Final Environmental Assessment of a Marine Geophysical Survey by the R/V *Marcus G. Langseth* in the Atlantic Ocean off New Jersey, July–Mid August 2014

Prepared for

Lamont-Doherty Earth Observatory
61 Route 9W, P.O. Box 1000
Palisades, NY 10964-8000

and

National Science Foundation
Division of Ocean Sciences
4201 Wilson Blvd., Suite 725
Arlington, VA 22230

by

LGL Ltd., environmental research associates
22 Fisher St., POB 280
King City, Ont. L7B 1A6

1 July 2014

LGL Report TA8349-1

TABLE OF CONTENTS

Page

ABSTRACT

Lamont-Doherty Earth Observatory (L-DEO), with funding from the U.S. National Science Foundation (NSF), proposes to conduct a high-energy, 3-D seismic survey on the R/V *Langseth* in the northwest Atlantic Ocean ~25–85 km from the coast of New Jersey in July–mid August 2014. Although the R/V *Langseth* is capable of conducting high energy seismic surveys using up to 36 airguns with a discharge volume of 6600 in^3, the proposed seismic survey would only use a small towed subarray of 4 or 8 airguns with a total discharge volume of ~700 in^3 or 1400 in^3. The seismic survey would take place outside of U.S. state waters within the U.S. Exclusive Economic Zone (EEZ) in water depths ~30–75 m.

NSF, as the funding agency, has a mission to "promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense…". The proposed seismic survey would collect data in support of a research proposal that has been reviewed under the NSF merit review process and identified as an NSF program priority. It would provide data necessary to study the arrangement of sediments deposited during times of changing global sea level from roughly 60 million years ago to present and enable follow-on studies to identify the magnitude, time, and impact of major changes in sea level.

This Final Environmental Assessment (EA) addresses NSF's requirements under the National Environmental Policy Act (NEPA) for the proposed NSF federal action. L-DEO requested an Incidental Harassment Authorization (IHA) from the U.S. National Oceanic and Atmospheric Administration'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 analysis in the Draft EA also supported the IHA application process and provided information on marine species not addressed by the IHA application, including seabirds and sea turtles that are listed under the U.S. Endangered Species Act (ESA), including candidate species. As analysis on endangered/threatened species was included, the Draft EA was used to support ESA Section 7 consultations with NMFS and U.S. Fish and Wildlife Service (USFWS). The Draft EA was also used in support of consultation with NMFS Greater Atlantic Regional Fisheries Office for Essential Fish Habitat (EFH) under the Magnuson-Stevens Act. Alternatives addressed in this Final EA consist of a corresponding program at a different time with issuance of an associated IHA and the no action alternative, with no IHA and no seismic survey. This document tiers to the 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 (June 2011) and Record of Decision (June 2012), referred to herein as PEIS. The proposed survey area off the coast of New Jersey is near one of the detailed analysis areas (DAAs) in the PEIS; however, this EA was prepared because a different energy source level and configuration would be used for the proposed survey, and the proposed survey covers only shelf waters whereas the DAA was on the shelf and slope.

Numerous species of marine mammals inhabit the proposed survey area off the coast of New Jersey. Several of these species are listed as ***endangered*** under the U.S. Endangered Species Act (ESA): the sperm, North Atlantic right, humpback, sei, fin, and blue whales. Other ESA-listed species that could occur in the area are the ***endangered*** leatherback, hawksbill, green, and Kemp's ridley turtles and roseate tern, and the ***threatened*** loggerhead turtle and piping plover. The ***endangered*** Atlantic sturgeon and shortnose sturgeon could also occur in or near the study area. ESA-listed ***candidate species*** that could occur in the area are the cusk, dusky shark, and great hammerhead shark.

Potential impacts of the seismic survey on the environment would be primarily a result of the operation of the airgun array. A multibeam echosounder, sub-bottom profiler, and acoustic Doppler current profiler would also be operated. Impacts would be associated with increased underwater noise, which could 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 minimize potential impacts of the proposed activities on marine animals present during the proposed research, and to 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, and are not likely to be caused by the other types of sound sources to be used. However, despite the relatively low levels of sound emitted by the subarray of airguns, a precautionary approach would still be taken. The planned monitoring and mitigation measures would reduce the possibility of any effects.

Protection measures designed to mitigate the potential environmental impacts to marine mammals and sea turtles would include the following: ramp ups; typically two, but a minimum of one dedicated observer maintaining a visual watch during all daytime airgun operations; two observers 30 min before and during ramp ups during the day and at night; no start ups during poor visibility or at night unless at least one airgun has been operating; passive acoustic monitoring (PAM) via towed hydrophones during both day and night to complement visual monitoring (unless the system and back-up systems are damaged during operations); and power downs (or if necessary shut downs) when marine mammals or sea turtles are detected in or about to enter designated exclusion zones. L-DEO and its contractors are committed to applying these measures in order to minimize effects on marine mammals and sea turtles and other environmental impacts.

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. Marine Mammal Protection Act (MMPA) definition of “Level B Harassment” for those species managed by NMFS. 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

~	approximately
ADCP	Acoustic Doppler current profiler
ALWTRP	Atlantic Large Whale Take Reduction Plan
AMVER	Automated Mutual-Assistance Vessel Rescue
BOEM	Bureau of Ocean Energy Management
CETAP	Cetacean and Turtle Assessment Program
CITES	Convention on International Trade in Endangered Species
DAA	Detailed Analysis Area
dB	decibel
DoN	Department of the Navy
EA	Environmental Assessment
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
ESA	(U.S.) Endangered Species Act
EZ	Exclusion Zone
FAO	Food and Agriculture Organization of the United Nations
FM	Frequency Modulated
GIS	Geographic Information System
h	hour
hp	horsepower
HRTRP	Harbor Porpoise Take Reduction Plan
Hz	Hertz
IHA	Incidental Harassment Authorization (under MMPA)
in	inch
IOC	Intergovernmental Oceanographic Commission of UNESCO
IODP	Integrated Ocean Drilling Program
IUCN	International Union for the Conservation of Nature
kHz	kilohertz
km	kilometer
kt	knot
L-DEO	Lamont-Doherty Earth Observatory
LFA	Low-frequency Active (sonar)
m	meter
min	minute
MBES	Multibeam Echosounder
MFA	Mid-frequency Active (sonar)
MMPA	(U.S.) Marine Mammal Protection Act
ms	millisecond
n.mi.	nautical mile
NEPA	(U.S.) National Environmental Policy Act
NJ	New Jersey
NEFSC	Northeast Fisheries Science Center
NMFS	(U.S.) National Marine Fisheries Service
NRC	(U.S.) National Research Council

NSF	National Science Foundation
OBIS	Ocean Biogeographic Information System
OCS	Outer Continental Shelf
OEIS	Overseas Environmental Impact Statement
OAWRS	Ocean Acoustic Waveguide Remote Sensing
p or pk	peak
PEIS	Programmatic Environmental Impact Statement
PI	Principal Investigator
PTS	Permanent Threshold Shift
PSO	Protected Species Observer
PSVO	Protected Species Visual Observer
RL	Received level
rms	root-mean-square
R/V	research vessel
s	second
SAR	U.S. Marine Mammal Stock Assessment Report
SBP	Sub-bottom Profiler
SCUBA	Self contained underwater breathing apparatus
SEFSC	Southeast Fisheries Science Center
TTS	Temporary Threshold Shift
SEL	Sound Exposure Level
SPL	Sound Pressure Level
UNEP	United Nations Environment Programme
U.S.	United States of America
USCG	U.S. Coast Guard
USGS	U.S. Geological Survey
USFWS	U.S. Fish and Wildlife Service
USN	U.S. Navy
μPa	microPascal
vs.	versus
WCMC	World Conservation Monitoring Centre

I. PURPOSE AND NEED

The purpose of this Final Environmental Assessment (EA) is to provide the information needed to assess the potential environmental impacts associated with the use of a 4- or 8-airgun subarray during the proposed seismic surveys. The Final EA was prepared under the National Environmental Policy Act (NEPA). This Final EA tiers to the 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) and Record of Decision (NSF 2012), referred to herein as the PEIS. The proposed survey area off the coast of New Jersey is near one of the detailed analysis areas (DAAs) presented in the PEIS; however, this EA was prepared because a different energy source level and configuration would be used for the proposed survey, and the proposed survey covers only shelf waters whereas the DAA was on the shelf and slope. The Final 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 invertebrates. The Draft EA was 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 IHA allows for non-intentional, non-injurious "take by harassment" of small numbers of marine mammals during the proposed seismic survey by L-DEO in the Atlantic Ocean off New Jersey during July–August 2014. The Draft EA was also used in support of consultation with NMFS Greater Atlantic Regional Fisheries Office for Essential Fish Habitat (EFH) under the Magnuson-Stevens Act.

To be eligible for an IHA under the U.S. Marine Mammal Protection Act (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 NSF

The National Science Foundation (NSF) was established by Congress with the National Science Foundation Act of 1950 (Public Law 810507, as amended) and is the only federal agency dedicated to the support of fundamental research and education in all scientific and engineering disciplines. Further details on the mission of NSF are described in § 1.2 of the PEIS.

Purpose of and Need for the Proposed Action

As noted in the PEIS, § 1.3, NSF has a continuing need to fund seismic surveys that enable scientists to collect data essential to understanding the complex Earth processes beneath the ocean floor. The purpose of the proposed action is to collect data across existing Integrated Ocean Drilling Program (IODP) Expedition 313 drill sites on the inner-middle shelf of the New Jersey continental margin to reveal the arrangement of sediments deposited during times of changing global sea level from roughly 60 million years ago to present. Features such as river valleys cut into coastal plain sediments, now buried under a km of younger sediment and flooded by today's ocean, cannot be identified and traced with existing 2-D seismic data, despite their existence being clearly indicated in sediment cores recovered during IODP Expedition 313. These and other erosional and depositional features would be imaged using 3-D seismic data and would enable follow-on studies to identify the magnitude, time, and impact of major changes in sea level. The proposed seismic survey would collect data in support of a research proposal

(Appendix B) that has been reviewed under the NSF merit review process and identified as an NSF program priority to meet NSF's critical need to foster a better understanding of Earth processes.

Background of NSF-funded Marine Seismic Research

The background of NSF-funded marine seismic research is described in § 1.5 of the PEIS.

Regulatory Setting

The regulatory setting of this Final EA is described in § 1.8 of the PEIS, including the

- National Environmental Protection Act (NEPA);
- Marine Mammal Protection Act (MMPA);
- Endangered Species Act (ESA); and
- Magnuson-Stevens Act for Essential Fish Habitat.

II. ALTERNATIVES INCLUDING PROPOSED ACTION

In this Final 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 L-DEO's planned seismic survey are described in the following subsections.

(1) Project Objectives and Context

L-DEO plans to conduct a 3-D seismic survey using the R/V *Marcus G. Langseth* (*Langseth*) on the inner-middle shelf of the New Jersey continental margin (Fig. 1). As noted previously, the goal of the proposed research is to collect and analyze data on the arrangement of sediments deposited during times of changing global sea level from roughly 60 million years ago to present. Despite their existence being clearly indicated in sediment cores recovered during IODP Expedition 313, features such as river valleys cut into coastal plain sediments, now buried under a km of younger sediment and flooded by today's ocean, cannot be resolved in existing 2-D seismic data to the degree required to map shifting shallow-water depositional settings in the vicinity of clinoform rollovers. To achieve the project's goals, the lead Principal Investigator (PI), Dr. G. Mountain (Rutgers University), and collaborating PIs Drs. J. Austin, C. Fulthorpe, and M. Nedimović (University of Texas at Austin), propose to use a 3-D seismic reflection survey to map sequences around existing IODP Expedition 313 drill sites and analyze their spatial/temporal evolution. Objectives that would then be met include establishing the impact of known Ice House base-level changes on the stratigraphic record; providing greater understanding of the response of nearshore environments to changes in elevation of global sea level; and determining the amplitudes and timing of global sea-level changes during the mid-Cenozoic.

