SIO's proposed activity includes the use of intermittent and impulsive seismic sources. These thresholds are provided in Table 4.

These thresholds are provided in the table below. The references, analysis, and methodology used in the development of the thresholds are described in NMFS 2016 Technical Guidance, which may be accessed at: *http://www.nmfs.noaa.gov/pr/acoustics/guidelines.htm.*

TABLE 4—THRESHOLDS IDENTIFYING THE ONSET OF PERMANENT THRESHOLD SHIFT IN MARINE MAMMALS

Hearing group	PTS Onset thresholds	
	Impulsive *	Non-impulsive
Low-Frequency (LF) Cetaceans	$L_{pk,flat}$: 219 dB; $L_{E,LF,24h}$: 183 dB	$L_{E,LF,24h}$: 199 dB.
Mid-Frequency (MF) Cetaceans	$L_{pk,flat}$: 230 dB; $L_{E,MF,24h}$: 185 dB	$L_{E,MF,24h}$: 198 dB.
High-Frequency (HF) Cetaceans	$L_{pk,flat}$: 202 dB; $L_{E,HF,24h}$: 155 dB	$L_{E,HF,24h}$: 173 dB.
Phocid Pinnipeds (PW) (Underwater)	$L_{pk,flat}$: 218 dB; $L_{E,PW,24h}$: 185 dB	$L_{E,PW,24h}$: 201 dB.
Otariid Pinnipeds (OW) (Underwater)	$L_{pk,flat}$: 232 dB; $L_{E,OW,24h}$: 203 dB	$L_{E,OW,24h}$: 219 dB.

Note: * Dual metric acoustic thresholds for impulsive sounds: Use whichever results in the largest isopleth for calculating PTS onset. If a non-impulsive sound has the potential of exceeding the peak sound pressure level thresholds associated with impulsive sounds, these thresholds should also be considered.

Note: Peak sound pressure (Lpk) has a reference value of 1 μPa, and cumulative sound exposure level (LE) has a reference value of 1μPa2s. In this Table, thresholds are abbreviated to reflect American National Standards Institute standards (ANSI 2013). However, peak sound pressure is defined by ANSI as incorporating frequency weighting, which is not the intent for this Technical Guidance. Hence, the subscript "flat" is being included to indicate peak sound pressure should be flat weighted or unweighted within the generalized hearing range. The subscript associated with cumulative sound exposure level thresholds indicates the designated marine mammal auditory weighting function (LF, MF, and HF cetaceans, and PW and OW pinnipeds) and that the recommended accumulation period is 24 hours. The cumulative sound exposure level thresholds could be exceeded in a multitude of ways (*i.e.,* varying exposure levels and durations, duty cycle). When possible, it is valuable for action proponents to indicate the conditions under which these acoustic thresholds will be exceeded.

Ensonified Area

Here, we describe operational and environmental parameters of the activity that will feed into estimating the area ensonified above the acoustic thresholds.

The proposed survey would entail the use of a 2-airgun array with a total discharge of 90 in³ at a tow depth of 2–4 m. The distances to the predicted isopleths corresponding to the threshold for Level B harassment (160 dB re 1 μPa) were calculated for both proposed array configurations based on results of modeling performed by LDEO. Received sound levels were predicted by LDEO's model (Diebold *et al.* 2010) as a function of distance from the airgun array. The LDEO modeling approach uses ray tracing for the direct wave traveling from the array to the receiver and its associated source ghost (reflection at the air-water interface in the vicinity of the array), in a constant-velocity half-space (infinite homogeneous ocean layer unbounded by a seafloor). In addition, propagation measurements of pulses from a 36-airgun array at a tow depth of 6 m have been reported in deep water (~1,600 m), intermediate water depth on the slope (~600–1100 m), and shallow water (~50 m) in the Gulf of Mexico in 2007–2008 (Tolstoy *et al.* 2009; Diebold *et al.* 2010). The estimated distances to Level B harassment isopleths for the two proposed configurations of the *Atlantis* airgun array are shown in Table 5.

TABLE 5—PREDICTED RADIAL DISTANCES FROM R/V ATLANTIS 90 in³ SEISMIC SOURCE TO ISOPLETH CORRESPONDING TO LEVEL B HARASSMENT THRESHOLD

Array configuration	Predicted distance to threshold (160 dB re 1 μPa) (m)
2 m airgun separation	578
8 m airgun separation	539

For modeling of radial distances to predicted isopleths corresponding to harassment thresholds in deep water (≤ 1,000 m), LDEO used the deep-water radii for various Sound Exposure Levels obtained from LDEO model results down to a maximum water depth of 2,000 m (see Figures 2 and 3 in the IHA application). LDEO's modeling methodology is described in greater detail in the IHA application (LGL, 20178) and we refer to the reader to that document rather than repeating it here.

Predicted distances to Level A harassment isopleths, which vary based on marine mammal functional hearing groups (Table 3), were calculated based on modeling performed by LDEO using the Nucleus software program and the NMFS User Spreadsheet, described below. The updated acoustic thresholds for impulsive sounds (such as airguns) contained in the Technical Guidance (NMFS, 2016) were presented as dual metric acoustic thresholds using both SEL_{cum} and peak sound pressure level metrics. As dual metrics, NMFS considers onset of PTS (Level A harassment) to have occurred when either one of the two metrics is exceeded *(i.e.,* metric resulting in the largest isopleth). The SEL_{cum} metric considers both level and duration of exposure, as well as auditory weighting functions by marine mammal hearing group. In recognition of the fact that the requirement to calculate Level A harassment ensonified areas could be more technically challenging to predict due to the duration component and the use of weighting functions in the new SEL_{cum} thresholds, NMFS developed an optional User Spreadsheet that includes tools to help predict a simple isopleth that can be used in conjunction with marine mammal density or occurrence to facilitate the estimation of take numbers.

The values for SEL_{cum} and peak SPL for the *Atlantis* airgun array were derived from calculating the modified farfield signature (Table 6). The farfield signature is often used as a theoretical representation of the source level. To compute the farfield signature, the source level is estimated at a large distance below the array (*e.g.,* 9 km), and this level is back projected mathematically to a notional distance of 1 m from the array's geometrical center. However, when the source is an array of multiple airguns separated in space, the source level from the theoretical farfield signature is not necessarily the best measurement of the source level that is physically achieved at the source (Tolstoy *et al.* 2009). Near the source (at short ranges, distances <1 km), the pulses of sound pressure from each individual airgun in the source array do not stack constructively, as they do for the theoretical farfield signature. The pulses from the different airguns spread out in time such that the source levels observed or modeled are the result of the summation of pulses from a few airguns, not the full array (Tolstoy *et al.* 2009). At larger distances, away from the source array center, sound pressure of all the airguns in the array stack coherently, but not within one time sample, resulting in smaller source levels (a few dB) than the source level derived from the farfield signature. Because the farfield signature does not take into account the array effect near the source and is calculated as a point source, the modified farfield signature is a more appropriate measure of the sound source level for distributed sound sources, such as airgun arrays. Though the array effect is not expected to be as pronounced in the case of a 2-airgun array as it would be with a larger airgun array, the modified farfield method is considered more appropriate than use of the theoretical farfield signature.

TABLE 6—MODELED SOURCE LEVELS (dB) FOR R/V ATLANTIS 90 in³ AIRGUN ARRAY

Functional hearing group	8-kt survey with 8-m airgun separation: Peak SPL_{flat}	8-kt survey with 8-m airgun separation: SEL_{cum}	5-kt survey with 2-m airgun separation: Peak SPL_{flat}	5-kt survey with 2-m airgun separation: SEL_{cum}
Low frequency cetaceans ($L_{pk,flat}$: 219 dB; $L_{E,LF,24h}$: 183 dB)	228.8	207	232.8	206.7
Mid frequency cetaceans ($L_{pk,flat}$: 230 dB; $L_{E,MF,24h}$: 185 dB)	N/A	206.7	229.8	206.9
High frequency cetaceans ($L_{pk,flat}$: 202 dB; $L_{E,HF,24h}$: 155 dB)	233	207.6	232.9	207.2
Phocid Pinnipeds (Underwater) ($L_{pk,flat}$: 218 dB; $L_{E,HF,24h}$: 185 dB)	230	206.7	232.8	206.9
Otariid Pinnipeds (Underwater) ($L_{pk,flat}$: 232 dB; $L_{E,HF,24h}$: 203 dB)	N/A	203	225.6	207.4

In order to more realistically incorporate the Technical Guidance's weighting functions over the seismic array's full acoustic band, unweighted spectrum data for the *Atlantis's* airgun array (modeled in 1 Hz bands) was used to make adjustments (dB) to the unweighted spectrum levels, by frequency, according to the weighting functions for each relevant marine mammal hearing group. These adjusted/weighted spectrum levels were then converted to pressures (μPa) in order to integrate them over the entire broadband spectrum, resulting in broadband weighted source levels by hearing group that could be directly incorporated within the User Spreadsheet (*i.e.,* to override the Spreadsheet's more simple weighting factor adjustment). Using the User Spreadsheet's ''safe distance'' methodology for mobile sources (described by Sivle *et al.,* 2014) with the hearing group-specific weighted source levels, and inputs assuming spherical spreading propagation, a source velocity of 2.06 m/second (for the 2 m airgun separation) and 5.14 m/second (for the 8 m airgun separation), and a shot interval of 12.15 seconds (for the 2 m airgun separation) and 9.72 seconds (for the 8 m airgun separation) (LGL, 2018), potential radial distances to auditory injury zones were calculated for SEL_{cum} thresholds, for both array configurations. Inputs to the User Spreadsheet are shown in Table 6. Outputs from the User Spreadsheet in the form of estimated distances to Level A harassment isopleths are shown in Table 7. As described above, the larger distance of the dual criteria (SEL_{cum} or Peak SPL_{flat}) is used for estimating takes by Level A harassment. The weighting functions used are shown in Table 3 of the IHA application.

TABLE 7—MODELED RADIAL DISTANCES (m) FROM R/V ATLANTIS 90 in³ AIRGUN ARRAY TO ISOPLETHS CORRESPONDING TO LEVEL A HARASSMENT THRESHOLDS

Functional hearing group (Level A harassment thresholds)	8-kt survey with 8-m airgun separation: Peak SPL_{flat}	8-kt survey with 8-m airgun separation: SEL_{cum}	5-kt survey with 2-m airgun separation: Peak SPL_{flat}	5-kt survey with 2-m airgun separation: SEL_{cum}
Low frequency cetaceans ($L_{pk,flat}$: 219 dB; $L_{E,LF,24h}$: 183 dB)	3.08	2.4	4.89	6.5
Mid frequency cetaceans ($L_{pk,flat}$: 230 dB; $L_{E,MF,24h}$: 185 dB)	0	0	0.98	0
High frequency cetaceans ($L_{pk,flat}$: 202 dB; $L_{E,HF,24h}$: 155 dB)	34.84	0	34.62	0
Phocid Pinnipeds (Underwater) ($L_{pk,flat}$: 218 dB; $L_{E,HF,24h}$: 185 dB)	4.02	0	5.51	0.1
Otariid Pinnipeds (Underwater) ($L_{pk,flat}$: 232 dB; $L_{E,HF,24h}$: 203 dB)	0	0	0.48	0

Note that because of some of the assumptions included in the methods used, isopleths produced may be overestimates to some degree, which will ultimately result in some degree of overestimate of Level A take. However, these tools offer the best way to predict appropriate isopleths when more sophisticated 3D modeling methods are not available, and NMFS continues to develop ways to quantitatively refine these tools and will qualitatively address the output where appropriate. For mobile sources, such as the proposed seismic survey, the User Spreadsheet predicts the closest distance at which a stationary animal would not incur PTS if the sound source traveled by the animal in a straight line at a constant speed.

Marine Mammal Occurrence

In this section we provide the information about the presence, density, or group dynamics of marine mammals that will inform the take calculations. The best available scientific information was considered in conducting marine mammal exposure estimates (the basis for estimating take). For all cetacean species, densities calculated by Mannocci *et al.* (2017) were used. These represent the most comprehensive and recent density data available for cetacean species in the survey area. Mannocci *et al.* (2017) modeled marine mammal densities using available line transect survey data and habitat-based covariates and extrapolated model predictions to unsurveyed regions, including the proposed survey area. The authors considered line transect surveys that used two or more protected species observers and met the assumptions of the distance sampling methodology as presented by Buckland *et al.* (2001), and included data from shipboard and aerial surveys conducted from 1992 to 2014 by multiple U.S. organizations (details provided in Roberts *et al.* (2016)). The data underlying the model predictions for the proposed survey area originated from shipboard survey data presented in Waring *et al.* (2008). To increase the success of model transferability to new regions, the authors considered biological covariates expected to be related directly to cetacean densities (Wenger & Olden, 2012), namely biomass and production of epipelagic micronekton and zooplankton predicted with the Spatial Ecosystem and Population DYnamics Model (SEAPODYM) (Lehodey *et al.* 2010). Zooplankton and epipelagic micronekton (*i.e.,* squid, crustaceans, and fish) constitute potential prey for many of the cetaceans considered, in particular dolphins and mysticetes (Pauly *et al.* 1998), and all these covariates correlate with cetacean distributions (*e.g.,* Ferguson *et al.* 2006; Doniol-Valcroze *et al.* 2007; Lambert *et al.* 2014). There is some uncertainty related to the estimated density data and the assumptions used in their calculations, as with all density data estimates. However, the approach used is based on the best available data.

Take Calculation and Estimation

Here we describe how the information provided above is brought together to produce a quantitative take estimate. In order to estimate the number of marine mammals predicted to be exposed to sound levels that would result in Level B harassment or Level A harassment, radial distances to predicted isopleths corresponding to the Level A harassment and Level B harassment thresholds are calculated, as described above (Table 8). Those distances are then used to calculate the area(s) around the airgun array predicted to be ensonified to sound levels that exceed the Level A and Level B harassment thresholds. The areas estimated to be ensonified in a single day of the survey are then calculated, based on the areas predicted to be ensonified around the array and the estimated trackline distance traveled per day (Table 9). This number is then multiplied by the number of survey days (*i.e.,* 7.5 days for the 5-kt survey with 2-m airgun separation and 17.5 days for the 8-kt survey with 8-m airgun separation). The product is then multiplied by 1.25 to account for an additional 25 percent contingency for potential additional seismic operations, as described above. This results in an estimate of the total areas (km²) expected to be ensonified to the Level A harassment and Level B harassment thresholds. For purposes of Level B take calculations, areas estimated to be ensonified to Level A harassment thresholds are subtracted from total areas estimated to be ensonified to Level B harassment thresholds in order to avoid double counting the animals taken (*i.e.,* if an animal is taken by Level A harassment, it is not also counted as taken by Level B harassment). Areas estimated to be ensonified over the duration of the survey are shown in Table 10. The marine mammals predicted to occur within these respective areas, based on estimated densities, are assumed to be incidentally taken. Estimated takes for all marine mammal species are shown in Table 11.

TABLE 8—DISTANCES (m) TO ISOPLETHS CORRESPONDING TO LEVEL A AND LEVEL B HARASSMENT THRESHOLDS

Survey	Level B harassment threshold	Level A harassment threshold [1]				
	All marine mammals	Low frequency cetaceans	Mid frequency cetaceans	High frequency cetaceans	Otariid pinnipeds	Phocid pinnipeds
5-kt survey with 2-m airgun separation ...	539	6.5	0.98	34.62	5.51	0.48
8-kt survey with 8-m airgun separation ...	578	3.08	0	34.84	4.02	0

[1] Level A ensonified areas are estimated based on the greater of the distances calculated to Level A isopleths using dual criteria (SEL_{cum} and peak PL).

TABLE 9—AREAS (km²) ESTIMATED TO BE ENSONIFIED TO LEVEL A AND LEVEL B HARASSMENT THRESHOLDS PER DAY

Survey	Level B harassment threshold	Level A harassment threshold [1]				
	All marine mammals	Low frequency cetaceans	Mid frequency cetaceans	High frequency cetaceans	Otariid pinnipeds	Phocid pinnipeds
5-kt survey with 2-m airgun separation ...	240.68	2.90	0.44	15.40	2.45	0.21
8-kt survey with 8-m airgun separation ...	412.10	2.19	0	24.78	2.86	0

[1] Level A ensonified areas are estimated based on the greater of the distances calculated to Level A isopleths using dual criteria (SEL_{cum} and peak PL).
Note: Estimated areas shown for single day do not include additional 25 percent contingency.

TABLE 10—AREAS (km²) ESTIMATED TO BE ENSONIFIED TO LEVEL A AND LEVEL B HARASSMENT THRESHOLDS OVER DURATION OF SURVEY

Survey	Level B harassment threshold	Level A harassment threshold [1]				
	All marine mammals	Low frequency cetaceans	Mid frequency cetaceans	High frequency cetaceans	Otariid pinnipeds	Phocid pinnipeds
5-kt survey with 2-m airgun separation ...	2256.33	27.10	4.09	144.40	22.97	2.0
8-kt survey with 8-m airgun separation ...	9014.56	47.84	0	542.09	62.50	0

[1] Level A ensonified areas are estimated based on the greater of the distances calculated to Level A isopleths using dual criteria (SEL_{cum} and peak PL).
Note: Estimated areas shown include additional 25 percent contingency.

TABLE 11—NUMBERS OF POTENTIAL INCIDENTAL TAKE OF MARINE MAMMALS PROPOSED FOR AUTHORIZATION

Species	Density (#/1,000 km²)	Estimated Level A takes	Proposed Level A takes	Estimated Level B takes	Proposed Level B takes	Total proposed Level A and Level B takes	Total proposed instances of takes as a percentage of SAR abundance [1]
Humpback whale [2]	10	1	0	112	113	113	0.9 *.
Minke whale	4	0	0	45	45	45	0.2 *.
Bryde's whale	0.1	0	0	1	1	1	unknown.
Sei whale [2]	10	1	0	112	113	113	31.4.
Fin whale	8	1	0	89	90	90	2.6 *.
Blue whale	0	0	0	0	1	1	0.2.
Sperm whale	40	0	0	451	451	451	19.7.
Cuvier's beaked whale [3]	60	0	0	135	135	135	2.0.
Northern bottlenose whale [4].	0.8	0	0	9	9	9	unknown.
True's beaked whale [3]	60	0	0	135	135	135	1.9.

TABLE 11—NUMBERS OF POTENTIAL INCIDENTAL TAKE OF MARINE MAMMALS PROPOSED FOR AUTHORIZATION—Continued

Species	Density (#/1,000 km²)	Estimated Level A takes	Proposed Level A takes	Estimated Level B takes	Proposed Level B takes	Total proposed Level A and Level B takes	Total proposed instances of takes as a percentage of SAR abundance [1]
Gervais beaked whale [3]	60	0	0	135	135	135	1.9.
Sowerby's beaked whale [3].	60	0	0	135	135	135	1.9.
Blainville's beaked whale [3].	60	0	0	135	135	135	1.9.
Rough-toothed dolphin ...	3	0	0	34	34	34	12.5.
Bottlenose dolphin	60	0	0	677	677	677	0.9.
Pantropical spotted dolphin.	10	0	0	113	113	113	3.4.
Atlantic spotted dolphin ..	40	0	0	451	451	451	1.0.
Striped dolphin	80	0	0	902	902	902	1.6.
Atlantic white-sided dolphin.	60	0	0	677	677	677	1.4.
White-beaked dolphin	1	0	0	11	11	11	0.6.
Common dolphin	800	3	0	9014	9017	9017	5.2 *.
Risso's dolphin	20	0	0	226	226	226	1.2.
Pygmy killer whale [4 5]	1.5	0	0	17	17	17	unknown.
False killer whale	2	0	0	23	23	23	5.2.
Killer whale [4 thnsp;6]	0.2	0	0	2	5	5	unknown.
Long-finned/short-finned Pilot whale [7].	200	1	0	2253	2254	2254	8.3.
Pygmy/dwarf sperm whale.	0.6	0	0	7	7	7	0.2.
Harbor porpoise	60	41	41	635	635	676	0.8.
Ringed seal [4]	0	0	0	0	1	1	unknown.
Hooded seal	0	0	0	0	1	1	<0.1.
Harp seal	0	0	0	0	1	1	<0.1.

[1] While we have in most cases provided comparisons of the proposed instances of takes as a percentage of SAR abundance as the best available information regarding population abundance, we note that these are likely underestimates of the relevant North Atlantic populations, as the proposed survey area is outside the U.S. EEZ. Asterisks denote that instances of takes are shown as a percentage of abundance as described by TNASS or NMFS Status Review, as described above.

[2] We have determined Level A take of these species is not likely, therefore estimated Level A takes have been added to the number of Level B takes proposed for authorization.

[3] Density value represents the value for all beaked whales combined. Requested take and take proposed for authorization based on proportion of all beaked whales expected to be taken (677 total estimated beaked whale takes divided by 5 species of beaked whales).

[4] The population abundance for the species is unknown.

[5] The density estimate for pygmy killer whales shown in Table 8 in the IHA application is incorrect; the correct density is 1.5 animals/km² as shown here.

[6] Proposed take number for killer whales has been increased from the calculated take to mean group size for the species. Source for mean group size is Waring *et al.* (2008).