(2) Proposed Activities

(a) Location of the Activities

The proposed survey area is located between ~39.3–39.7°N and ~73.2–73.8°W in the Atlantic Ocean, ~25–85 km off the coast of New Jersey (Fig. 1). Water depths in the survey area are ~30–75 m.

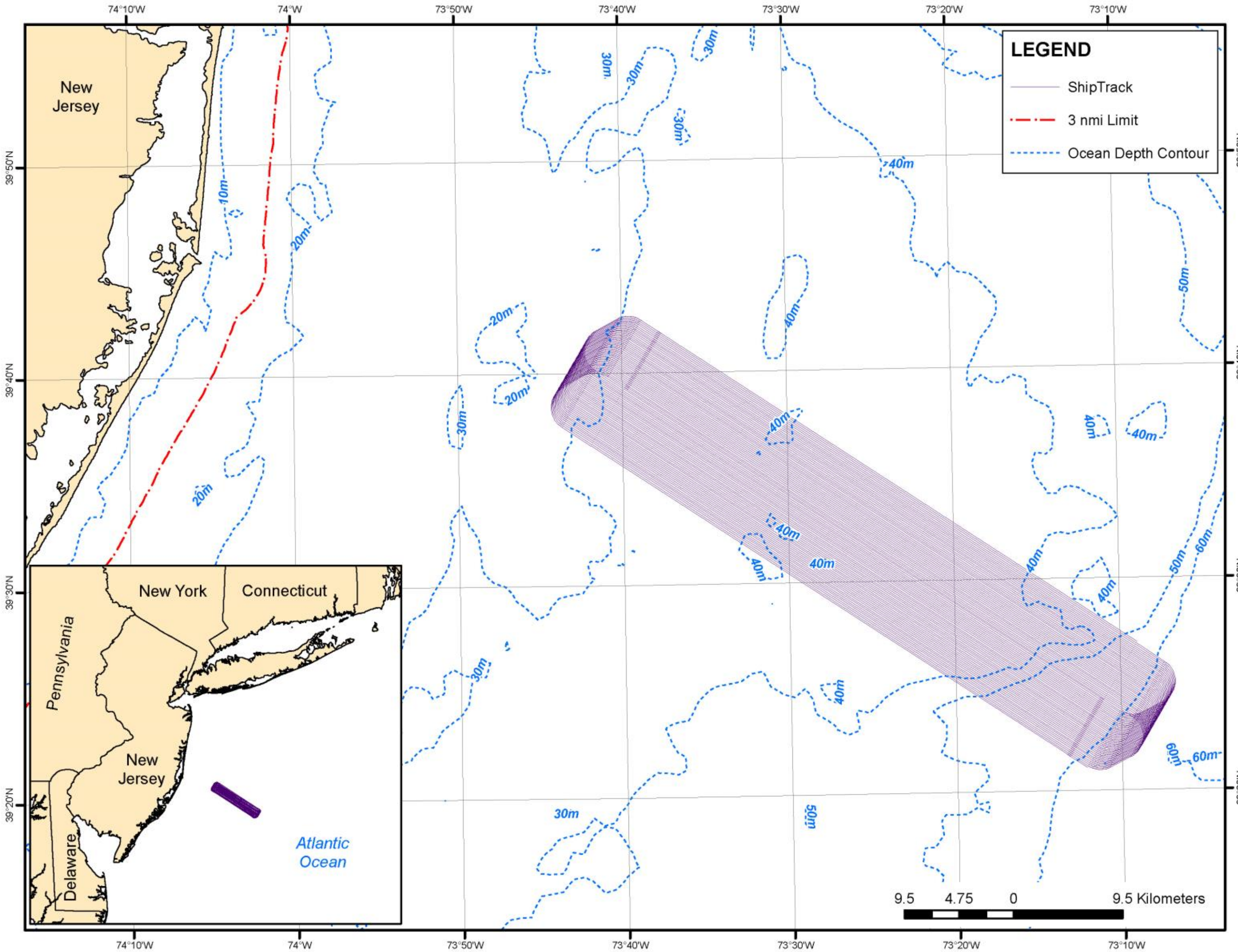

Figure 1. Location of the proposed seismic survey in the Atlantic Ocean off the coast of New Jersey.

The seismic survey would be conducted outside of state waters and within the U.S. EEZ, and is scheduled to occur for ~30 days during the effective period of the IHA, July to mid August 2014. Although the proposed survey area is near the NW Atlantic DAA described in the PEIS, it does not include intermediate- and deep-water depths.

(b) Description of the Activities

The procedures to be used for the survey would be similar to those used during previous seismic surveys by L-DEO and would use conventional seismic methodology. The survey would involve one source vessel, the R/V *Langseth*, which is owned by NSF and operated on its behalf by Columbia University's L-DEO through a Cooperative Agreement entered into in 2012, and one support vessel. The *Langseth* would deploy two pairs of subarrays of either 4 or 8 airguns as an energy source; the subarrays would fire alternately, with a total volume of ~700 in^3 or ~1400 in^3. The receiving system would consist of four 3000-m hydrophone streamers at 75-m spacing. As the airgun array is towed along the survey lines, the hydrophone streamers would receive the returning acoustic signals and transfer the data to the on-board processing system.

A total of ~4900 km of 3-D survey lines, including turns, would be shot in an area 12 x 50 km with a line spacing of 150 m in two 6-m wide race-track patterns (Fig. 1). There would be additional seismic operations in the survey area associated with airgun testing and repeat coverage of any areas where initial data quality is sub-standard. In our calculations [see § IV(3)], 25% has been added for those additional operations. The survey parameters noted here support the proposed research goals and therefore differ from the NW Atlantic DAA survey parameters presented in the PEIS.

In addition to the operations of the airgun array, a multibeam echosounder (MBES), a sub-bottom profiler (SBP), and an acoustic Doppler current profiler (ADCP) would also be operated from the *Langseth* continuously throughout the survey. All planned geophysical data acquisition activities would be conducted by L-DEO 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 with some personnel transfer on/off the *Langseth* by a small vessel.

(c) Schedule

The *Langseth* would depart from New York, NY, and spend ~8 h in transit to the proposed survey area. Setup, deployment, and streamer ballasting would take ~3 days. The seismic survey would take 30 days plus 2 contingency days, and the *Langseth* would spend one day for gear retrieval and transit back to Newark. The survey would be conducted within the effective period of the IHA, which would be from the date of issue thru August 17, 2014. Operations may be delayed or interrupted because of a variety of factors including equipment malfunctions and weather-related issues, but use of the airguns would not occur outside of the effective IHA period.

(d) Vessel Specifications

The R/V *Langseth* is described in § 2.2.2.1 of the PEIS. The vessel speed during seismic operations would be ~4.5 kt (~8.3 km/h).

The support vessel would be a multi-purpose offshore utility vessel similar to the *Northstar Commander*, which is 28 m long with a beam of 8 m and a draft of 2.6 m. It is powered by a twin-screw Volvo D125-E, with 450 hp for each screw.

(e) Airgun Description

During the survey, the airgun array to be used would be the full 4-string array with most of the airguns turned off (see § II 3(a) for an explanation of the source level selection). The active airguns would be either 4 airguns in one string or 8 airguns in two strings on the port side forming Source 1, and 4 airguns in one string or 8 airguns in two strings on the starboard side forming Source 2. These identical port and starboard sources would be operated in “flip-flop” mode, firing alternately as the ship progresses along the track, as is common for 3-D seismic data acquisition. Thus, the source volume would not exceed 700 in^3 or 1400 in^3 at any time. Whereas the full array is described and illustrated in § 2.2.3.1 of the PEIS, the smaller subarrays proposed for this survey are described further in Appendix A. The subarrays would be towed at a depth of 4.5 or 6 m. The shot interval would be ~5-6 s (~12.5 m). Because the choice of array size and tow depth would not be made until the survey, we have assumed the use of the 8-airgun array towed at 6 m for the impacts analysis and take estimate calculations, as that results in the farthest sound propagation. Mitigation zones have been calculated for both source levels and tow depths, however (see below and Appendix A, Table A2), and during operations the relevant mitigation zone would be applied.

(f) Additional Acoustical Data Acquisition Systems

Along with the airgun operations, three additional acoustical data acquisition systems would be operated during the survey, but not during transits: a multibeam echosounder (MBES), sub-bottom profiler (SBP), and an acoustic Doppler current profiler (ADCP). The ocean floor would be mapped with the Kongsberg EM 122 MBES and a Knudsen Chirp 3260 SBP. These sources are described in § 2.2.3.1 of the PEIS.

Currents would be measured with a Teledyne OS75 75-kHz ADCP. The ADCP is configured as a 4-beam phased array with a beam angle of 30°. The source level is proprietary information. The PEIS stated that ADCPs (makes and models not specified) had a maximum acoustic source level of 224 dB re 1µPa · m.

(3) Monitoring and Mitigation Measures

Standard monitoring and mitigation measures for seismic surveys are described in § 2.4.4.1 of the PEIS and are described to occur in two phases: pre-cruise planning and during operations. The following sections describe the efforts during both stages for the proposed actions.

(a) Planning Phase

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

1. Energy Source—Part of the considerations for the proposed survey was to evaluate whether the research objectives could be met with a smaller energy source than the full, 36-airgun, 6600-in^3 *Langseth* array, and it was decided that the scientific objectives could be met using an energy source comprising either 4 airguns (total volume 700 in^3 volume) or 8 airguns (total volume 1400 in^3), and towed at a depth of ~4.5 or 6 m. Two such subarrays of either 4 or 8 airguns would be used alternately (flip-flop mode); one would be towed on the port side, the other one on the starboard side. Thus, the source volume would not exceed 700 in^3 or 1400 in^3 at any time. Because the choice of subarray size and tow depth would not be made until the survey, we have assumed in the impacts analysis and take estimate calculations the use of the 8-airgun array towed at 6 m as that would result in the farthest sound propagation. Based on the research goals and current knowledge of the survey area environmental conditions, however, it is viewed most likely that only the smaller subarray (700 in^3) would be used. For the DAA off the coast of New Jersey included in the PEIS, the energy source level analyzed was a pair of 45/105-in^3 GI guns.

2. Survey Timing—The PIs worked with L-DEO and NSF to identify potential times to carry out the survey taking into consideration key factors such as environmental conditions (i.e., the seasonal presence of marine mammals, sea turtles, and seabirds), weather conditions, equipment, and optimal timing for other proposed seismic surveys using the *Langseth*. 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. Some migratory species are expected to be farther north at the time of the survey, so the survey timing is beneficial for those species.
3. Mitigation Zones—During the planning phase, mitigation zones for the proposed survey were calculated based on modeling by L-DEO for both the exclusion zone (EZ) and the safety zone; these zones are given in Table 1 and Appendix Table A2. A more detailed description of the modeling process used to develop the mitigation zones can be found in Appendix A. Received sound levels in deep water have been predicted by L-DEO for the two airgun arrays (4- and 8-airguns) and the single Bolt 1900LL 40-in^3 airgun that would be used during power downs. Scaling factors between those arrays and the 18-airgun, 3300-in^3 array, taking into account tow depth differences, were developed and applied to empirical data for the 18-airgun array in shallow water in the Gulf of Mexico from Diebold et al. (2010). Because the choice of array size and tow depth would not be made until the survey, the use of the 8-airgun array towed at 6 m is assumed in the impacts and take estimate analysis, as that results in the farthest sound propagation. During actual operations, however, the corresponding mitigation zone would be applied for the selected source level.