[7] Values for density, proposed take number, and percentage of population proposed for authorization are for short-finned and long-finned pilot whales combined.

For some marine mammal species, we propose to authorize a different number of incidental takes than the number of incidental takes requested by SIO (see Table 8 in the IHA application for requested take numbers). For instance, SIO requested 1 take of a North Atlantic right whale and 3 takes of bowhead whales; however, we have determined the likelihood of the survey encountering these species is so low as to be discountable, therefore we do not propose to authorize takes of these species. Also, SIO requested Level A takes of humpback whales, sei whales, fin whales, common dolphins, and pilot whales; however, due to very small zones corresponding to Level A harassment for low-frequency and mid-frequency cetaceans (Table 7) we have determined the likelihood of Level A take occurring for species from these functional hearing groups is so low as to be discountable, therefore we do not propose to authorize Level A take of these species. Note that the Level A takes that were calculated for these species (humpback whales, sei whales, fin whales, common dolphins, and pilot whales) have been included in the proposed number of Level B takes. Finally, SIO requested 2,254 takes of short-finned pilot whales and 2,254 takes of long-finned pilot whales (total 4,508 pilot whale takes requested); however, as Mannocci *et al.* (2017) presents one single density estimate for all pilot whales (the pilot whale ''guild''), a total of 2,254 takes of pilot whales were calculated as potentially taken by the proposed survey. Thus SIO's request take number is actually double the number of take that was calculated. We do not think doubling the take estimate is warranted, thus we propose to authorize a total of 2,254 takes of pilot whales (short-finned and long-finned pilot whales combined).

Species With Take Estimates Less Than Mean Group Size: Using the approach described above to estimate take, the take estimate for killer whales was less than the average group size estimated for the species (Waring *et al.,* 2008). Information on the social structure and life history of the species indicates it is common for the species to be encountered in groups. The results of take calculations support the likelihood that SIO's survey may encounter and incidentally take the species, and we believe it is likely that the species may be encountered in groups; therefore it is reasonable to conservatively assume that one group of the species will be taken during the proposed survey. We therefore propose to authorize the take of the average (mean) group size for the species to account for the possibility that SIO's survey encounters a group of killer whales.

Species With No Available Density Data: No density data were available for the blue whale; however, blue whales have been observed in the survey area (Waring *et al.,* 2008), thus we determined there is a possibility that the proposed survey may encounter one blue whale and that one blue whale may be taken by Level B harassment by the proposed survey; we therefore propose to authorize one take of blue whale as requested by SIO. No density data were available for ringed seal, hooded seal or harp seal; however based on the ranges of these species we have determined it is possible they may be encountered and taken by Level B harassment by the proposed survey, therefore we propose to authorize one take of each species as requested by SIO.

It should be noted that the proposed take numbers shown in Table 11 are believed to be conservative for several reasons. First, in the calculations of estimated take, 25 percent has been added in the form of operational survey days (equivalent to adding 25 percent to the proposed line km to be surveyed) to account for the possibility of additional seismic operations associated with airgun testing, and repeat coverage of any areas where initial data quality is sub-standard. Additionally, marine mammals would be expected to move away from a sound source that represents an aversive stimulus. However, the extent to which marine mammals would move away from the sound source is difficult to quantify and is therefore not accounted for in take estimates shown in Table 8.

Proposed Mitigation

In order to issue an IHA 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 (latter not applicable for this action). NMFS regulations require applicants for incidental take authorizations to include information about the availability and feasibility (economic and technological) of equipment, methods, and manner of conducting such activity or other means of effecting the least practicable adverse impact upon the affected species or stocks and their habitat (50 CFR 216.104(a)(11)).

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

(1) The manner in which, and the degree to which, the successful implementation of the measure(s) is expected to reduce impacts to marine mammals, marine mammal species or stocks, and their habitat. This considers the nature of the potential adverse impact being mitigated (likelihood, scope, range). It further considers the likelihood that the measure will be effective if implemented (probability of accomplishing the mitigating result if implemented as planned) the likelihood of effective implementation (probability implemented as planned), and

(2) The practicability of the measures for applicant implementation, which may consider such things as cost, impact on operations, and, in the case of a military readiness activity, personnel safety, practicality of implementation, and impact on the effectiveness of the military readiness activity.

SIO has reviewed mitigation measures employed during seismic research surveys authorized by NMFS under previous incidental harassment authorizations, as well as recommended best practices in Richardson *et al.* (1995), Pierson *et al.* (1998), Weir and Dolman (2007), Nowacek *et al.* (2013), Wright (2014), and Wright and Cosentino (2015), and has incorporated a suite of proposed mitigation measures into their project description based on the above sources.

To reduce the potential for disturbance from acoustic stimuli associated with the activities, SIO has proposed to implement the following mitigation measures for marine mammals:

(1) Vessel-based visual mitigation monitoring;

(2) Establishment of a marine mammal exclusion zone (EZ);

(3) Shutdown procedures;

(4) Ramp-up procedures; and

(5) Vessel strike avoidance measures.

In addition to the measures proposed by SIO, NMFS has proposed the following mitigation measure: Establishment of a marine mammal buffer zone.

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 *Atlantis* 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 EZ (as described below).

During seismic operations, three visual PSOs would be based aboard the *Atlantis.* PSOs would be appointed by SIO with NMFS approval. During the majority of seismic operations, two PSOs would monitor for marine mammals around the seismic vessel. A minimum of one PSO must be on duty at all times when the array is active. PSO(s) would be on duty in shifts of duration no longer than 4 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 *Atlantis* 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 and optical range finders. 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 PSOs 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 vessel operator. 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.

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 for 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 for all marine mammal hearing groups (Table 7) while also providing a consistent, reasonably observable zone within which PSOs would typically be able to conduct effective observational effort. In this case, the 100 m radial distance would also be expected to contain sound that would exceed the Level A harassment threshold based on sound exposure level (SEL_{cum}) criteria for all marine mammal hearing groups (Table 7). In the 2011 Programmatic Environmental Impact Statement for marine scientific research funded by the National Science Foundation or the U.S. Geological Survey (NSF–USGS 2011), Alternative B (the Preferred Alternative) conservatively applied a 100 m EZ for all low-energy acoustic sources in water depths >100 m, with low-energy acoustic sources defined as any towed acoustic source with a single or a pair of clustered airguns with individual volumes of ≤250 in^3. Thus the 100 m EZ proposed for this survey is consistent with the PEIS.

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 200 m buffer zone. During use of the acoustic source, occurrence of marine mammals within the buffer zone (but outside the EZ) would be communicated to the operator to prepare for potential shutdown of the acoustic source. The buffer zone is discussed further under *Ramp Up Procedures* below.

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, or
- 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, and beaked whales.

This shutdown requirement would be in place for all marine mammals, with the exception of small delphinoids under certain circumstances. As defined here, the small delphinoid group is intended to encompass those members of the Family Delphinidae most likely to voluntarily approach the source vessel for purposes of interacting with the vessel and/or airgun array (*e.g.,* bow riding). This exception to the shutdown requirement would apply solely to specific genera of small dolphins—*Tursiops, Steno, Stenella, Lagenorhynchus* and *Delphinus*—and would only apply if the animals were traveling, including approaching the vessel. If, for example, an animal or group of animals is stationary for some reason (*e.g.,* feeding) and the source vessel approaches the animals, the shutdown requirement applies. An animal with sufficient incentive to remain in an area rather than avoid an otherwise aversive stimulus could either incur auditory injury or disruption of important behavior. If there is uncertainty regarding identification (*i.e.,* whether the observed animal(s) belongs to the group described above) or whether the animals are traveling, the shutdown would be implemented.

We propose 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). Please see ''Potential Effects of the Specified Activity on Marine Mammals'' above for further discussion of sound metrics and thresholds and marine mammal hearing.

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 *Atlantis* 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 system as well as some more severe behavioral reactions for any such animals in close proximity to the source vessel.

At any distance, shutdown of the acoustic source would also be required upon observation of any of the following:

- A large whale (*i.e.,* sperm whale or any baleen whale) with a calf; or
- 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.).

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

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 would begin with the activation of one 45 in^3 airgun, with the second 45 in^3 airgun activated after 5 minutes.

At least two PSOs would be required to monitor during ramp-up. During ramp up, the PSOs would monitor the EZ, and if marine mammals were observed within the EZ or buffer zone, 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 during this pre-clearance period, ramp-up would not be initiated until all marine mammals cleared the EZ. 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 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 200 m buffer zone have been monitored by visual PSOs for 30 minutes prior to ramp-up.

The operator 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 operator must receive confirmation from the PSO to proceed. The operator must provide information to PSOs documenting that appropriate procedures were followed. Following deactivation of the array for reasons other than mitigation, the operator would be required to communicate the near-term operational plan to the lead PSO with justification for any planned nighttime ramp-up.

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: Vessel operator 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 would maintain a minimum separation distance of 100 m from large whales (*i.e.,* baleen whales and sperm whales). If a large whale is within 100 m of the vessel the vessel would reduce speed and shift the engine to neutral, and would not engage the engines until the whale has moved outside of the vessel's path and the minimum separation distance has been established. If the vessel is stationary, the vessel would not engage engines until the whale(s) has moved out of the vessel's path 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 knots or less when mother/calf pairs, pods, or large assemblages of cetaceans are observed near the vessel.

Based on our evaluation of the applicant's proposed measures, NMFS has preliminarily 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.

Proposed Monitoring and Reporting

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

Monitoring and reporting requirements prescribed by NMFS should contribute to improved understanding of one or more of the following:

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

SIO submitted a marine mammal monitoring and reporting plan in their IHA application. Monitoring that is designed specifically to facilitate mitigation measures, such as monitoring of the EZ to inform potential shutdowns of the airgun array, are described above and are not repeated here.

SIO's monitoring and reporting plan includes the following measures:

Vessel-Based Visual Monitoring

As described above, PSO observations would take place during daytime airgun operations and nighttime start-ups (if applicable) of the airguns. During seismic operations, three visual PSOs would be based aboard the *Atlantis.* PSOs would be appointed by SIO with NMFS approval. During the majority of seismic operations, one PSO would monitor for marine mammals around the seismic vessel. PSOs would be on duty in shifts of duration no longer than 4 hours. Other crew would also be instructed to assist in detecting marine mammals and in implementing mitigation requirements (if practical). During daytime, PSOs would scan the area around the vessel systematically with reticle binoculars (*e.g.,* 7x50 Fujinon) and with the naked eye. At night, PSOs would be equipped with night-vision equipment.