   Table 1 shows the 180-dB EZ and 160-dB "Safety Zone" (distances at which the rms sound levels are expected to be received) for the mitigation airgun and the 4- and 8-airgun subarrays. The 160 and 180-dB re 1 μPa_{rms} distances are the criteria currently specified by NMFS (2000) for cetaceans. Per the Biological Opinion (Appendix C), a 166-dB distance would be used for Level B takes for sea turtles. Per the IHA for this survey (Appendix D), the Exclusion Zone was increased by 3 dB (thus operational mitigation would be at the 177-dB isopleth), which adds ~50% to the power-down/shut-down radius; the IHA includes the new distances. The 180-dB distance has been used as the EZ for sea turtles, as required by NMFS in most other recent seismic projects per the IHAs. For operational purposes, however, the 177-dB isopleth would be observed for marine mammals, sea turtles, and foraging endangered and threatened sea birds.

   Southall et al. (2007) made detailed recommendations for new science-based noise exposure criteria. In December 2013, NOAA published draft guidance for assessing the effects of anthropogenic sound on marine mammals (NOAA 2013a), although at the time of preparation of this Final EA, the date of release of the final guidelines and how they will be implemented are unknown. As such, this Final EA has been 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), and Wright (2014).

   Enforcement of mitigation zones via power and shut downs would be implemented in the Operational Phase, as noted below.

(b) Operational Phase

Marine species, including marine mammals and sea turtles, are known to occur in the proposed survey 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. To minimize the likelihood that potential impacts could occur to the species and stocks, monitoring and mitigation

TABLE 1. Predicted distances in meters to which sound levels ≥180 and 160 dB re 1 μPa_{rms} would be received during the proposed 3-D survey off New Jersey, using either a 4-gun, 700-in^3 subset of 1 string (at 4.5- or 6-m tow depth), or an 8-gun, 1400-in^3 subset of two strings (at 4.5- or 6-m tow depth), and the 40-in^3 airgun during power-downs. Radii are based on scaling described in the text of Appendix A and Figures A1 to A6, and the assumption that received levels on an rms basis are, numerically, 10 dB higher than the SEL values.[1]

		Predicted RMS Radii (m)	
Source and Volume	Water Depth	180 dB	160 dB
4-airgun subarray (700 in^3) @ 4.5 m	<100 m	378	5240
4-airgun subarray (700 in^3) @ 6 m	<100 m	439	6100
8-airgun subarray (1400 in^3) @ 4.5 m	<100 m	478	6670
8-airgun subarray (1400 in^3) @ 6 m	<100 m	585	8150
Single Bolt airgun (40 in^3) @ 6 m	<100 m	73	995

measures proposed during the operational phase of the proposed activities, which are consistent with the PEIS and past IHA requirements, include:

1. monitoring by protected species visual observers (PSVOs) for marine mammals, sea turtles, and seabirds;
2. passive acoustic monitoring (PAM);
3. PSVO data and documentation;
4. mitigation during operations (speed or course alteration; power-down, shut-down, and ramp-up procedures; and special mitigation measures for rare species, species concentrations, and sensitive habitats).

The proposed operational mitigation measures are standard for all high energy seismic cruises, per the PEIS, and therefore are not discussed further here. Special mitigation measures were considered for this cruise. Although it is very unlikely that a North Atlantic right whale would be encountered, the airgun array would be shut down if one is sighted at any distance from the vessel because of its rarity and conservation status. It is also unlikely that concentrations of large whales would be encountered, but if so, they would be avoided.

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

[1] Sound sources are primarily described in sound pressure level (SPL) units. SPL is often referred to as rms or "root mean square" pressure, averaged over the pulse duration. Sound exposure level (SEL) is a measure of the received energy in a pulse and represents the SPL that would be measured if the pulse energy were spread evenly over a 1-s period.

species and stocks. Ultimately, survey operations would be conducted in accordance with all applicable U.S. federal regulations and IHA 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. 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 issue an IHA and do not conduct the research operations. If the research was not conducted, the "No Action" alternative would result in no disturbance to marine mammals due to the proposed activities. Although the No-Action Alternative is not considered a reasonable alternative because it does not meet the purpose and need for the Proposed Action, per CEQ regulations it is included and carried forward for analysis in § IV.

Alternatives Considered but Eliminated from Further Analysis

(1) Alternative E1: Alternative Location

The New Jersey (NJ) continental margin has for decades been recognized as among the best siliciclastic passive margins for elucidating the timing and amplitude of eustatic change during the "Ice House" period of Earth history, when glacioeustatic changes shaped continental margin sediment sections around the world. There is a fundamental need to constrain the complex forcing functions tying evolution and preservation of the margin stratigraphic record to base-level changes. This could be accomplished by following the transect strategy adopted by the international scientific ocean drilling community. This strategy involves integration of drilling results with seismic imaging. In keeping with this strategy, the proposed seismic survey would acquire a 3-D seismic volume encompassing the three existing IODP Expedition 313 (Exp313) drill sites on the inner-middle shelf of the NJ margin. Exp313, the latest chapter in the multi-decade Mid-Atlantic Transect, represents the scientific community's best opportunity to link excellently sampled and logged late Paleogene-Neogene prograding clinoforms to state-of-the-art 3-D images. Exp313 borehole data would provide lithostratigraphy, geochronology, and paleobathy-metry. 3-D seismic imaging would put these sampled records in a spatially accurate, stratigraphically meaningful context. Such imagery would allow researchers to map sequences around Exp313 sites with a resolution and confidence previously unattainable, and to analyze their spatio-temporal evolution.

No other scientific ocean drilling boreholes are available on the NJ shelf or elsewhere that provide such high sediment recoveries and high-quality well logs as those of Exp313. The need to tie the proposed 3-D survey to Exp313 drill sites means that it is not possible to conduct the survey in a different area. Also, positioning a 3-D volume requires broad coverage by pre-existing 2-D seismic data. Such data, collected over more than two decades, are readily available on the NJ shelf. Furthermore, the proposed research underwent the NSF merit review process, and the science, including the site location, was determined to be meritorious.

(2) Alternative E2: Use of Alternative Technologies

As described in § 2.6 of the PEIS, alternative technologies to the use of airguns were investigated to conduct high-energy seismic surveys. At the present time, these technologies are still not feasible, commercially viable, or appropriate to meet the Purpose and Need. NSF currently owns the *Langseth*, and its primary capability is to conduct seismic surveys.

Table 2 provides a summary of the proposed action, alternatives, and alternatives eliminated from further analysis.

Table 2. Summary of Proposed Action, Alternatives Considered, and Alternatives Eliminated

Proposed Action	Description
Proposed Action: Conduct a marine geophysical survey and associated activities in the Atlantic Ocean off New Jersey	Under this action, a 3-D seismic reflection survey is proposed. When considering transit; equipment deployment, maintenance, and retrieval; weather; marine mammal activity; and other contingencies, the proposed activities would be expected to be completed in ~35 days. The standard monitoring and mitigation measures identified in the NSF PEIS would apply and are described in further detail in this document (§ II [3]), along with any additional requirements identified by regulating agencies. All necessary permits and authorizations, including an IHA, were requested from regulatory bodies.
Alternatives	Description
Alternative 1: Alternative Survey Timing	Under this Alternative, L-DEO would conduct survey operations at a different time of the year. The standard monitoring and mitigation measures identified in the NSF PEIS would apply. These measures are described in further detail in this document (§ II [3]) and would apply to survey activities conducted during an alternative survey time period, along with any additional requirements identified by regulating agencies as a result of the change. 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. No permits and authorizations, including an IHA, would be requested from regulatory bodies, as the proposed action would not be conducted.
Alternatives Eliminated from Further Analysis	Description
Alternative E1: Alternative Location	The survey location has been specifically identified because of the data available for that location, including borehole data from three IODP Expedition 313 drill sites that would provide lithostratigraphy, geochronology, and paleobathymetry, and broad coverage by pre-existing 2-D seismic data. The proposed 3-D seismic imaging would put these sampled records in a spatially accurate, stratigraphically meaningful context. Such imagery would allow researchers to map sequences around the drill sites with a resolution and confidence previously unattainable, and to analyze their spatio-temporal evolution. Furthermore, the proposed science underwent the NSF merit review process, and the science, including the site location, was determined to be meritorious.
Alternative E2: Alternative Survey Techniques	Under this alternative, L-DEO would use alternative survey techniques, such as marine vibroseis, that could potentially reduce impacts on the marine environment. Alternative technologies were evaluated in the PEIS, § 2.6. At the present time, however, these technologies are still not feasible, commercially viable, or appropriate to meet the Purpose and Need. NSF currently owns the *Langseth*, and its primary capability is to conduct seismic surveys.

III. AFFECTED ENVIRONMENT

As described in the 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) has focused mainly on those related to marine biological resources, as the proposed short-term activities have the potential to impact marine biological resources within the Project area. These resources are identified in Section III, and the potential impacts to these resources are discussed in Section IV. Initial review and analysis of the proposed Project activities determined that the following resource areas did not require further analysis in this Final EA:

- *Air Quality/Greenhouse Gases*—Project 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;
- *Land Use*—All proposed activities would be in the marine environment. Therefore, no changes to current land uses or activities in the Project area would result from the proposed Project;
- *Safety and Hazardous Materials and Management*—No hazardous materials would be generated or used during proposed activities. All Project-related wastes would be disposed of in accordance with Federal and international requirements;
- *Geological Resources (Topography, Geology and Soil)*—The proposed Project would result in no displacement of soil and seafloor sediments. Proposed activities would not adversely affect geologic resources as no impacts would occur;
- *Water Resources*—No discharges to the marine environment are proposed within the Project area 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 impact 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. Because of the location of the proposed activity and distance from shore, human activities in the area around the survey vessel would be limited to SCUBA diving, commercial and recreational fishing activities and other vessel traffic. Fishing, SCUBA diving, vessel traffic, and potential impacts are described in further detail in § III and IV. Additionally, there is a marine mammal watching industry in New Jersey. Because of the distance from shore to the proposed survey site, it would be unlikely that marine mammal watching boat tours would coincide with the proposed survey site or be impacted by the proposed activities. Most activities are conducted within 14 mi of the coast, with the majority occurring closer inshore. Some boat tours occur south of the proposed survey area around Cape May and in Delaware Bay. Some dolphin watching cruises take place off Atlantic City fairly close to shore. Tours typically are ~1.5–3 h long. Although marine mammals around the seismic survey may avoid the vessel during operations, this behavior would be of short duration and temporary. Given the distance from shore to the proposed activities, the likely distance from any of the few marine mammal watching activities, and the short and temporary duration of any potential impacts to marine mammals, it would be unlikely that the marine mammal watching industry would be affected by the proposed activities and, therefore, this issue is not analyzed further in this assessment. No other socioeconomic impacts would be anticipated as a result of the proposed activities;
- *Visual Resources*—No visual resources would be anticipated to be negatively impacted as the area of operation is significantly outside of the land and coastal view shed; and
- *Cultural Resources*—With the following possible exceptions, there are no known cultural resources in the proposed Project area. Two shipwrecks, both known dive sites, are in or near the survey area (see Fig. 2in § III): the *Lillian* (Galiano 2009; Fisherman's Headquarters 2014; NOAA 2014) and the *Maurice Tracy* (DiveBuddy 2014). Shipwrecks are discussed further in §

IV. Airgun sounds would have no effects on solid structures; no significant impacts on shipwrecks would be anticipated (§ IV). No impacts to cultural resources would be anticipated.