PSOs would record data to estimate the numbers of marine mammals exposed to various received sound levels and to document apparent disturbance reactions or lack thereof. Data would be used to estimate numbers of animals potentially 'taken' by harassment (as defined in the MMPA). They would also provide information needed to order a shutdown of the airguns when a marine mammal is within or near the EZ. When a sighting is made, the following information about the sighting would be recorded:

(1) Species, group size, age/size/sex categories (if determinable), behavior when first sighted and after initial sighting, heading (if consistent), bearing and distance from seismic vessel, sighting cue, apparent reaction to the airguns or vessel (*e.g.,* none, avoidance, approach, paralleling, etc.), and behavioral pace; and

(2) Time, location, heading, speed, activity of the vessel, sea state, visibility, and sun glare.

All observations and shutdowns would be recorded in a standardized format. Data would be entered into an electronic database. The accuracy of the data entry would be verified by computerized data validity checks as the data are entered and by subsequent manual checking of the database. These procedures would allow initial summaries of data to be prepared during and shortly after the field program and would facilitate transfer of the data to statistical, graphical, and other programs for further processing and archiving. The time, location, heading, speed, activity of the vessel, sea state, visibility, and sun glare would also be recorded at the start and end of each observation watch, and during a watch whenever there is a change in one or more of the variables.

Results from the vessel-based observations would provide:

(1) The basis for real-time mitigation (*e.g.,* airgun shutdown);

(2) Information needed to estimate the number of marine mammals potentially taken by harassment, which must be reported to NMFS;

(3) Data on the occurrence, distribution, and activities of marine mammals in the area where the seismic study is conducted;

(4) Information to compare the distance and distribution of marine mammals relative to the source vessel at times with and without seismic activity; and

(5) Data on the behavior and movement patterns of marine mammals seen at times with and without seismic activity.

Reporting

A report would be submitted to NMFS within 90 days after the end of the survey. The report would describe the operations that were conducted and sightings of marine mammals near the operations. The report would provide full documentation of methods, results, and interpretation pertaining to all monitoring and would summarize the dates and locations of seismic operations, and all marine mammal sightings (dates, times, locations, activities, associated seismic survey activities). The report would also include estimates of the number and nature of exposures that occurred above the harassment threshold based on PSO observations, including an estimate of those on the trackline but not detected.

Negligible Impact Analysis and Determination

NMFS has defined negligible impact as an impact resulting from the specified activity that cannot be reasonably expected to, and is not reasonably likely to, adversely affect the species or stock through effects on annual rates of recruitment or survival (50 CFR 216.103). A negligible impact finding is based on the lack of likely adverse effects on annual rates of recruitment or survival (*i.e.,* population-level effects). An estimate of the number of takes alone is not enough information on which to base an impact determination. In addition to considering estimates of the number of marine mammals that might be ''taken'' through harassment, NMFS considers other factors, such as the likely nature of any responses (*e.g.,* intensity, duration), the context of any responses (*e.g.,* critical reproductive time or location, migration), as well as effects on habitat, and the likely effectiveness of the mitigation. We also assess the number, intensity, and context of estimated takes by evaluating this information relative to population status. Consistent with the 1989 preamble for NMFS's implementing regulations (54 FR 40338; September 29, 1989), the impacts from other past and ongoing anthropogenic activities are incorporated into this analysis via their impacts on the environmental baseline (*e.g.,* as reflected in the regulatory status of the species, population size and growth rate where known, ongoing sources of human-caused mortality, or ambient noise levels).

To avoid repetition, our analysis applies to all the species listed in Table 2, given that NMFS expects the anticipated effects of the proposed seismic survey to be similar in nature. Where there are meaningful differences between species or stocks, or groups of species, in anticipated individual responses to activities, impact of expected take on the population due to differences in population status, or impacts on habitat, NMFS has identified species-specific factors to inform the analysis.

NMFS does not anticipate that serious injury or mortality would occur as a result of SIO's proposed seismic survey, even in the absence of proposed mitigation. Thus the proposed authorization does not authorize any mortality. As discussed in the *Potential Effects* section, non-auditory physical effects, stranding, and vessel strike are not expected to occur.

We propose to authorize a limited number of instances of Level A harassment (Table 11) for one species. However, we believe that any PTS incurred in marine mammals as a result of the proposed activity would be in the form of only a small degree of PTS and not total deafness that would not be likely to affect the fitness of any individuals, because of the constant movement of both the *Atlantis* and of the marine mammals in the project area, as well as the fact that the vessel is not expected to remain in any one area in which individual marine mammals would be expected to concentrate for an extended period of time (*i.e.,* since the duration of exposure to loud sounds will be relatively short). Also, as described above, we expect that marine mammals would be likely to move away from a sound source that represents an aversive stimulus, especially at levels that would be expected to result in PTS, given sufficient notice of the *Atlantis's* approach due to the vessel's relatively low speed when conducting seismic surveys. We expect that the majority of takes would be in the form of short-term Level B behavioral harassment in the form of temporary avoidance of the area or decreased foraging (if such activity were occurring), reactions that are considered to be of low severity and with no lasting biological consequences (*e.g.,* Southall *et al.,* 2007).

Potential impacts to marine mammal habitat were discussed previously in this document (see *Potential Effects of the Specified Activity on Marine Mammals and their Habitat*). Marine mammal habitat may be impacted by elevated sound levels, but these impacts would be temporary. Feeding behavior is not likely to be significantly impacted, as marine mammals appear to be less likely to exhibit behavioral reactions or avoidance responses while engaged in feeding activities (Richardson *et al.,* 1995). Prey species are mobile and are broadly distributed throughout the project area; therefore, marine mammals that may be temporarily displaced during survey activities are expected to be able to resume foraging once they have moved away from areas with disturbing levels of underwater noise. Because of the temporary nature of the disturbance, the availability of similar habitat and resources in the surrounding area, and the lack of important or unique marine mammal habitat, the impacts to marine mammals and the food sources that they utilize are not expected to cause significant or long-term consequences for individual marine mammals or their populations. In addition, there are no feeding, mating or calving areas known to be biologically important to marine mammals within the proposed project area.

As described above, though marine mammals in the survey area would not be assigned to NMFS stocks, for purposes of the small numbers analysis we rely on stock numbers from the U.S. Atlantic SARs as the best available information on the abundance estimates for the species of marine mammals that could be taken. The activity is expected to impact a very small percentage of all marine mammal populations that would be affected by SIO's proposed survey (less than 34 percent each for all marine mammal stocks, when compared with stocks from the U.S. Atlantic as described above). Additionally, the acoustic ''footprint'' of the proposed survey would be very small relative to the ranges of all marine mammals that would potentially be affected. Sound levels would increase in the marine environment in a relatively small area surrounding the vessel compared to the range of the marine mammals within the proposed survey area. The seismic array would be active 24 hours per day throughout the duration of the proposed survey. However, the very brief overall duration of the proposed survey (25 days) would further limit potential impacts that may occur as a result of the proposed activity.

The proposed mitigation measures are expected to reduce the number and/or severity of takes by allowing for detection of marine mammals in the vicinity of the vessel by visual and acoustic observers, and by minimizing the severity of any potential exposures via shutdowns of the airgun array. Based on previous monitoring reports for substantially similar activities that have been previously authorized by NMFS, we expect that the proposed mitigation will be effective in preventing at least some extent of potential PTS in marine mammals that may otherwise occur in the absence of the proposed mitigation.

Of the marine mammal species under our jurisdiction that are likely to occur in the project area, the following species are listed as endangered under the ESA: Fin, sei, blue, and sperm whales. There are currently insufficient data to determine population trends for these species (Hayes *et al.,* 2017); however, we are proposing to authorize very small numbers of takes for these species (Table 11), relative to their population sizes (again, when compared to U.S. Atlantic stocks, for purposes of comparison only), therefore we do not expect population-level impacts to any of these species. The other marine mammal species that may be taken by harassment during SIO's seismic survey are not listed as threatened or endangered under the ESA. There is no designated critical habitat for any ESA-listed marine mammals within the project area; of the non-listed marine mammals for which we propose to authorize take, none are considered ''depleted'' or ''strategic'' by NMFS under the MMPA.

NMFS concludes that exposures to marine mammal species due to SIO's proposed seismic survey would result in only short-term (temporary and short in duration) effects to individuals exposed, or some small degree of PTS to a very small number of individuals of four species. Marine mammals may temporarily avoid the immediate area, but are not expected to permanently abandon the area. Major shifts in habitat use, distribution, or foraging success are not expected. NMFS does not anticipate the proposed take estimates to impact annual rates of recruitment or survival.

In summary and as described above, the following factors primarily support our preliminary determination that the impacts resulting from this activity are not expected to adversely affect the species or stock through effects on annual rates of recruitment or survival:

- No mortality is anticipated or authorized;
- The anticipated impacts of the proposed activity on marine mammals would primarily be temporary behavioral changes due to avoidance of the area around the survey vessel. The relatively short duration of the proposed survey (25 days) would further limit the potential impacts of any temporary behavioral changes that would occur;
- The number of instances of PTS that may occur are expected to be very small in number (Table 11). Instances of PTS that are incurred in marine mammals would be of a low level, due

to constant movement of the vessel and of the marine mammals in the area, and the nature of the survey design (not concentrated in areas of high marine mammal concentration);

- The availability of alternate areas of similar habitat value for marine mammals to temporarily vacate the survey area during the proposed survey to avoid exposure to sounds from the activity;
- The proposed project area does not contain areas of significance for feeding, mating or calving;
- The potential adverse effects on fish or invertebrate species that serve as prey species for marine mammals from the proposed survey would be temporary and spatially limited; and
- The proposed mitigation measures, including visual and acoustic monitoring and shutdowns, are expected to minimize potential impacts to marine mammals.

Based on the analysis contained herein of the likely effects of the specified activity on marine mammals and their habitat, and taking into consideration the implementation of the proposed monitoring and mitigation measures, NMFS preliminarily finds that the total marine mammal take from the proposed activity will have a negligible impact on all affected marine mammal species or stocks.

Small Numbers

As noted above, only small numbers of incidental take may be authorized under Section 101(a)(5)(D) of the MMPA for specified activities other than military readiness activities. The MMPA does not define small numbers and so, in practice, where estimated numbers are available, NMFS compares the number of individuals taken to the most appropriate estimation of abundance of the relevant species or stock in our determination of whether an authorization is limited to small numbers of marine mammals. Additionally, other qualitative factors may be considered in the analysis, such as the temporal or spatial scale of the activities.

Marine mammals potentially taken by the proposed survey would not be expected to originate from the U.S. Atlantic stocks as defined by NMFS (Hayes *et al.,* 2017). However, population abundance data for marine mammal species in the survey area is not available, therefore in most cases the U.S. Atlantic SARs represent the best available information on marine mammal abundance in the Northwest Atlantic Ocean. For certain species (*i.e.,* fin whale, minke whale and common dolphin) the 2007 Canadian Trans-North Atlantic Sighting Survey (TNASS), which provided full coverage of the Atlantic Canadian coast (Lawson and Gosselin, 2009) represents the best available information on abundance. Abundance estimates from TNASS were corrected for perception and availability bias, when possible. In general, where the TNASS survey effort provided more extensive coverage of a stock's range (as compared with NOAA shipboard survey effort), we elected to use the resulting abundance estimate over the current NMFS abundance estimate (derived from survey effort with more limited coverage of the stock range). For the humpback whale, NMFS defines a stock of humpback whales in the Atlantic only on the basis of the Gulf of Maine feeding population; however, multiple feeding populations originate from the DPS of humpback whales that is expected to occur in the proposed survey area (the West Indies DPS). As West Indies DPS whales from multiple feeding populations may be encountered in the proposed survey area, the total abundance of the West Indies DPS best reflects the abundance of the population that may encountered by the proposed survey. The West Indies DPS abundance estimate used here reflects the latest estimate as described in the NMFS Status Review of the Humpback Whale under the Endangered Species Act (Bettridge *et al.,* 2015). Therefore, we use abundance data from the SARs in most cases, as well as from the TNASS and NMFS Status Review, for purposes of the small numbers analysis. The numbers of takes that we propose for authorization to be taken, for all species and stocks are less than a third of the population abundance for all species and stocks, when compared to abundance estimates from U.S. Atlantic SARs and TNASS and NMFS Status Review (Table 11). We again note that while some animals from U.S. stocks may occur in the proposed survey area, the proposed survey area is outside the geographic boundaries of the U.S. Atlantic SARs, thus populations of marine mammals in the proposed survey area would not be limited to the U.S. stocks and those populations may in fact be larger than the U.S. stock abundance estimates. In addition, it should be noted that take numbers represent instances of take, not individuals taken. Given the relatively small survey grids (Figure 1 in the IHA application), it is reasonable to expect that some individuals may be exposed more than one time, which would mean that the number of individuals taken is somewhat smaller than the total instances of take indicated in Table 1.

No known current regional population estimates are available for 5 marine mammal species that could be incidentally taken as a result of the proposed survey: The Bryde's whale, killer whale, pygmy killer whale, Northern bottlenose whale, and ringed seal. NMFS has reviewed the geographic distributions of these species in determining whether the numbers of takes proposed for authorization herein are likely to represent small numbers. Bryde's whales are distributed worldwide in tropical and sub-tropical waters (Kato and Perrin, 2009). Killer whales are broadly distributed in the Atlantic from the Arctic ice edge to the West Indies (Waring *et al.,* 2015). The pygmy killer whale is distributed worldwide in tropical to sub-tropical waters (Jefferson *et al.* 1994). Northern bottlenose whales are distributed in the North Atlantic from Nova Scotia to about 70° N in the Davis Strait, along the east coast of Greenland to 77° N and from England, Norway, Iceland and the Faroe Islands to the south coast of Svalbard (Waring *et al.,* 2015). The harp seal occurs throughout much of the North Atlantic and Arctic Oceans (Lavigne and Kovacs 1988). Based on the broad spatial distributions of these species relative to the areas where the proposed surveys would occur, NMFS preliminarily concludes that the authorized take of these species represent small numbers relative to the affected species' overall population sizes, though we are unable to quantify the proposed take numbers as a percentage of population.

Based on the analysis contained herein of the proposed activity (including the proposed mitigation and monitoring measures) and the anticipated take of marine mammals, NMFS preliminarily finds that small numbers of marine mammals will be taken relative to the population size of the affected species or stocks.

Unmitigable Adverse Impact Analysis and Determination

There are no relevant subsistence uses of the affected marine mammal stocks or species implicated by this action. Therefore, NMFS has preliminarily determined that the total taking of affected species or stocks would not have an unmitigable adverse impact on the availability of such species or stocks for taking for subsistence purposes.

Endangered Species Act (ESA)

Section 7(a)(2) of the ESA of 1973 (16 U.S.C. 1531 *et seq.*) requires that each Federal agency insure 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. To ensure ESA compliance for the issuance of IHAs, NMFS consults internally, in this case with the ESA Interagency Cooperation Division, whenever we propose to authorize take for endangered or threatened species.

The NMFS Permits and Conservation Division is proposing to authorize the incidental take of 4 species of marine mammals which are listed under the ESA: the sei whale, fin whale, blue whale and sperm whale. We have requested initiation of Section 7 consultation with the Interagency Cooperation Division for the issuance of this IHA. NMFS will conclude the ESA section 7 consultation prior to reaching a determination regarding the proposed issuance of the authorization.

Proposed Authorization

As a result of these preliminary determinations, NMFS proposes to issue an IHA to SIO for conducting a low-energy seismic survey in the Northwest Atlantic Ocean in June-July 2018, provided the previously mentioned mitigation, monitoring, and reporting requirements are incorporated. This section contains a draft of the IHA itself. The wording contained in this section is proposed for inclusion in the IHA (if issued).

1. This IHA is valid for a period of one year from the date of issuance.

2. This IHA is valid only for marine geophysical survey activity, as specified in the SIO IHA application and using an airgun array aboard the R/V *Atlantis* with characteristics specified in the application, in the Northwest Atlantic Ocean.

3. General Conditions

(a) A copy of this IHA must be in the possession of SIO, the vessel operator and other relevant personnel, the lead PSO, and any other relevant designees of SIO operating under the authority of this IHA.

(b) The species authorized for taking are listed in Table 11. The taking, by Level A and Level B harassment only, is limited to the species and numbers listed in Table 11. Any taking exceeding the authorized amounts listed in Table 11 is prohibited and may result in the modification, suspension, or revocation of this IHA.

(c) The taking by serious injury or death of any species of marine mammal is prohibited and may result in the modification, suspension, or revocation of this IHA.

(d) During use of the airgun(s), if marine mammal species other than those listed in Table 11 are detected by PSOs, the acoustic source must be shut down to avoid unauthorized take.

(e) SIO shall ensure that the vessel operator and other relevant vessel personnel are briefed on all responsibilities, communication procedures, marine mammal monitoring protocol, operational procedures, and IHA requirements prior to the start of survey activity, and when relevant new personnel join the survey operations.

4. Mitigation Requirements

The holder of this Authorization is required to implement the following mitigation measures:

(a) SIO must use at least three (3) dedicated, trained, NMFS-approved PSOs. The PSOs must have no tasks other than to conduct observational effort, record observational data, and communicate with and instruct relevant vessel crew with regard to the presence of marine mammals and mitigation requirements. PSO resumes shall be provided to NMFS for approval.

(b) At least one PSO must have a minimum of 90 days at-sea experience working as a PSO during a deep penetration seismic survey, with no more than eighteen months elapsed since the conclusion of the at-sea experience. One ''experienced'' visual PSO shall be designated as the lead for the entire protected species observation team. The lead PSO shall serve as primary point of contact for the vessel operator.

(c) Visual Observation

(i) During survey operations (*e.g.,* any day on which use of the acoustic source is planned to occur; whenever the acoustic source is in the water, whether activated or not), typically two, and minimally one, PSO(s) must be on duty and conducting visual observations at all times during daylight hours (*i.e.,* from 30 minutes prior to sunrise through 30 minutes following sunset).

(ii) Visual monitoring must begin not less than 30 minutes prior to ramp-up, including for nighttime ramp-ups of the airgun array, and must continue until one hour after use of the acoustic source ceases or until 30 minutes past sunset.

(iii) PSOs shall coordinate to ensure 360° visual coverage around the vessel from the most appropriate observation posts and shall conduct visual observations using binoculars and the naked eye while free from distractions and in a consistent, systematic, and diligent manner.

(iv) PSOs may be on watch for a maximum of four consecutive hours followed by a break of at least one hour between watches and may conduct a maximum of 12 hours observation per 24 hour period.

(v) During good conditions (*e.g.,* daylight hours; Beaufort sea state 3 or less), visual PSOs shall conduct observations when the acoustic source is not operating for comparison of sighting rates and behavior with and without use of the acoustic source and between acquisition periods, to the maximum extent practicable.

(d) Exclusion Zone and buffer zone—PSOs shall establish and monitor a 100 m EZ and 200 m buffer zone. The zones shall be based upon radial distance from any element of the airgun array (rather than being based on the center of the array or around the vessel itself). During use of the acoustic source, occurrence of marine mammals outside the EZ but within 200 m from any element of the airgun array shall be communicated to the operator to prepare for potential further mitigation measures as described below. During use of the acoustic source, occurrence of marine mammals within the EZ, or on a course to enter the EZ, shall trigger further mitigation measures as described below.

(i) Ramp-up—A ramp-up procedure is required at all times as part of the activation of the acoustic source. Ramp-up would begin with one 45 in^3 airgun, and the second 45 in^3 airgun would be added after 5 minutes.

(ii) If the airgun array has been shut down due to a marine mammal detection, ramp-up shall not occur until all marine mammals have cleared the EZ. A marine mammal is considered to have cleared the EZ if:

(A) It has been visually observed to have left the EZ; or

(B) It has not been observed within the EZ, for 15 minutes (in the case of small odontocetes) or for 30 minutes (in the case of mysticetes and large odontocetes including sperm, pygmy sperm, and beaked whales).

(iii) Thirty minutes of pre-clearance observation of the 100 m EZ and 200 m buffer zone are required prior to ramp-up for any shutdown of longer than 30 minutes. This pre-clearance period may occur during any vessel activity. If any marine mammal (including delphinids) is observed within or approaching the EZ or buffer zone during the 30 minute pre-clearance period, ramp-up may not begin until the animal(s) has been observed exiting the EZ or buffer zone or until an additional time period has elapsed with no further sightings (*i.e.,* 15 minutes for small odontocetes and 30 minutes for all other species).

(iv) During ramp-up, at least two PSOs shall monitor the 100 m EZ and 200 m buffer zone. Ramp-up may not be initiated if any marine mammal (including delphinids) is observed within or approaching the 100 m EZ. If a marine mammal is observed within or approaching the 100 m EZ during ramp-up, a shutdown shall be implemented as though the full array were operational. Ramp-up may not begin again until the animal(s) has been observed exiting the 100 m EZ or until an additional time period has elapsed with no further sightings (*i.e.,* 15 minutes for small odontocetes and 30 minutes for mysticetes and large odontocetes including sperm, pygmy sperm, and beaked whales).

(v) 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 visual detections of any marine mammal have occurred within the buffer zone.

(vi) Ramp-up at night and at times of poor visibility shall only occur where operational planning cannot reasonably avoid such circumstances. Ramp-up may occur at night and during poor visibility if the 100 m EZ and 200 m buffer zone have been continually monitored by visual PSOs for 30 minutes prior to ramp-up with no marine mammal detections.