Physical Environment and Oceanography

The water off the U.S. east coast consists of three water masses: coastal or shelf waters, slope waters, and the Gulf Stream. Coastal waters off Canada, which originate mostly in the Labrador Sea, move southward over the continental shelf until they reach Cape Hatteras, NC, where they are entrained between the Gulf Stream and slope waters. North of Cape Hatteras, an elongated cyclonic gyre of slope water that forms because of the southwest flow of coastal water and the northward flowing Gulf Stream is present most of the year and shifts seasonally relative to the position of the north edge of the Gulf Stream. Slope water eventually merges with the Gulf Stream water. The Gulf Stream flows through the Straits of Florida and then parallel to the continental margin, becoming stronger as it moves northward. It turns seaward near Cape Hatteras and moves northeast into the open ocean.

The shelf waters off New Jersey are part of the Mid-Atlantic Bight, which includes shelf waters from Cape Hatteras, NC, to southern Cape Cod. The shelf is dominated by a sandy to muddy-sandy bottom (Steimle and Zetlin 2000; USGS 2000 *in* DoN 2005). The shelf off New Jersey slopes gently and is relatively shallow. It ranges from 120–150 km in width, and the shelf break begins at a depth of 120–160 m (Carey et al. 1998 *in* GMI 2010). The shelf is bound by the Hudson Canyon in the north and the Wilmington Canyon in the south. Several smaller canyons also occur along the shelf edge. The Hudson Canyon is the largest canyon off the east coast of the U.S.

The shelf waters off New Jersey become stratified in the spring as the water warms, and are fully stratified throughout the summer, i.e., warmer, fresher water accumulates at the surface and denser, colder, more saline waters occur near the seafloor. The stratification breaks down in fall because of mixing by wind and surface cooling (Castelao et al. 2008). Summer upwelling occurs off New Jersey, where nutrient-rich cold water is brought closer to the surface and stimulates primary production (Glenn et al. 2004; NEFSC 2013a). The primary production of the northeast U.S. continental shelf is 1536 mg C/m^2/day (Sea Around Us 2013). The salinity of shelf water usually increases with depth and is generally lower than the salinity of water masses farther offshore primarily because of the low-salinity input from rivers and estuaries.

There are numerous artificial reefs in shelf waters off New Jersey, including materials such as decommissioned ships, barges, and reef balls or hollow concrete domes (Steimle and Zetlin 2000; Figley 2005); these reefs can provide nursery habitat, protection, and foraging sites to marine organisms. Since 1984, more than 3500 patch reefs have been constructed off New Jersey (Figley 2005).

Protected Areas

Several federal Marine Protected Areas (MPAs) or sanctuaries have been established north of the proposed survey area, primarily with the intention of preserving cetacean habitat (Hoyt 2005; CetaceanHabitat 2013). These include the Cape Cod Bay Northern Right Whale Critical Habitat Area, the Great South Channel Northern Right Whale Critical Habitat Area east of Cape Cod, the Gerry E Studds Stellwagen Bank National Marine Sanctuary in the Gulf of Maine, and Jeffrey's Ledge, a proposed extension to the Stellwagen Bank National Marine Sanctuary. The Monitor National Marine Sanctuary is located to the southeast of Cape Hatteras, North Carolina. There are also five state Ocean Sanctuaries in Massachusetts waters including Cape Cod, Cape Cod Bay, Cape and Islands, North Shore, and South Essex Ocean Sanctuaries (Mass.Gov 2013). These sanctuaries include most Massachusetts state waters except for the area east of Boston. In addition, three Canadian protected areas also occur in the Northwest Atlantic for cetacean habitat protection, including the Bay of Fundy Right Whale

Conservation Area, Roseway Basin Right Whale Conservation Area, and Gully Marine Protected Area off the Scotian Shelf. The proposed survey is not located within or near any federal, state, or international MPA or sanctuary.

The Harbor Porpoise Take Reduction Plan (HPTRP) is intended to reduce the interactions between harbor porpoises and commercial gillnets in four management areas: waters off New Jersey, Mudhole North, Mudhole South, and Southern Mid Atlantic (NOAA 2010b). The HPTRP is not relevant to this EA because harbor porpoises are not expected to occur in the survey area.

Marine Mammals

Thirty-one cetacean species (6 mysticetes and 25 odontocetes) could occur near the proposed survey site (Table 3). Six of the 31 species are listed under the U.S. Endangered Species Act (ESA) as ***Endangered***: the North Atlantic right, humpback, blue, fin, sei, and sperm whales. An additional four cetacean species, although present in the wider western North Atlantic Ocean, likely would not be found near the proposed survey area between ~39–40°N because their ranges generally do not extend as far north (Clymene dolphin, *Stenella clymene*; Fraser's dolphin, *Lagenodelphis hosei*; melon-headed whale, *Peponocephala electra*; and Bryde's whale, *Balaenoptera brydei*). Although the secondary range of the beluga whale (*Delphinapterus leucas*) may range as far south as New Jersey (Jefferson et al. 2008), and there have been at least two sightings off the coast of New Jersey (IOC 2013), this species is not included here as it is unlikely to be encountered during the proposed survey. Similarly, no pinnipeds are included; harp seals (*Pagophilus groenlandicus*) and hooded seals (*Cystophora cristata*) are rare in the proposed survey area, and gray (*Halichoerus grypus*) and harbor seals (*Phoca vitulina*) have a more northerly distribution during the summer (DoN 2005) and are therefore not expected to occur there during the survey. Information on grey, harbor, and harp seals is included in the NMFS EA for this project, and is incorporated into this Final EA by reference as is fully set forth herein (Appendix E).

General information on the taxonomy, ecology, distribution and movements, and acoustic capabilities of marine mammals are given in § 3.6.1 and § 3.7.1 of the PEIS. The proposed survey area off New Jersey is near one of the DAAs in the PEIS. The general distributions of mysticetes and odontocetes in this region of the Atlantic Ocean are discussed in § 3.6.2.1 and § 3.7.2.1 of the PEIS, respectively. Additionally, information on marine mammals in this region is included in § 4.2.2.1 of the Bureau of Ocean Energy Management (BOEM) Final PEIS for Atlantic OCS Proposed Geological and Geophysical Activities, Mid-Atlantic and South Atlantic Planning Areas (BOEM 2014). The rest of this section deals with more specific species distribution off the coast of New Jersey. For the sake of completeness, an additional six odontocetes that are expected to be rare or extralimital in the proposed survey area were included here but were not included in the PEIS.

The main sources of information used here are the 2010 and Draft 2013 U.S. Atlantic and Gulf of Mexico marine mammal stock assessment reports (SARs: Waring et al. 2010, 2013), the Ocean Biogeographic Information System (OBIS: IOC 2013), and the Cetacean and Turtle Assessment Program (CETAP 1982). The SARs include maps of sightings for most species from NMFS' Northeast and Southeast Fisheries Science Centers (NEFSC and SEFSC) surveys in summer 1995, 1998, 1999, 2002, 2004, 2006, 2007, 2008, 2010, and 2011. OBIS is a global database of marine species sightings. CETAP covered 424,320 km of trackline on the U.S. outer continental shelf from Cape Hatteras to Nova Scotia. Aerial and shipboard surveys were conducted over a 39-month period from 1 November 1978 to 28 January 1982. The mid-Atlantic area referred to in the following species accounts included waters south of Georges Bank down to Cape Hatteras, and from the coast out to ~1830 m depth.

TABLE 3. The habitat, occurrence, regional population sizes, and conservation status of marine mammals that could occur in or near the proposed survey area in the Northwest Atlantic Ocean off New Jersey.

Species	Habitat	Occurrence in survey area in summer	Regional/SAR abundance estimates[1]	ESA[2]	IUCN[3]	CITES[4]
Mysticetes						
North Atlantic right whale	Coastal and shelf	Rare	455 / 455[5]	EN	EN	I
Humpback whale	Mainly coastal, banks	Common	11,600[6] / 823[7]	EN	LC	I
Minke whale	Mainly coastal	Rare	138,000[8] / 20,741[9]	NL	LC	I
Sei whale	Mainly offshore	Uncommon	10,300[10] / 357[11]	EN	EN	I
Fin whale	Slope, pelagic	Uncommon	26,500[12] / 3522[5]	EN	EN	I
Blue whale	Coastal, shelf, pelagic	Rare	855[13] / 440[5]	EN	EN	I
Odontocetes						
Sperm whale	Pelagic	Common	13,190[14] / 2288[15]	EN	VU	I
Pygmy sperm whale	Off shelf	Uncommon	N.A. / 3785[16]	NL	DD	II
Dwarf sperm whale	Off shelf	Uncommon	N.A. / 3785[16]	NL	DD	II
Cuvier's beaked whale	Pelagic	Uncommon	N.A. / 6532[17]	NL	LC	II
Northern bottlenose whale	Pelagic	Rare	N.A. / N.A.	NL	DD	II
True's beaked whale	Pelagic	Rare	N.A. / 7092[17]	NL	DD	II
Gervais' beaked whale	Pelagic	Rare	N.A. / 7092[17]	NL	DD	II
Sowerby's beaked whale	Pelagic	Rare	N.A / 7092[17]	NL	DD	II
Blainville's beaked whale	Pelagic	Rare	N.A. / 7092[17]	NL	DD	II
Rough-toothed dolphin	Mainly pelagic	Rare	N.A. / 271[5]	NL	LC	II
Bottlenose dolphin	Coastal, offshore	Common	N.A / 89,080[18]	NL^	LC	II
Pantropical spotted dolphin	Mainly pelagic	Rare	N.A. / 3333[5]	NL	LC	II
Atlantic spotted dolphin	Mainly coastal	Common	N.A. / 44,715[5]	NL	DD	II
Spinner dolphin	Coastal, pelagic	Rare	N.A. / N.A.	NL	DD	II
Striped dolphin	Off shelf	Uncommon	N.A. / 54,807[5]	NL	LC	II
Short-beaked common dolphin	Shelf, pelagic	Common	N.A. / 173,486[5]	NL	LC	II
White-beaked dolphin	Shelf <200 m	Rare	10s–100s of 1000s[19] / 2003[5]	NL	LC	II
Atlantic white-sided dolphin	Shelf and slope	Uncommon	10s–100s of 1000s[20] / 48,819[5]	NL	LC	II
Risso's dolphin	Mainly shelf, slope	Common	N.A. /18,250[5]	NL	LC	II
False killer whale	Pelagic	Extralimital	N.A. / N.A.	NL	DD	II
Pygmy killer whale	Mainly pelagic	Rare	N.A. / N.A.	NL	DD	II
Killer whale	Coastal	Rare	N.A. / N.A.	NL*	DD	II
Long-finned pilot whale	Mainly pelagic	Uncommon	780K[21] / 26,535[5]	NL[†]	DD	II
Short-finned pilot whale	Mainly pelagic	Uncommon	780K[21] / 21,515[5]	NL	DD	II
Harbor porpoise	Coastal	Rare	~500K[22] / 79,883[23]	NL	LC	II

N.A. = Data not available or species status was not assessed.