(vii) The vessel operator must notify a designated PSO of the planned start of ramp-up. The designated PSO must be notified again immediately prior to initiating ramp-up procedures and the operator must receive confirmation from the PSO to proceed.

(e) Shutdown requirements—An exclusion zone of 100 m shall be established and monitored by PSOs. If a marine mammal is observed within, entering, or approaching the 100 m exclusion zone all airguns shall be shut down.

(i) Any PSO on duty has the authority to call for shutdown of the airgun array. When there is certainty regarding the need for mitigation action on the basis of visual detection, the relevant PSO(s) must call for such action immediately.

(ii) The operator must establish and maintain clear lines of communication directly between PSOs on duty and crew controlling the airgun array to ensure that shutdown commands are conveyed swiftly while allowing PSOs to maintain watch.

(iii) When a shutdown is called for by a PSO, the shutdown must occur and any dispute resolved only following shutdown.

(iv) The shutdown requirement is waived for dolphins of the following genera: *Tursiops, Steno, Stenella, Lagenorhynchus* and *Delphinus.* The shutdown waiver only applies if animals are traveling, including approaching the vessel. If animals are stationary and the vessel approaches the animals, the shutdown requirement applies. If there is uncertainty regarding identification (*i.e.,* whether the observed animal(s) belongs to the group described above) or whether the animals are traveling, shutdown must be implemented.

(v) Upon implementation of a shutdown, the source may be reactivated under the conditions described at 4(e)(vi). Where there is no relevant zone (*e.g.,* shutdown due to observation of a calf), a 30-minute clearance period must be observed following the last observation of the animal(s).

(vi) Shutdown of the array is required upon observation of a whale (*i.e.,* sperm whale or any baleen whale) with calf, with ''calf'' defined as an animal less than two-thirds the body size of an adult observed to be in close association with an adult, at any distance.

(vii) Shutdown of the array is required upon observation of an aggregation (*i.e.,* six or more animals) 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.) at any distance.

(f) Vessel Strike Avoidance—Vessel operator and crew must maintain a vigilant watch for all marine mammals and slow down or stop the vessel or alter course, as appropriate, to avoid striking any marine mammal. 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. A visual observer aboard the vessel must monitor a vessel strike avoidance zone around the vessel according to the parameters stated below. Visual observers monitoring the vessel strike avoidance zone can be either third-party observers or crew members, but crew members responsible for these duties must be provided sufficient training to distinguish marine mammals from other phenomena.

(i) The vessel must maintain a minimum separation distance of 100 m from large whales. The following avoidance measures must be taken if a large whale is within 100 m of the vessel:

(A) The vessel must reduce speed and shift the engine to neutral, when feasible, and must not engage the engines until the whale has moved outside of the vessel's path and the minimum separation distance has been established.

(B) If the vessel is stationary, the vessel must not engage engines until the whale(s) has moved out of the vessel's path and beyond 100 m.

(ii) The vessel must maintain a minimum separation distance of 50 m from all other marine mammals, with an exception made for animals described in 4(e)(iv) that approach the vessel. If an animal is encountered during transit, the vessel shall attempt to remain parallel to the animal's course, avoiding excessive speed or abrupt changes in course.

(iii) Vessel speeds must be reduced to 10 knots or less when mother/calf pairs, pods, or large assemblages of cetaceans are observed near the vessel.

(g) Miscellaneous Protocols

(i) The airgun array must be deactivated when not acquiring data or preparing to acquire data, except as necessary for testing. Unnecessary use of the acoustic source shall be avoided. Operational capacity of 90 in^3 (not including redundant backup airguns) must not be exceeded during the survey, except where unavoidable for source testing and calibration purposes. All occasions where activated source volume exceeds notified operational capacity must be noticed to the PSO(s) on duty and fully documented. The lead PSO must be granted access to relevant instrumentation documenting acoustic source power and/or operational volume.

(ii) Testing of the acoustic source involving all elements requires normal mitigation protocols (*e.g.,* ramp-up). Testing limited to individual source elements or strings does not require ramp-up but does require pre-clearance.

5. Monitoring Requirements

The holder of this Authorization is required to conduct marine mammal monitoring during survey activity. Monitoring shall be conducted in accordance with the following requirements:

(a) The operator must provide a night-vision device suited for the marine environment for use during nighttime ramp-up pre-clearance, at the discretion of the PSOs. At minimum, the device should feature automatic brightness and gain control, bright light protection, infrared illumination, and optics suited for low-light situations.

(b) PSOs must also be equipped with reticle binoculars (*e.g.,* 7x50) of appropriate quality (*i.e.,* Fujinon or equivalent), GPS, compass, and any other tools necessary to adequately perform necessary tasks, including accurate determination of distance and bearing to observed marine mammals.

(c) PSO Qualifications

(i) 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.

(ii) PSOs 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 experience. Requests for such a waiver must include written justification. Alternate experience that may be considered includes, but is not limited to (1) secondary education and/or experience comparable to PSO duties; (2) previous work experience conducting academic, commercial, or government-sponsored marine mammal surveys; or (3) previous work experience as a PSO; the PSO should demonstrate good standing and consistently good performance of PSO duties.

(d) Data Collection—PSOs must use standardized data forms, whether hard copy or electronic. PSOs shall record detailed information about any implementation of mitigation requirements, including the distance of animals to the acoustic source and description of specific actions that ensued, the behavior of the animal(s), any observed changes in behavior before and after implementation of mitigation, and if shutdown was implemented, the length of time before any subsequent ramp-up of the acoustic source to resume survey. If required mitigation was not implemented, PSOs should submit a description of the circumstances. We require that, at a minimum, the following information be reported:

(i) PSO names and affiliations

(ii) Dates of departures and returns to port with port name

(iii) Dates and times (Greenwich Mean Time) of survey effort and times corresponding with PSO effort

(iv) Vessel location (latitude/longitude) when survey effort begins and ends; vessel location at beginning and end of visual PSO duty shifts

(v) Vessel heading and speed at beginning and end of visual PSO duty shifts and upon any line change

(vi) Environmental conditions while on visual survey (at beginning and end of PSO shift and whenever conditions change significantly), including wind speed and direction, Beaufort sea state, Beaufort wind force, swell height, weather conditions, cloud cover, sun glare, and overall visibility to the horizon

(vii) Factors that may be contributing to impaired observations during each PSO shift change or as needed as environmental conditions change (*e.g.,* vessel traffic, equipment malfunctions)

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

(ix) If a marine mammal is sighted, the following information should be recorded:

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

(B) PSO who sighted the animal;

(C) Time of sighting;

(D) Vessel location at time of sighting;

(E) Water depth;

(F) Direction of vessel's travel (compass direction);

(G) Direction of animal's travel relative to the vessel;

(H) Pace of the animal;

(I) Estimated distance to the animal and its heading relative to vessel at initial sighting;

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

(K) Estimated number of animals (high/low/best);

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

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

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

(O) Animal's closest point of approach and/or closest distance from the center point of the acoustic source;

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

(Q) Description of any actions implemented in response to the sighting (*e.g.,* delays, shutdown, ramp-up, speed or course alteration, etc.) and time and location of the action.

6. Reporting

(a) SIO shall submit a draft comprehensive report on all activities and monitoring results within 90 days of the completion of the survey or expiration of the IHA, whichever comes sooner. The report must describe all activities conducted and sightings of marine mammals near the activities, must provide full documentation of methods, results, and interpretation pertaining to all monitoring, and must summarize the dates and locations of survey operations and all marine mammal sightings (dates, times, locations, activities, associated survey activities). Geospatial data regarding locations where the acoustic source was used must be provided as an ESRI shapefile with all necessary files and appropriate metadata. In addition to the report, all raw observational data shall be made available to NMFS. The report must summarize the data collected as required under condition 5(d) of this IHA. The draft report must be accompanied by a certification from the lead PSO as to the accuracy of the report, and the lead PSO may submit directly to NMFS a statement concerning implementation and effectiveness of the required mitigation and monitoring. A final report must be submitted within 30 days following resolution of any comments from NMFS on the draft report.

(b) Reporting injured or dead marine mammals:

(i) In the event that the specified activity clearly causes the take of a marine mammal in a manner not prohibited by this IHA (if issued), such as serious injury or mortality, SIO shall immediately cease the specified activities and immediately report the incident to the NMFS Office of Protected Resources. The report must include the following information:

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

(B) Vessel's speed during and leading up to the incident;

(C) Description of the incident;

(D) Status of all sound source use in the 24 hours preceding the incident;

(E) Water depth;

(F) Environmental conditions (*e.g.,* wind speed and direction, Beaufort sea state, cloud cover, and visibility);

(G) Description of all marine mammal observations in the 24 hours preceding the incident;

(H) Species identification or description of the animal(s) involved;

(I) Fate of the animal(s); and

(J) Photographs or video footage of the animal(s).

Activities shall not resume until NMFS is able to review the circumstances of the prohibited take.

NMFS will work with SIO to determine what measures are necessary to minimize the likelihood of further prohibited take and ensure MMPA compliance. SIO may not resume their activities until notified by NMFS.

(ii) In the event that SIO discovers an injured or dead marine mammal, and the lead observer determines that the cause of the injury or death is unknown and the death is relatively recent (*e.g.,* in less than a moderate state of decomposition), SIO shall immediately report the incident to the NMFS Office of Protected Resources. The report must include the same information identified in condition 6(b)(i) of this IHA. Activities may continue while NMFS reviews the circumstances of the incident. NMFS will work with SIO to determine whether additional mitigation measures or modifications to the activities are appropriate.

(iii) In the event that SIO discovers an injured or dead marine mammal, and the lead observer determines that the injury or death is not associated with or related to the specified activities (*e.g.,* previously wounded animal, carcass with moderate to advanced decomposition, or scavenger damage), SIO shall report the incident to the NMFS Office of Protected Resources within 24 hours of the discovery. SIO shall provide photographs or video footage or other documentation of the sighting to NMFS.

7. This Authorization may be modified, suspended or withdrawn if the holder fails to abide by the conditions prescribed herein, or if NMFS determines the authorized taking is having more than a negligible impact on the species or stock of affected marine mammals.

Request for Public Comments

We request comment on our analyses, the proposed authorization, and any other aspect of this Notice of Proposed IHA for the proposed survey. We also request comment on the potential for renewal of this proposed IHA as described in the paragraph below. Please include with your comments any supporting data or literature citations to help inform our final decision on the request for MMPA authorization.

On a case-by-case basis, NMFS may issue a second one-year IHA without additional notice when (1) another year of identical or nearly identical activities as described in the Specified Activities section is planned or (2) the activities would not be completed by the time the IHA expires and a second IHA would allow for completion of the activities beyond that described in the Dates and Duration section, provided all of the following conditions are met:

- A request for renewal is received no later than 60 days prior to expiration of the current IHA.
- The request for renewal must include the following:

(1) An explanation that the activities to be conducted beyond the initial dates either are identical to the previously analyzed activities or include changes so minor (*e.g.,* reduction in pile size) that the changes do not affect the previous analyses, take estimates, or mitigation and monitoring requirements.