[1] SAR (stock assessment report) abundance estimates are from the 2012 U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments (Waring et al. 2013) as noted, and regional abundance estimates are for the North Atlantic regions as noted.

[2] U.S. Endangered Species Act; EN = Endangered, NL = Not listed

[3] Codes for IUCN classifications from IUCN Red List of Threatened Species (IUCN 2013): EN = Endangered; VU = Vulnerable; LC = Least Concern; DD = Data Deficient

[4] Convention on International Trade in Endangered Species of Wild Fauna and Flora (UNEP-WCMC 2013): Appendix I = Threatened with extinction; Appendix II = not necessarily now threatened with extinction but may become so unless trade is closely controlled

[5] Estimate for the Western North Atlantic Stock (Waring et al. 2013)

[6] Best estimate for the western North Atlantic in 1992–1993 (IWC 2013)

[7] Minimum estimate for the Gulf of Maine stock (Waring et al. 2013)

[8] Best estimate for the North Atlantic in 2002–2007 (IWC 2013)

[9] Estimate for the Canadian East Coast Stock (Waring et al. 2013)
[10] Estimate for the Northeast Atlantic in 1989 (Cattanach et al. 1993)
[11] Estimate for the Nova Scotia Stock (Waring et al. 2013)
[12] Best estimate for the North Atlantic in 2007 (IWC 2013)
[13] Estimate for the central and northeast Atlantic in 2001 (Pike et al. 2009)
[14] Estimate for the North Atlantic (Whitehead 2002)
[15] Estimate for the North Atlantic Stock (Waring et al. 2013)
[16] Combined estimate for pygmy and dwarf sperm whales (Waring et al. 2013)
[17] Combined estimate for *Mesoplodon* spp. (Waring et al. 2013)
[18] Combined estimate for the Western North Atlantic Offshore Stock and the Northern Migratory Coastal Stock (Waring et al. 2013)
[19] High tens to low hundreds of thousands in the North Atlantic (Reeves et al. 1999a)
[20] Tens to low hundreds of thousands in the North Atlantic (Reeves et al. 1999b)
[21] Estimate for both long- and short-finned pilot whales in the central and eastern North Atlantic in 1989 (IWC 2013)
[22] Estimate for the North Atlantic (Jefferson et al. 2008)
[23] Estimate for the Gulf of Maine/Bay of Fundy Stock (Waring et al. 2013)
* Killer whales in the eastern Pacific Ocean, near Washington state, are listed as endangered under the U.S. ESA but not in the Atlantic Ocean.
^ The Western North Atlantic Coastal Morphotype stocks, ranging from NJ to FL, are listed as depleted under the U.S. Marine Mammal Protection Act, as are some other stocks to the south of the proposed survey area.
† Considered a strategic stock.

(1) Mysticetes

North Atlantic Right Whale (*Eubalaena glacialis*)

The North Atlantic right whale is known to occur primarily in the continental shelf waters off the eastern U.S. and Canada, from Florida to Nova Scotia (Winn et al. 1986; Jefferson et al. 2008). There are five well-known habitats in the northwest Atlantic used annually by right whales (Winn et al. 1986; NMFS 2005). These include the winter calving grounds in coastal waters of the southeastern U.S. (Florida/Georgia); spring feeding grounds in the Great South Channel (east of Cape Cod); late winter/spring feeding grounds and nursery grounds in Massachusetts Bay and Cape Cod Bay; summer/fall feeding and nursery grounds in the Bay of Fundy; and summer/fall feeding grounds on the Nova Scotian Shelf. In addition, Jeffreys Ledge, off the coast of northern Massachusetts, New Hampshire, and Maine, could be an important fall feeding area for right whales and an important nursery area during summer, especially in July and August (Weinrich et al. 2000). The first three habitats were designated as Critical Habitat Areas by NMFS (1994).

There is a general seasonal north-south migration of the North Atlantic population between feeding and calving areas, but right whales could be seen anywhere off the Atlantic U.S. throughout the year (Gaskin 1982). The seasonal occurrence of right whales in mid Atlantic waters is mostly between November and April, with peaks in December and April (Winn et al. 1986) when whales transit through the area on their migrations to and from breeding grounds or feeding grounds. The migration route between the Cape Cod summer feeding grounds and the Georgia/Florida winter calving grounds, known as the mid-Atlantic corridor, has not been considered to include "high use" areas, yet the whales clearly 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).

North Atlantic right whales are found commonly on the northern feeding grounds off the north-eastern U.S. during early spring and summer. The highest abundance in Cape Cod Bay is in February and April (Winn et al. 1986; Hamilton and Mayo 1990) and from April to June in the Great South Channel east of Cape Cod (Winn et al. 1986; Kenney et al. 1995). Throughout the remainder of summer and into fall (June–November), they are most commonly seen farther north on feeding grounds in Canadian waters, with peak abundance during August, September, and early October (Gaskin 1987). Morano et al. (2012) and Mussoline et al. (2012) indicated that right whales are present in the southern Gulf of Maine year-round and that they occur there over longer periods than previously thought.

Some 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 upon 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).

Knowlton et al. (2002) provided an extensive and detailed analysis of survey data, satellite tag data, whale strandings, and opportunistic sightings along State waters of the mid-Atlantic migratory corridor[2], from the border of Georgia/South Carolina to south of New England, including waters in the proposed seismic survey area, spanning the period from 1974 to 2002. The majority of sightings (94%) along the migration corridor were within 56 km of shore, and more than half (64%) were within 18.5 km of shore (Knowlton et al. 2002). Water depth preference was for shallow waters; 80% of all sightings were in depths <27 m, and 93% were in depths <45 m (Knowlton et al. 2002). Most sightings >56 km from shore occurred at the northern end of the corridor, off New York and south of New England. North of Cape Hatteras, most sightings were reported for March–April. Sighting data analyzed by Winn et al. (1986) dating back to 1965 showed that the occurrence of right whales in the mid Atlantic, including the proposed survey area, peaked in April and December (Winn et al. 1986). A review of the mid-Atlantic whale sighting and tracking data archive from 1974 to 2002 showed right whale sightings off the coast of New Jersey throughout the year, except during May–June, August, and November (Beaudin Ring 2002).

The Interactive North Atlantic Right Whale Sighting Map showed 32 sightings in the shelf waters off New Jersey between 2006 and 2012 (NEFSC 2013b). Two of these sightings occurred just to the north of the proposed survey site. Three sightings were made in June, and none were made in July. However, two sightings were made during July to the far east of the proposed survey area (NEFSC 2013b). There are also at least eight sightings of right whales off New Jersey in the Ocean Biogeographic Information System (OBIS; IOC 2013), which were made during the 1978–1982 Cetacean and Turtle Assessment Program (CETAP) surveys (CETAP 1982).

Palka (2006) reviewed North Atlantic right whale density in the U.S. Navy NE Operating Area based on summer abundance surveys conducted during 1998–2004. One of the lowest whale densities (including right whales) was found in the mid-Atlantic stratum, which includes the proposed survey area. However, survey effort for this stratum was also the lowest; only two surveys were conducted. No right whales were sighted.

Whitt et al. (2013) surveyed for right whales off the coast of New Jersey using acoustic and visual techniques from January 2008 to December 2009. Whale calls were detected off New Jersey year-round and four sightings were made: one in November, one in December, one in January just to the west of the survey area, and one cow-calf pair in May. In light of these findings, Whitt et al. (2013) suggested expanding the existing critical habitat to include waters of the mid-Atlantic. NMFS (2010) previously noted that such a revision could be warranted, but no revisions have been made to the critical habitat yet.

---

[2] Multi-year datasets for the analysis were provided by the New England Aquarium, North Atlantic Right Whale Consortium, Oregon State University, Coastwise Consulting Inc., Georgia Department of Natural Resources, University of North Carolina Wilmington, Continental Shelf Associates, CETAP, NOAA, and University of Rhode Island.

Federal and Other Action.—In 2002, NMFS received a petition to revise and expand the designation of critical habitat for the North Atlantic right whale. The revision was declined and the critical habitat designated in 1994 remained in place (NMFS 2005). Another petition for a revision to the critical habitat was received in 2009 that sought to expand the currently designated critical feeding and calving habitat areas and include a migratory corridor as critical habitat (NMFS 2010). NMFS noted that the requested revision may be warranted, but no revisions have been made as of June 2014. The designation of critical habitat does not restrict activities within the area or mandate any specific management action. However, actions authorized, funded, or carried out by Federal agencies that may have an impact on critical habitat must be consulted upon in accordance with Section 7 of the ESA, regardless of the presence of right whales at the time of impacts. Impacts on these areas that could affect primary constituent elements such as prey availability and the quality of nursery areas must be considered when analyzing whether habitat may be adversely modified.

A number of other actions have been taken to protect North Atlantic right whales, including establishing the Right Whale Sighting Advisory System designed to reduce collisions between ships and right whales by alerting mariners to the presence of the whales (see NEFSC 2012); a Mandatory Ship Reporting System implemented by the U.S. Coast Guard in the right whale nursery and feeding areas (USCG 1999, 2001; Ward-Geiger et al. 2005); recommended shipping routes in key right whale aggregation areas (NOAA 2006, 2007, 2013b); regulations to implement seasonal mandatory vessel speed restrictions in specific locations (Seasonal Management Areas or SMAs) during times when whales are likely present, including ~37 km around points near the Ports of New York/New Jersey (40.495ºN, 73.933ºW) and Philadelphia and Wilmington (38.874ºN, 75.026ºW) during 1 November–30 April (NMFS 2008); temporary Dynamic Management Areas (DMAs) in response to actual whale sightings, requiring gear modifications to traps/pots and gillnets in areas north of 40°N with unexpected right whale aggregations (NOAA 2012a); and a voluntary seasonal (April 1 to July 31) Area to be Avoided in the Great South Channel off Massachusetts (NOAA 2013b). Furthermore, in its Final PEIS (BOEM 2014), BOEM proposed that no seismic surveys would be authorized within right whale critical habitat from 15 November to April 15, nor within the Mid-Atlantic and Southeast U.S. SMAs from 1 November to 30 April 30. Additionally, G&G seismic surveys would not be allowed in active DMAs. The proposed survey area is not in any of these areas.

North Atlantic right whales likely would not be encountered during the proposed survey.

Humpback Whale (*Megaptera novaeangliae*)

In the North Atlantic, a Gulf of Maine stock of the humpback whale is recognized off the northeastern U.S. coast as a distinct feeding stock (Palsbøll et al. 2001; Vigness-Raposa et al. 2010). Whales from this stock feed during spring, summer, and fall in areas ranging from Cape Cod to Newfoundland. In the spring, greatest concentrations of humpback whales occur in the western and southern edges of the Gulf of Maine. During summer, the greatest concentrations are found throughout the Gulf of Maine, east of Cape Cod, and near the coast from Long Island to northern Virginia. Similar distribution patterns are seen in the fall, although sightings south of Cape Cod Bay are less frequent than those near the Gulf of Maine. From December to March, there are few occurrences of humpback whales over the continental shelf of the Gulf of Maine, and in Cape Cod and Massachusetts Bay (Clapham et al. 1993; Fig. B-5a *in* DoN 2005).

GMI (2010) reported 17 sightings of humpback whales during surveys conducted in shallow water (<30 m) on the continental shelf off New Jersey in January 2008–December 2009, with sightings during every season (including 1 in spring and 4 in summer[3]). There are >40 OBIS sighting records of humpback whales for the continental shelf off New Jersey, including sightings near the proposed survey area (IOC 2013).

Common Minke Whale (*Balaenoptera acutorostrata*)

Four populations of the minke whale are recognized in the North Atlantic, including the Canadian East Coast stock that ranges from the eastern U.S. coast to Davis Strait (Waring et al. 2013). Minke whales are common off the U.S. east coast over continental shelf waters, especially off New England during spring and summer (CETAP 1982). Seasonal movements in the Northwest Atlantic are apparent, with animals moving south and offshore from New England waters during the winter (Fig. B-11a *in* DoN 2005; Waring et al. 2013). There are approximately 30 OBIS sightings of minke whales off New Jersey (IOC 2013), most of which were observed in the spring and summer during CETAP surveys (CETAP 1982).

GMI (2010) reported four sightings of minke whales during surveys conducted in shallow water (<30 m) on the continental shelf off New Jersey in January 2008–December 2009: two during winter and two during spring. Two sightings were also reported during summer NEFSC and SEFSC surveys between 1998 and 2011 on the shelf break off New Jersey (Waring et al. 2013). Minke whales likely would not be encountered during the proposed survey.

Sei Whale (*Balaenoptera borealis*)

Two stocks of the sei whale are recognized in the North Atlantic: the Labrador Sea Stock and the Nova Scotia Stock; the latter has a distribution that includes continental shelf waters from the northeastern U.S. to areas south of Newfoundland (Waring et al. 2013). The southern portion of the Nova Scotia stock's range includes the Gulf of Maine and Georges Bank during spring and summer (Waring et al. 2013). Peak sightings occur in spring and are concentrated along the eastern edge of Georges Bank into the Northeast Channel and the southwestern edge of Georges Bank (Fig. B-6a *in* DoN 2005; Waring et al. 2013). Mitchell and Chapman (1977) suggested that this stock moves from spring feeding grounds on or near Georges Bank to the Scotian Shelf in June and July, eastward to Newfoundland and the Grand Banks in late summer, back to the Scotian Shelf in fall, and offshore and south in winter. During summer and fall, most sei whale sightings occur in feeding grounds in the Bay of Fundy and on the Scotian Shelf; sightings south of Cape Cod are rare (Fig. B-6a *in* DoN 2005).

There are at least three OBIS sightings of sei whales off New Jersey, and several more sightings to the south of the proposed survey area (IOC 2013). Palka (2012) reported one sighting on the shelf break off New Jersey in water depths ranging from 100–2000 m during June–August 2011 surveys. There were no sightings of sei whales during the CETAP surveys (CETAP 1982).

Fin Whale (*Balaenoptera physalus*)

Fin whales are present in U.S. shelf waters during winter, and are sighted more frequently than any other large whale at this time (DoN 2005). They occur year-round in shelf waters of New England and New Jersey (CETAP 1982; Fig. B-8a *in* DoN 2005). Winter sightings are most concentrated around Georges Bank and in Cape Cod Bay. During spring and summer, most fin whale sightings are north of 40ºN, with smaller numbers on the shelf south of there, including off New Jersey (Fig. B-8a *in* DoN 2005). During fall, almost all fin whales move out of U.S. waters to feeding grounds in the Bay of Fundy

[3] GMI defined spring as 11 April–21 June and summer as 22 June–27 September.

and on the Scotian Shelf, remain at Stellwagen Bank and Murray Basin (Fig. B-8a *in* DoN 2005), or begin a southward migration (Clark 1995).

GMI (2010) reported 37 sightings of fin whales during surveys conducted in shallow water (<30 m) on the continental shelf off New Jersey in January 2008–December 2009, with sightings during every season (including 11 in spring and 4 in summer). Acoustic detections were also made during all seasons (GMI 2010). Numerous sightings were also made off New Jersey during NEFSC and SEFSC summer surveys between 1995 and 2011, with two sightings on the shelf and other sightings on the shelf break and beyond (Waring et al. 2013). There are 170 OBIS sightings of fin whales off New Jersey (IOC 2013), most of which were made during the CETAP surveys (CETAP 1982).

Blue Whale (*Balaenoptera musculus*)

In the western North Atlantic, the distribution of the blue whale extends as far north as Davis Strait and Baffin Bay (Sears and Perrin 2009). Little is known about the movements and wintering grounds of the stocks (Mizroch et al. 1984). Acoustic detection of blue whales using the U.S. Navy's Sound Surveillance System (SOSUS) program has tracked blue whales throughout most of the North Atlantic, including deep waters east of the U.S. Atlantic EEZ and subtropical waters north of the West Indies (Clark 1995).

Wenzel et al. (1988) reported the occurrence of three blue whales in the Gulf of Maine in 1986 and 1987, which were the only reports of blue whales in shelf waters from Cape Hatteras to Nova Scotia. Several other sightings for the waters off the east coast of the U.S. were reported by DoN (2005). Wenzel et al. (1988) suggested that it is unlikely that blue whales occur regularly in the shelf waters off the U.S. east coast. Similarly, Waring et al. (2010) suggested that the blue whale is, at best, an occasional visitor in the U.S. Atlantic EEZ.

During CETAP surveys, the only two sightings of blue whales were made south of Nova Scotia (CETAP 1982). There are two offshore sightings of blue whales in the OBIS database to the southeast of New Jersey and several sightings to the north off New England and in the Gulf of Maine (IOC 2013). Blue whales likely would not be encountered during the proposed survey.

(2) Odontocetes

Sperm Whale (*Physeter macrocephalus*)

In the northwest Atlantic, the sperm whale generally occurs in deep water along the continental shelf break from Virginia to Georges Bank, and along the northern edge of the Gulf Stream (Waring et al. 2001). Shelf edge, oceanic waters, seamounts, and canyon shelf edges are also predicted habitats of sperm whales in the Northwest Atlantic (Waring et al. 2001). Off the eastern U.S. coast, they are also known to concentrate in regions with well-developed temperature gradients, such as along the edges of the Gulf Stream and warm core rings, which may aggregate their primary prey, squid (Jaquet 1996).

Sperm whales appear to have a well-defined seasonal cycle in the Northwest Atlantic. In winter, most historical records are in waters east and northeast of Cape Hatteras, with few animals north of 40ºN; in spring, they shift the center of their distribution northward to areas east of Delaware and Virginia, but they are widespread throughout the central area of the Mid-Atlantic Bight and southern tip of Georges Bank (Fig. B-10a in DoN 2005; Waring et al. 2013). During summer, they expand their spring distribution to include areas east and north of Georges Bank, the Northeast Channel, and the continental shelf south of New England (inshore of 100 m deep). By fall, sperm whales are most common south of New England on the continental shelf but also along the shelf edge in the Mid-Atlantic Bight (Fig. B-10a in DoN 2005; Waring et al. 2013).

There are several hundred OBIS records of sperm whales in deep waters off New Jersey and New England (IOC 2013), and numerous sightings were reported on and seaward of the shelf break during CETAP surveys (CETAP 1982) and during summer NEFSC and SEFSC surveys between 1998 and 2011 (Waring et al. 2013).

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

In the northwest Atlantic, both pygmy and dwarf sperm whales are thought to occur as far north as the Canadian east coast, with the pygmy sperm whale ranging as far as southern Labrador; both species prefer deep, offshore waters (Jefferson et al. 2008). Between 2006 and 2010, 127 pygmy and 32 dwarf sperm whale strandings were recorded from Maine to Puerto Rico, mostly off the southeastern U.S. coast; five strandings of pygmy sperm whales were reported for New Jersey (Waring et al. 2013).

There are 14 OBIS sightings of pygmy or dwarf sperm whales in offshore waters off New Jersey (IOC 2013). Several sightings of *Kogia* sp. (pygmy or dwarf sperm whales) for shelf-break waters off New Jersey were also reported during summer NEFSC and SEFSC surveys between 1995 and 2011 (Waring et al. 2013).

Cuvier's Beaked Whale (*Ziphius cavirostris*)

In the northwest Atlantic, Cuvier's beaked whale has stranded and been sighted as far north as the Nova Scotian shelf, and occurs most commonly from Massachusetts to Florida (MacLeod et al. 2006). Most sightings in the northwest Atlantic occur in late spring or summer, particularly along the continental shelf edge in the mid-Atlantic region (CETAP 1982; Waring et al. 2001, 2013). Mapping of combined beaked whale sightings in the northwest Atlantic suggests that beaked whales are rare in winter and fall, uncommon in spring, and abundant in summer in waters north of Virginia, off the shelf break and over the continental slope and areas of high relief, including the waters off New Jersey (Fig. B-13a *in* DoN 2005).

DoN mapped several sightings of Cuvier's beaked whales during the summer along the shelf break off New Jersey (Fig. B-13a *in* DoN 2005). One sighting was made off New Jersey during the CETAP surveys (CETAP 1982). Palka (2012) reported one sighting on the shelf break off New Jersey in water depths 100–2000 m during June–August 2011 surveys. There are eight OBIS sighting records of Cuvier's beaked whale in offshore waters off New Jersey (IOC 2013).

Northern Bottlenose Whale (*Hyperoodon ampullatus*)

Northern bottlenose whales are considered extremely uncommon or rare within waters of the U.S. Atlantic EEZ (Reeves et al. 1993; Waring et al. 2010), but there are known sightings off New England and New Jersey (CETAP 1982; McLeod et al. 2006; Waring et al. 2010). Two sightings of three individuals were made during the CETAP surveys; one sighting was made during May to the east of Cape Cod and the second sighting was made on 12 June along the shelf edge east of Cape May, New Jersey (CETAP 1982). Three sightings were made during summer surveys along the southern edge of Georges Bank in 1993 and 1996, and another three sightings were made in water depths 1000–4000 m at ~38–40ºN during NEFSC and SEFSC surveys between 1998 and 2006 (Waring et al. 2010). In addition, there is one OBIS sighting off New England in 2005 made by the Canadian Department of Fisheries and Oceans (IOC 2013). DoN (2005) also reported northern bottlenose whale sightings beyond the shelf break off New Jersey during spring and summer. Northern bottlenose whales likely would not be encountered during the proposed survey.

True's Beaked Whale (*Mesoplodon mirus*)

In the Northwest Atlantic, True's beaked whale occurs from Nova Scotia to Florida and the Bahamas (Rice 1998). Carwardine (1995) suggested that this species could be associated with the Gulf

Stream. DoN did not report any sightings of True's beaked whale off New Jersey (Fig. B-13a *in* DoN 2005); however, several sightings of undifferentiated beaked whales were reported for shelf break waters off New Jersey during summer NEFSC and SEFSC surveys between 1995 and 2011 (Waring et al. 2013). There are no OBIS sightings of True's beaked whale off New Jersey, but there is one stranding record off North Carolina and one record off New England (IOC 2013). There are numerous other stranding records for the east coast of the U.S. (Macleod et al. 2006). True's beaked whales likely would not be encountered during the proposed survey.

Gervais' Beaked Whale (*Mesoplodon europaeus*)

Based on stranding records, Gervais' beaked whale appears to be more common in the western Atlantic than in the eastern Atlantic (Macleod et al. 2006; Jefferson et al. 2008). Off the U.S. east coast, it occurs from Cape Cod Bay, Massachusetts (Moore et al. 2004) to Florida, with a few records in the Gulf of Mexico (Mead 1989). DoN mapped two sightings of Gervais' beaked whale during summer to the south of the proposed survey area and numerous other sightings along the shelf break off the northeast coast of the U.S. (Fig. B-13a *in* DoN 2005). Palka (2012) reported three sightings in deep offshore waters during June–August 2011 surveys off the northeastern coast of the U.S. There are four OBIS stranding records of Gervais' beaked whale for Virginia, but no records for New Jersey (IOC 2013). Gervais' beaked whales likely would not be encountered during the proposed survey.