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

- Upon review of the request for renewal, the status of the affected species or stocks, and any other pertinent information, NMFS determines that there are no more than minor changes in the activities, the mitigation and monitoring measures remain the same and appropriate, and the original findings remain valid.

Dated: April 24, 2018.

Donna S. Wieting,

Director, Office of Protected Resources, National Marine Fisheries Service.

[FR Doc. 2018–08891 Filed 4–26–18; 8:45 am]

BILLING CODE 3510–22–P

Appendix K. Comment Received in Response to NMFS FR Notice

2 July 2018

Ms. Jolie Harrison, Chief
Permits and Conservation Division
Office of Protected Resources
National Marine Fisheries Service
1315 East-West Highway
Silver Spring, MD 20910-3225

Dear Ms. Harrison:

The Marine Mammal Commission (the Commission), in consultation with its Committee of Scientific Advisors on Marine Mammals, has reviewed the application submitted by U.S. Geological Survey (USGS) seeking authorization under section 101(a)(5)(D) of the Marine Mammal Protection Act (the MMPA) to take small numbers of marine mammals by harassment. The taking would be incidental to a marine geophysical survey to be conducted in the North Atlantic Ocean in August 2018. The Commission also has reviewed the National Marine Fisheries Service's (NMFS) 31 May 2018 notice announcing receipt of the application and proposing to issue the authorization, subject to certain conditions (83 Fed. Reg. 25268).

Background

USGS proposes to conduct a geophysical survey in the U.S. exclusive economic zone from Cape Hatteras to south of Hudson Canyon. The purpose of the survey is to investigate 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. The survey would be conducted along approximately 2,350 km of tracklines in waters estimated to be 100 to 3,700 m in depth. USGS would use the R/V *Hugh R. Sharp (Sharp)* to operate a two- or four-airgun array with a maximum discharge volume of 840 in^3 at a tow depth of 3 m. In addition, the *Sharp* would (1) tow a 750- to 1,300-m hydrophone streamer and (2) use a 38-kHz split-beam echosounder (an EK60), and (3) deploy up to 90 sonobuoys during the survey. The survey is expected to last for up to 22 days[1].

NMFS preliminarily has determined that, at most, the proposed activities would result in the incidental taking of small numbers of up to 29 species of marine mammals by Level B harassment and that any impact on the affected species would be negligible. NMFS does not anticipate any take of marine mammals by death or serious injury. It also has preliminarily determined that the proposed mitigation measures provide the means of effecting the least practicable impact on the affected species or stocks. Those measures include (1) using two protected species observers to

[1] A 25-percent contingency was added for airgun testing and repeat coverage of any areas where initial data quality is deemed substandard or when partial equipment failure occurs.

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monitor the Level A and B harassment zones for 30 minutes before, during, and for 30 minutes after the survey, (2) implementing speed and course alterations, and (3) using shut-down[2] and ramp-up procedures. In addition, USGS would shut down the airguns immediately if a large whale[3] with a calf or an aggregation[4] of large whales is observed regardless of the distance from the *Sharp*. Ramp-up procedures would not be initiated until the animal(s) has not been seen at any distance for 30 minutes. USGS would report any injured or dead marine mammal to NMFS's Office of Protected Resources and the Greater Atlantic Regional or Southeast Stranding Coordinator[5] using its phased approach.

Flaws in modeling methodologies

USGS used Lamont-Doherty Earth Observatory's (LDEO) model to estimate the extent of the Level A and B harassment zones and the numbers of marine mammal takes. The Commission has raised concerns regarding LDEO's model and has provided extensive comments regarding the inappropriateness of that model[6] for nearly eight years. In more recent years, other stakeholders[7] have expressed similar concerns regarding the inappropriateness of those methods (80 Fed. Reg. 67713). LDEO uses the Nucleus source model and a simple ray trace–based modeling approach[8] that assumes spherical spreading, a constant sound speed, and no bottom interactions for surveys in deep water (Diebold et al. 2010).

The Commission notes that LDEO's model provides results only for deep water (>1,000 m) and only up to a depth of 2,000 m—the current survey occurs in waters from 100 to 3,700 m in depth. For intermediate water depths (100 to 1,000 m), USGS applied a correction factor of 1.5 to the deep-water results. Environmental conditions in waters off New Jersey (up to 1,500 m in depth) indicate a surface duct at 50 m, in-water refraction, and bathymetry and sediment characteristics that reflect sound in summer. Those parameters were not accounted for in USGS's modeling approach. Many studies, including multiple LDEO-associated studies,[9] have emphasized the importance of incorporating site-specific environmental and operational parameters into estimating Level A and B harassment zones. LDEO's simple model and crude assumptions, that could very well represent underestimated harassment zones in deep water and overestimated harassment zones in intermediate water, are not considered best available science.

These issues have been further complicated with the finalization a few years ago of NMFS's updated acoustic thresholds for permanent threshold shift (i.e., Level A harassment). LDEO continues to claim that its model cannot incorporate more than a single shot and thus cannot

[2] Shut downs would not be required for small delphinids (*Delphinus* spp., *Tursiops* spp., *Stenella* spp., *Steno* spp., and *Lagenorhynchus* spp.) that are traveling and voluntarily approaching the source vessel to interact with the vessel and/or airgun array.
[3] A sperm whale or mysticete.
[4] Six or more individuals that do not appear to be traveling and are feeding, socializing, etc.
[5] The Commission informally noted that NMFS did not specify which stranding coordinator should be contacted. NMFS indicated it would clarify which stranding coordinator should be contacted for the specific areas in the final authorization.
[6] Which should be reviewed in conjunction with this letter (see the Commission's 2 May 2016 letter) and are not reiterated herein
[7] Natural Resources Defense Council and Whale and Dolphin Conservation.
[8] Essentially a MATLAB algorithm.
[9] Tolstoy et al. (2004), Tolstoy et al. (2009), Diebold et al. (2010), and Crone et al. (2014).

readily estimate ranges to the cumulative sound exposure level (SEL_{cum}) thresholds. In the absence of such a model, LDEO used NMFS's user spreadsheet to estimate the Level A harassment zones[10] for the various functional hearing groups.

To estimate the Level A harassment zones, LDEO computed 'modified' frequency-weighted, farfield source levels. USGS noted that those are more appropriate than the 'actual' farfield source levels[11] because an 'actual' farfield source level "does not take into account the interactions of the two airguns that occur near the source center and is calculated as a point source (single airgun)"[12]. The modified farfield source levels[13] are essentially back-calculated source levels[14] based on the relevant frequency-weighted threshold. The *Federal Register* notice further indicated that, although the array effect is not expected to be as pronounced for the four-airgun array as it would be for a larger airgun array, the modified farfield source level was considered more appropriate than use of the theoretical farfield signature. The Commission is unaware of any other seismic operators using such a circuitous approach to estimate harassment zones. Generally, source levels are inputs to models rather than products of those models, and the sound field from spatially-distributed sources (e.g., airgun arrays) is modeled as sums of point sources, under the assumption that individual airgun pressures do not substantially influence each other. Such an approach is straightforward, easy to implement, and accounts for both the 'near-field' and 'far-field' effects. LDEO also appears to be using both radial distances (i.e., slant ranges) and radii indiscriminately. Radial distances have been used for metrics based on SEL_{cum} and SPL root-mean-square (SPL_{rms}), and radii have been used for metrics based on SPL_{peak}, which would yield smaller zones Therefore, the Commission recommends that NMFS require USGS to specify why LDEO is using radial distances for SEL_{cum} and SPL_{rms} metrics and radii for SPL_{peak} metrics.

LDEO's method did incorporate the spectral aspects of the two- and four-airgun configurations to better refine the frequency-specific weighting function adjustments for the SEL_{cum} thresholds rather than using NMFS's simple weighting factor adjustment (i.e., 1 kHz for seismic). The Commission supports incorporation of spectral data but wonders why the spectral levels were effectively cut off at 2.5 to 3 kHz, since airguns emit energy above 3 kHz. The Commission suspects that this anomaly occurred because the Nucleus source model only provides data up to 2.5 or 3 kHz, which would affect the estimated ranges to the Level A harassment thresholds for various species (including mid-frequency (MF) and HF[15] cetaceans). Airgun sound in the MF and HF[16]

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[10] The Level A harassment zone based on peak sound pressure levels (SPL_{peak}) for the 4 x 105 in^3 array was incorrectly noted for high-frequency (HF) cetaceans in the *Federal Register* notice—it should be 70.79 m. NMFS plans to include that revision in the final authorization. However, this is the second proposed authorization involving LDEO's model for which the Commission noted errors in the SPL_{peak} zones (see the Commission's 21 May 2018 letter). LDEO also appears to be using indiscriminately both radial distances (i.e., slant ranges) and radii. LDEO should specify why it is using radial distances for metrics based on SEL_{cum} and SPL root-mean-square and radii for metrics based on SPL_{peak}, as radii would yield smaller zones.

[11] Deemed a 'theoretical representation of the source level' or a 'theoretical far-field signature' in the application.

[12] Where the effects of the array are the greatest and coherent summation does not occur.

[13] Although USGS did not present both the modified and actual source levels in its application, the University of Hawaii (UH) presented those data in its recent application. UH's source levels were similar for some functional hearing groups but the modified source levels varied from the actual source levels by approximately 3 to 18 dB for other functional hearing groups.

[14] Assuming spherical propagation loss.

[15] Particularly since the Level A harassment threshold is 155 dB re 1 μ Pa^2-sec.

[16] 1–10 kHz and > 10 kHz, respectively.

range contributes to the overall sound exposure level for those species and should not be assumed to be to zero above 3 kHz. Other source models (including Gundalf Optimizer[17] and JASCO's Airgun Array Source Model[18] (AASM)) provide sound levels into the HF range and could have been used. The Commission recommends that NMFS provide justification for why it believes that LDEO's use of the Nucleus source model, which does not provide data above 2.5 kHz, is appropriate for determining the extents of the Level A harassment zones for MF and HF cetaceans.