Sowerby's Beaked Whale (*Mesoplodon bidens*)

Sowerby's beaked whale occurs in cold temperate waters of the North Atlantic (Mead 1989). In the western North Atlantic, it is found from at least Massachusetts to the Labrador Sea (Mead et al. 2006; Jefferson et al. 2008). Palka (2012) reported one sighting on the shelf break off New Jersey during June–August 2011 surveys. There are also at least five OBIS sighting records in deep waters off New Jersey (IOC 2013). DoN mapped one stranding in New Jersey in fall and one in Delaware in spring, but no sightings off New Jersey (Fig. B-13a *in* DoN 2005). Sowerby's beaked whales likely would not be encountered during the proposed survey.

Blainville's Beaked Whale (*Mesoplodon densirostris*)

In the western North Atlantic, Blainville's beaked whale is found from Nova Scotia to Florida, the Bahamas, and the Gulf of Mexico (Würsig et al. 2000). There are numerous strandings records along the east coast of the U.S. (Macleod et al. 2006). DoN mapped several sightings of Blainville's beaked whale during summer along the shelf break off the northeastern coast of the U.S. (Fig. B-13a *in* DoN 2005). There is one OBIS sighting record in offshore waters to the southeast of New Jersey and one in offshore waters off New England (IOC 2013). Blainville's beaked whales likely would not be encountered during the proposed survey.

Rough-toothed Dolphin (*Steno bredanensis*)

The rough-toothed dolphin is distributed worldwide in tropical, subtropical, and warm temperate waters (Miyazaki and Perrin 1994). They are generally seen in deep, oceanic water, although they can occur in shallow coastal waters in some locations (Jefferson et al. 2008). The rough-toothed dolphin rarely ranges north of 40°N (Jefferson et al. 2008).

One sighting of 45 individuals was made south of Georges Bank seaward of the shelf edge during the CETAP surveys (CETAP 1982), and another sighting was made in the same areas during 1986 (Waring et al. 2010). In addition, two sightings were made off New Jersey to the southeast of the proposed survey area during 1979 and 1998 (Waring et al. 2010; IOC 2013). Palka (2012) reported a sighting in deep offshore waters off New Jersey during June–August 2011 surveys. Rough-toothed dolphins likely would not be encountered during the proposed survey.

Common Bottlenose Dolphin (*Tursiops truncatus*)

In the northwest Atlantic, the common bottlenose dolphin occurs from Nova Scotia to Florida, the Gulf of Mexico and the Caribbean, and south to Brazil (Würsig et al. 2000). There are regional and seasonal differences in the distribution of the offshore and coastal forms of bottlenose dolphins off the U.S. east coast. Although strandings of bottlenose dolphins are a regular occurrence along the U.S. east coast, since July 2013, an unusually high number of dead or dying bottlenose dolphins (971 as of 8 December 2013; 1175 as of 16 March 2014; 1219 as of 13 April 3014; and 1283 as of 18 May 2014) have washed up on the mid-Atlantic coast from New York to Florida (NOAA 2013c). NOAA declared an unusual mortality event (UME), the tentative cause of which is thought to be cetacean morbillivirus. As of 8 December 2013, 163 of 174 dolphins tested (215 of 225 as of 18 May 2014) were confirmed positive or suspect positive for morbillivirus. NOAA personnel observed that the affected dolphins occur in nearshore waters, whereas dolphins in offshore waters >50 m deep did not appear to be affected (Environment News Service 2013), but have stated that it is uncertain exactly what populations have been affected (NOAA 2013c). In addition to morbillivirus, the bacteria *Brucella* was confirmed in 12 of 51 dolphins tested (NOAA 2013c). The NOAA web site is updated frequently, and it is apparent that the strandings have been moving south; in the 4 November update, dolphins had been reported washing up only as far south as South Carolina, and in the 8 December update, strandings were also reported in Georgia and Florida.

Evidence of year-round or seasonal residents and migratory groups exist for the coastal form of bottlenose dolphins, with the so-called “northern migratory management unit” occurring north of Cape Hatteras to New Jersey, but only during summer and in waters <25 m deep (Waring et al. 2010). The offshore form appears to be most abundant along the shelf break and is differentiated from the coastal form by occurring in waters typically >40 m deep (Waring et al. 2010). Bottlenose dolphin records in the Northwest Atlantic suggest that they generally can occur year-round from the continental shelf to deeper waters over the abyssal plain, from the Scotian Shelf to North Carolina (Fig. B-14a *in* DoN 2005).

GMI (2010) reported 319 sightings of bottlenose dolphins during surveys conducted in shallow water (<30 m) on the continental shelf off New Jersey in January 2008–December 2009, with most sightings made during spring and summer. Palka (2012) also reported numerous sightings on the shelf break off New Jersey in water depths ranging from 100–2000 m during June–August 2011 surveys. There are also several hundred OBIS records off New Jersey, including sightings near the proposed survey area on the shelf and along the shelf edge (IOC 2013).

Pantropical Spotted Dolphin (*Stenella attenuata*)

Pantropical spotted dolphins generally occur in deep offshore waters between 40°N and 40°S (Jefferson et al. 2008). There have been a few sightings at the southern edge of Georges Bank (Waring et al. 2010). In addition, there are at least 10 OBIS sighting records for waters off New Jersey that were made during surveys by the Canadian Wildlife Service between 1965 and 1992 (IOC 2013). Pantropical spotted dolphins likely would not be encountered during the proposed survey.

Atlantic Spotted Dolphin (*Stenella frontalis*)

In the western Atlantic, the distribution of the Atlantic spotted dolphin extends from southern New England, south to the Gulf of Mexico, the Caribbean Sea, Venezuela, and Brazil (Leatherwood et al. 1976; Perrin et al. 1994; Rice 1998). During summer, Atlantic spotted dolphins are sighted in shelf waters south of Chesapeake Bay, and near the continental shelf edge, on the slope, and offshore north of there, including the waters of New Jersey (Fig. B-15a *in* DoN 2005; Waring et al. 2013). Several sightings were also reported during summer NEFSC and SEFSC surveys between 1998 and 2011 on the shelf break off New Jersey (Waring et al. 2013). There are two OBIS sighting records northeast of the survey area and at least eight records to the southeast of the survey area (IOC 2013).

Spinner dolphin (*Stenella longirostris*)

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). Several sightings were mapped by DoN (Fig. B-16 *in* DoN 2005) for offshore waters to the far east of New Jersey. There are also seven OBIS sighting records off the eastern U.S. but no records near the proposed survey area or in shallow water (IOC 2013). Spinner dolphins likely would not be encountered during the proposed survey.

Striped Dolphin (*Stenella coeruleoalba*)

In the western North Atlantic, the striped dolphin occurs from Nova Scotia to the Gulf of Mexico and south to Brazil (Würsig et al. 2000). Off the northeastern U.S. coast, striped dolphins occur along the continental shelf edge and over the continental slope from Cape Hatteras to the southern edge of Georges Bank (Waring et al. 2013). In all seasons, striped dolphin sightings have been centered along the 1000-m depth contour, and sightings have been associated with the north edge of the Gulf Stream and warm core rings (Waring et al. 2013). Their occurrence off the northeastern U.S. coast seems to be highest in the summer and lowest during the fall (Fig. B-17a *in* DoN 2005).

There are approximately 100 OBIS sighting records of striped dolphins for the waters off New Jersey to the east of the proposed survey area, mainly along the shelf break (IOC 2013). Numerous sightings were also reported during summer NEFSC and SEFSC surveys between 1998 and 2011 off the shelf break (Waring et al. 2013).

Short-beaked Common Dolphin (*Delphinus delphis*)

The short-beaked common dolphin occurs from Cape Hatteras to Georges Bank during mid January–May, moves onto Georges Bank and the Scotian Shelf during mid summer and fall, and has been observed in large aggregations on Georges Bank in fall (Selzer and Payne 1988; Waring et al. 2013). Sightings off New Jersey have been made during all seasons (Fig. B-19a *in* DoN 2055). GMI (2010) reported 32 sightings of short-beaked common dolphins during surveys conducted in shallow water (<30 m) on the continental shelf off New Jersey in January 2008–December 2009, with sightings during fall and winter. There are over 100 OBIS sighting records near the proposed survey area off New Jersey, with most sightings near the shelf edge, but there are also several sightings in shelf waters (IOC 2013).

White-beaked Dolphin (*Lagenorhynchus albirostris*)

The white-beaked dolphin is widely distributed in cold temperature and subarctic North Atlantic waters (Reeves et al. 1999a), and mainly occurs over the continental shelf, especially along the shelf edge (Carwardine 1995). It occurs in immediate offshore waters of the east coast of the North America, from Labrador to Massachusetts (Rice 1998). Off the northeastern U.S. coast, white-beaked dolphins are mainly found in the western Gulf of Maine and around Cape Cod (CETAP 1982; Fig. B-20a *in* DoN 2005; Waring et al. 2010). There are two OBIS sighting records to the east of the proposed survey area off New Jersey, and one to the south off North Carolina (IOC 2013). White-beaked dolphins likely would not be encountered during the proposed survey.

Atlantic White-sided Dolphin (*Lagenorhynchus acutus*)

The Atlantic white-sided dolphin occurs in cold temperate to subpolar waters of the North Atlantic in deep continental shelf and slope waters (Jefferson et al. 2008). In the western North Atlantic, it ranges from Labrador and southern Greenland to ~38ºN (Jefferson et al. 2008). There are seasonal shifts in Atlantic white-sided dolphin distribution off the northeastern U.S. coast, with low numbers in winter from Georges Basin to Jeffrey's Ledge and very high numbers in spring in the Gulf of Maine. In summer, Atlantic white-sided dolphins are mainly distributed northward from south of Cape Cod with the highest numbers from Cape Cod north to the lower Bay of Fundy; sightings off New Jersey appear to be sparse (Fig. B-21a *in* DoN 2005). There are over 20 OBIS sighting records in the shelf waters off New Jersey, including near the proposed survey area (IOC 2013).

Risso's Dolphin (*Grampus griseus*)

The highest densities of Risso's dolphin occur in mid latitudes ranging from 30° to 45°, and primarily in outer continental shelf and slope waters (Jefferson et al. 2013). Off the northeast U.S. coast during spring, summer, and autumn, Risso's dolphins are distributed along the continental shelf edge from Cape Hatteras to Georges Bank, but they range into oceanic waters during the winter (Waring et al. 2013). Mapping of Risso's dolphin sightings off the U.S. east coast suggests that they could occur year-round from the Scotian Shelf to the coast of the southeastern U.S. in waters extending from the continental shelf to the continental rise (DoN 2005). Off New Jersey, the greatest number of sightings occurs near the continental slope during summer (Fig. B-22a *in* DoN 2005).

There are at least 170 OBIS records near the proposed survey area off New Jersey, including shelf waters and at the shelf edge (IOC 2013). Numerous sightings were also reported during summer NEFSC and SEFSC surveys between 1998 and 2011 for the shelf break off New Jersey (Waring et al. 2013).

Pygmy Killer Whale (*Feresa attenuata*)

The pygmy killer whale is pantropical/subtropical, generally occurring between 40ºN and 35ºS (Jefferson et al. 2008). There is no abundance estimate for the pygmy killer whale off the U.S. east coast because it is rarely sighted during surveys (Waring et al. 2010). One group of six pygmy killer whales was sighted off Cape Hatteras in waters >1500 m deep during a NMFS vessel survey in 1992 (Hansen et al. 1994 *in* Waring et al. 2010). There are an additional three OBIS sighting records to the southeast of the proposed survey area (Palka et al. 1991 *in* IOC 2013). Pygmy killer whales likely would not be encountered during the proposed survey.