The use of truncated spectra and modified farfield source levels further supports the Commission's continued recommendation that NMFS require LDEO, and in turn USGS and other affiliated entities[19], to revise their source and sound propagation modeling methodologies. The Commission additionally underscores the need for NMFS to hold USGS, LDEO, National Science Foundation (NSF), and affiliated entities to the same standard as other action proponents (e.g., Bureau of Ocean Energy Management, the oil and gas industry, U.S. Navy, U.S. Air Force), as LDEO's model does not represent the best available science. Thus, the Commission again recommends that NMFS require USGS, in collaboration with LDEO, to re-estimate the proposed Level A and B harassment zones and associated takes of marine mammals using (1) both operational (including number/type/spacing of airguns, tow depth, source level/operating pressure, operational volume) and site-specific environmental (including sound speed profiles, bathymetry, and sediment characteristics[20] at a minimum) parameters, (2) a comprehensive source model (i.e., Gundalf Optimizer or AASM) and (3) an appropriate sound propagation model for the proposed incidental harassment authorization. Specifically, the Commission reiterates that LDEO should be using the ray-tracing sound propagation model BELLHOP—which is a free, standard propagation code that readily incorporates all environmental inputs listed herein, rather than the limited, in-house MATLAB code currently in use.

Furthermore, USGS will be deploying up to 90 sonobuoys in water depths greater than 1,000 m to provide velocity control and possibly wide-angle reflections along the highest-priority transects. Those sonobuoys[21] also would provide in-situ data on the extents of the various harassment zones. In addition, the hydrophone streamer would be equipped with Soundguard software, which can record signals from 64 Hz to 50 kHz. NMFS has been including in numerous authorizations the requirement that sound source verification studies (SSVs) be conducted for a myriad of activities, including seismic surveys, high-resolution geophysical surveys, confined underwater blasting, and various construction-related activities. SSVs have been required when action proponents use proxy source levels, as well as proxy sound propagation assumptions. Given the shortcomings noted for LDEO's source and sound propagation modeling and the requirement that other action proponents are obliged to fulfill, the Commission recommends that NMFS require USGS to archive, analyze, and compare the in-situ data collected by the sonobuoys and hydrophone streamer to LDEO's modeling results for the extents of the Level A and B harassment

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[17] https://www.gundalf.com/environmental/
[18] http://www.nmfs.noaa.gov/pr/permits/incidental/oilgas/boem_2016rule_app_appendix.pdf
[19] Including the Scripps Institution of Oceanography (SIO).
[20] Those data can be obtained from the National Geophysical Data Center, Leviticus, and the U.S. Navy Oceanographic and Atmospheric Master Library's databases including Generalized Digital Environmental Model, Digital Bathymetric Database Variable-Resolution, Surface Marine Gridded Climatology.
[21] USGS indicated that the sonobuoys, although uncalibrated, would provide data primarily between 10 and 400 Hz (but up to 1 kHz), which is the frequency range where most of the energy is centered.

zones based on the various airgun configurations and water depths to be surveyed and provide the data and results to NMFS.

Take estimates in general

In 2014 NMFS revised the manner in which takes were estimated for seismic surveys. Historically, action proponents used simple area x density methods that vastly underestimated the numbers of marine mammals that could be taken during a seismic survey, or any other activity with a moving sound source. NMFS's revised method has included determining the ensonified area to be surveyed in a given location based on the line-kilometers[22] that could be surveyed over a given number of days[23], which is then to be multiplied by site- and species-specific densities and the number of days during which those activities could occur in that location. All site- or location-specific takes are then to be summed to determine the total numbers of takes to be authorized for the activity as a whole.

USGS did not follow that approach. USGS specified that it did not calculate the numbers of takes as a function of time, but rather calculated them based on the area ensonified within the Level B harassment zones along all the exemplary tracks adjacent to all of the exemplary lines and interseismic linking lines. USGS further stipulated that its approach is more precise than that often used by applicants since it relies completely on the marine mammal density grids and "shooting through" specific locations[24], but is a departure from the "daily ensonified method" that is typically used. The Commission doesn't disagree. Many action proponents that conduct seismic surveys rely on site-specific marine mammal densities and the associated ensonified areas within each location as refined in GIS. However, the action proponents also account for the time spent conducting the survey in each location, which USGS apparently did not do.

USGS indicated that the method used to estimate the numbers of takes was appropriate and conservative. USGS stated that the calculated number of days to complete all of the tracklines is 25 days, but the airguns would only be in operation for 19 days. Assuming 2,350 line-kilometers are to be surveyed, only 94 km would be surveyed on each of the 25 days. USGS also indicated that it would only use the airguns on 50 percent of the interseismic linking lines but assumed 100-percent use of the airguns for those lines. Assuming an additional 750 km[25] were added to the line-kilometers to account for those interseismic linking lines, 124 km would be surveyed on each of the 25 days. That would equate to the survey vessel traveling at less than 3 knots. The *Sharp* would be traveling at 4 knots and would cover more area (83 Fed. Reg. 25270).

USGS further stated that it assumed 'double ensonification' by estimating the numbers of Level B harassment takes based on the extent of the entire zone without subtracting the Level A harassment zone[26]. That point is moot since *Kogia* spp. are the only species for which takes could

[22] And relevant Level B harassment radii.
[23] Which generally has been based on a 5-knot survey speed, see 83 Fed. Reg. 18683 as just one example.
[24] USGS defined 11 different locations for its proposed survey based on the 11 transect lines.
[25] USGS did not specify how many line-kilometers would comprise the interseismic linking lines, but 750 km includes surveying the exemplary lines in 100–1,000 m of water *and* 50 percent of interseismic linking lines (Table 1 of the *Federal Register*). Lesser line-kilometers for the interseismic linking lines would yield an even smaller area to be surveyed and a slower speed.
[26] Level A harassment takes were not estimated or proposed to be authorized.

have been calculated based on the size of the Level A harassment zones and those still will equate to less than 1 take[27]. In addition, USGS noted that the 25-percent correction factor[28] will ensure that the take estimates are as conservative as possible. That is only true if USGS does not have to conduct airgun testing or repeat tracklines if data are substandard or partial equipment failure occurs. Furthermore, USGS's application indicated that the 25 days of activities included the 25-percent contingency, yet it indicated otherwise in response to Commission questions. For all of these reasons, it is unclear how 'conservative' the takes truly are.

Since USGS did not provide the line-kilometers assumed to be surveyed in each of the 11 locations, associated ensonified areas, or site-specific densities, the numbers of takes cannot be reviewed for appropriateness or even basic mathematical accuracy[29]. USGS's approach for enumerating takes is neither consistent with the approaches of other applicants that use moving sound sources nor transparent. Accordingly, the Commission recommends that NMFS ensure that USGS calculated the numbers of takes appropriately based on the line-kilometers to be surveyed in each of the 11 locations and the number of days it would take to survey each location, the associated ensonified areas, and site-specific densities—species-specific takes from each of the 11 locations should be summed to yield the total numbers of takes for each species. Furthermore, the Commission recommends that NMFS require USGS to provide in all future applications all relevant information regarding line-kilometers to be surveyed and days necessary to survey each location based on a presumed survey speed, associated ensonified areas, site-specific densities, and any other assumptions (including the assumed 25-percent contingency).

Rounding of take estimates

The method used to estimate the numbers of takes during the proposed activities, which summed fractions of takes for each species across project days, does not account for and negates the intent of NMFS's 24-hour reset policy. As the Commission has indicated in previous letters regarding this matter[30], the issue at hand involves policy rather than mathematical accuracy. The Commission understands that NMFS has nearly completed revising its draft criteria and plans to share them with the Commission in the near term. The Commission recommends that NMFS provide those criteria without further delay.

Use of the echosounder

Action proponents that conduct research-related seismic surveys, including LDEO, SIO, and other NSF-affiliated entities, refrain from using echosounders and subbottom profiles during transit. A number of years ago, it was brought to NMFS's attention that those sources—that were not being used as navigational aids—were active from the time the vessel left port until it returned, which was unnecessary. From that time onward, LDEO, SIO, and other NSF-affiliated entities have not used echosounders or subbottom profilers during transits (see SIO's recent application for

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[27] Similarly Level A harassment takes would be less than 0.1 for low-frequency cetaceans and are non-existent for mid-frequency cetaceans.
[28] That accounts for airgun testing and repeat coverage of any areas where initial data quality is deemed substandard.
[29] The Commission further notes that, based on rounding errors, the takes of Risso's dolphins, sperm whales, Clymene dolphins, and striped dolphins were incorrectly rounded down. NMFS plans to increase the numbers of takes for each species by 1.
[30] See the Commission's 29 November 2016 letter detailing this issue.

its Mid-Atlantic Ridge survey as an example). USGS, however, plans to use the echosounder during transits to and from the survey area.

The Commission questioned why the echosounder needed to be used, since NMFS clarified that the device would be used to detect methane gas hydrates rather than as a navigational aid. USGS initially responded that the echosounder needed to be calibrated in 30 m of water. When the Commission further questioned why the echosounder couldn't be deactivated when it wasn't being calibrated during the remainder of the transits and when in deeper water, NMFS responded that data would be collected at shallower depths as well. Those responses do not comport.

Calibrating a source is not the same as collecting actual gas hydrate data[31]. If gas hydrate data are being collected with the echosounder during transits to and from the survey area, then it is unclear why Level B harassment takes were not requested by USGS during that portion of the activity. Level B harassment takes are not generally requested during seismic surveys, because the Level B harassment zone associated with an echosounder or subbottom profiler is subsumed by the Level B harassment zone of the airgun array. However, Level B harassment takes have been authorized multiple times in the past when only an echosounder was used, including for the same EK60 echosounder that USGS plans to use in this instance (see Table 6 in 81 Fed. Reg. 53076 as one example[32]). USGS noted in its application that Cholewiak et al. (2017) observed a reduced number of beaked whale sightings and vocalizations during surveys that used the EK60 and could detect the EK60 transmissions at depths of 800 m 1.3 km from the source. USGS also acknowledged that there is a possibility of some odontocetes exhibiting a behavioral response to EK60 transmissions, despite the fact that the modeled Level B harassment zones are small.

The Commission sees this issue quite simply. Echosounders, subbottom profilers, and other sources that are intended to image the ocean bottom and not serve as navigational tools should not be active except when necessary. In this instance, that would be limited to the airgun survey and during calibration. If USGS intends to use the echosounder to collect gas hydrate data during transit to the survey area before the survey begins and from the survey area when it ends, then it needs to obtain authorization for taking during those activities as well. Therefore, <u>the Commission recommends</u> that NMFS condition the authorization to limit USGS's use of the echosounder during transits to and from the survey area except during calibration (apparently in water depths of 30 m or less). If USGS intends to use the echosounder to collect gas hydrate data during transits to and from the area, <u>the Commission recommends</u> that NMFS advise USGS that it needs to obtain additional authorization to take marine mammals during such activities.

[31] Furthermore, the use of the echosounder in water depths greater than 30 m was not addressed.
[32] This source also is similar to or the same as those used during high-resolution geophysical surveys.

The Commission looks forward to working with NMFS on the various issues raised in this and past letters. Please contact me if you have questions concerning the Commission's recommendations.

Sincerely,

Peter O. Thomas, Ph.D.,
Executive Director

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