False Killer Whale (*Pseudorca crassidens*)

The false killer whale is found worldwide in tropical and temperate waters generally between 50ºN and 50ºS (Odell and McClune 1999). It is widely distributed, but not abundant anywhere (Carwardine 1995). In the western Atlantic, it occurs from Maryland to Argentina (Rice 1998). Very few false killer whales were sighted off the U.S. northeast coast in the numerous surveys mapped by DoN (2005). There are 13 OBIS sighting records for the waters off the eastern U.S., but none are near the proposed survey area (IOC 2013). False killer whales likely would not be encountered during the proposed survey.

Killer Whale (*Orcinus orca*)

In the western North Atlantic, killer whales occur from the polar ice pack to Florida and the Gulf of Mexico (Würsig et al. 2000). Based on historical sightings and whaling records, killer whales apparently were most often found along the shelf break and offshore in the northwest Atlantic (Katona et al. 1988). They are considered uncommon or rare in waters of the U.S. Atlantic EEZ (Katona et al. 1988). Killer whales represented <0.1 % of all cetacean sightings (12 of 11,156 sightings) in CETAP surveys during 1978–1981 (CETAP 1982). Four of the 12 sightings made during the CETAP surveys were made offshore from New Jersey. Off New England, killer whales are more common in summer than in any other season, occurring nearshore and off the shelf break (Fig. B-24 *in* DoN 2005). There are 39 OBIS sighting records for the waters off the eastern U.S., but none off New Jersey (IOC 2013). Killer whales likely would not be encountered during the proposed survey.

Long- and Short-finned Pilot Whales (*Globicephala melas* and *G. macrorhynchus*)

There are two species of pilot whale, both of which could occur in the survey area. The long-finned pilot whale (*G. melas*) is distributed antitropically, whereas the short-finned pilot whale (*G. macrorhynchus*) is found in tropical, subtropical, and warm temperate waters (Olson 2009). In the northwest Atlantic, pilot whales often occupy areas of high relief or submerged banks and associated with the Gulf Stream edge or thermal fronts along the continental shelf edge (Waring et al. 1992). The ranges of the two species overlap in the shelf/shelf-edge and slope waters of the northeastern U.S. between New Jersey and Cape Hatteras, with long-finned pilot whales occurring to the north (Bernard and Reilly 1999). During winter and early spring, long-finned pilot whales are distributed along the continental shelf edge off the northeast U.S. coast and in Cape Cod Bay, and in summer and fall they also occur on Georges Bank, in the Gulf of Maine, and north into Canadian waters (Fig. B-25a *in* DoN 2005).

There are at least 200 OBIS sighting records for pilot whales for the waters off New Jersey, including sightings over the shelf; these sightings include *Globicephala* sp. and *G. melas* (IOC 2013). Numerous sightings were also reported during summer NEFSC and SEFSC surveys between 1998 and 2007 for the shelf break off New Jersey (Waring et al. 2013).

Harbor Porpoise (*Phocoena phocoena*)

The harbor porpoise inhabits cool temperate to subarctic waters of the Northern Hemisphere (Jefferson et al. 2008). There are likely four populations in the western North Atlantic: Gulf of Maine/Bay of Fundy, Gulf of St. Lawrence, Newfoundland, and Greenland (Gaskin 1984, 1992). Individuals found off the eastern U.S. coast likely would be almost exclusively from the Gulf of Maine/Bay of Fundy stock.

Harbor porpoises concentrate in the northern Gulf of Maine and southern Bay of Fundy during July–September, with a few sightings ranging as far south as Georges Bank and one off Virginia (Waring et al. 2013). In summer, sightings mapped from numerous sources extended only as far south as off northern Long Island, New York (Fig. B-26a *in* DoN 2005). During October–December and April–June, harbor porpoises are dispersed and range from New Jersey to Maine, although there are lower densities at the northern and southern extremes (DoN 2005; Waring et al. 2013). Most would be found over the continental shelf, but some are also encountered over deep waters (Westgate et al. 1998). During January–March, harbor porpoises concentrate farther south, from New Jersey to North Carolina, with lower densities occurring from New York to New Brunswick (DoN 2005; Waring et al. 2013).

GMI (2010) reported 51 sightings of harbor porpoise during surveys conducted in shallow water (<30 m) on the continental shelf off New Jersey in January 2008–December 2009, with sightings during fall and winter. There are 10 OBIS sighting records for the waters off New Jersey during March–June, most of which are from the CETAP surveys (CETAP 1982; IOC 2013). Harbor porpoises likely would not be encountered during the proposed survey.

Sea Turtles

Two species of sea turtle, the leatherback and loggerhead turtles, are common off the U.S. east coast. Kemp's ridley and green turtles also occur in this area at much lower densities. A fifth species, the hawksbill turtle, is considered very rare in the northwest Atlantic Ocean. General information on the taxonomy, ecology, distribution and movements, and acoustic capabilities of sea turtles are given in § 3.4.1 of the PEIS. The general distribution of sea turtles in the northwest Atlantic is also discussed in § 3.4.2.1 of the PEIS and § 4.2.3.1 of the BOEM Final PEIS (BOEM 2014). The rest of this section deals specifically with their distribution off the northeastern coast of the U.S., particularly off New Jersey.

(1) Leatherback Turtle (*Dermochelys coriacea*)

Leatherback turtles commonly occur along the eastern U.S. coast and as far north as New England (Eckert 1995a), although important nesting areas occur only as far north as Florida (NMFS and USFWS 2013a). Leatherback occurrence in New England waters has been documented for many years, with most historic records during March–August focused around the Gulf of Maine and Georges and Browns Banks; in fall, they were focused more southerly in New England bays and sounds (Lazell 1980). Leatherbacks tagged off Cape Breton and mainland Nova Scotia during summer remained off eastern Canada and the northeastern U.S. coast before most began migrating south in October (James et al. 2005); foraging adults off Nova Scotia mainly originate from Trinidad (NMFS and USFWS 2013a). Some of these tags remained attached long enough to observe northward migrations, with animals leaving nesting grounds during February–March and typically arriving north of 38ºN during June, usually in areas within several hundred km of where they were observed in the previous year. Virtually all of the leatherbacks in sighting records off the northeastern U.S. occurred in summer off southern New Jersey, the southeastern tip of Long Island, and southern Nova Scotia (Fig. C-2a *in* DoN 2005).

GMI (2010) reported 12 sightings of leatherback sea turtles on the continental shelf off New Jersey during surveys conducted in January 2008–December 2009, with all sightings occurring during summer. There are over 200 OBIS sighting records for the waters off New Jersey (IOC 2013). Palka (2012) also reported several sightings off northern New Jersey south of Long Island during June–August 2011 surveys.

(2) Green Turtle (*Chelonia mydas*)

Important feeding areas for green turtles in U.S. waters are primarily located in Florida and southern Texas, but Long Island Sound and inshore waters of North Carolina appear to be important to juveniles during summer months (NMFS and USFWS 2007). Small numbers of juvenile green turtles have occurred historically in Long Island and Nantucket Sounds in New England (Lazell 1980). There are few sighting records, but DoN (Fig. C-5 *in* DoN 2005) suggested that small numbers can be found from spring to fall as far north as Cape Cod Bay, including off New Jersey. There are seven OBIS sightings of green turtles off the coast of New Jersey (IOC 2013). Palka (2012) also reported several sightings off northern New Jersey south of Long Island during June–August 2011 surveys.

(3) Loggerhead Turtle (*Caretta caretta*)

Major nesting areas for loggerheads in the western North Atlantic are located in the southeastern U.S., principally southern Florida, but also as far north as the Carolinas and occasionally Virginia; the nesting season is from May to August (Spotila 2004). Most females tagged on North Carolina nesting beaches traveled north to forage at higher latitudes (primarily off New Jersey, Maryland, and Delaware) during summer, and south to wintering grounds off the southeastern U.S. in the fall (Hawkes et al. 2007).

Some juveniles make seasonal foraging migrations into temperate latitudes as far north as Long Island, New York (Shoop and Kenney 1992 *in* Musick and Limpus 1997). Lazell (1980) reported that loggerheads were historically common in New England waters and the Gulf of Maine. Sighting records of loggerheads off the northeastern U.S. were in all seasons in continental shelf and slope waters from Cape Cod to southern Florida, with greatest concentrations in mid-continental shelf waters off New Jersey during the summer (Fig. C-3a *in* DoN 2005). There are increased stranding records of loggerheads from Cape Cod Bay and Long Island Sound in the fall (DoN 2005); loggerheads may be unable to exit these inshore habitats, which can result in hypothermia as temperatures drop in late fall (Burke et al. 1991 *in* DoN 2005).

GMI (2010) reported 69 sightings of loggerhead turtles on the continental shelf off New Jersey during surveys conducted in January 2008–December 2009; sightings occurred from spring through fall, with most sightings during summer. There are over 1000 OBIS sighting records off the coast of New Jersey, including within the proposed project area (IOC 2013). Palka (2012) also reported several sightings off northern New Jersey south of Long Island during June–August 2011 surveys.

(4) Hawksbill Turtle (*Eretmochelys imbricata*)

The hawksbill is the most tropical of all sea turtles, generally occurring between ~30ºN and ~30ºS (Eckert 1995b). In the Atlantic Ocean, most nesting beaches are in the Caribbean Sea as far north as Cuba and the Bahamas (NMFS and USFWS 2013b). It is considered very rare and possibly extralimital in the northwest Atlantic (Lazell 1980; Eckert 1995b). Nonetheless, DoN (Fig. C-6 *in* DoN 2005) mapped two hawksbill turtle sightings off New Jersey (one during spring and one during fall) and several south of New Jersey. In addition, there is one OBIS sighting record offshore New Jersey, east of the proposed survey area (SEFSC 1992 *in* IOC 2013).

(5) Kemp's Ridley Turtle (*Lepidochelys kempii*)

Kemp's ridley turtle has a more restricted distribution than other sea turtles, with adults primarily located in the Gulf of Mexico; some juveniles also feed along the U.S. east coast, including Chesapeake Bay, Delaware Bay, Long Island Sound, and waters off Cape Cod (Spotila 2004). Nesting occurs primarily along the central and southern Gulf of Mexico coast during May–late July (Morreale et al. 2007). There have also been some rare records of females nesting on Atlantic beaches of Florida, North Carolina, and South Carolina (Plotkin 2003). After nesting, female Kemp's ridley turtles travel to foraging areas along the coast of the Gulf of Mexico, typically in waters <50 m deep from Mexico's Yucatan Peninsula to southern Florida; males tend to stay near nesting beaches in the central Gulf of Mexico year-round (Morreale et al. 2007). Only juvenile and immature Kemp's ridley turtles appear to move beyond the Gulf of Mexico into more northerly waters along the U.S. east coast.

Hatchlings are carried by the prevalent currents off the nesting beaches and do not reappear in the neritic zone until they are about two years old (Musick and Limpus 1997). Those juvenile and immature Kemp's ridley turtles that migrate northward past Cape Hatteras probably do so in April and return southward in November (Musick et al. 1994). North of Cape Hatteras, juvenile and immature Kemp's ridleys prefer shallow-water areas, particularly along North Carolina and in Chesapeake Bay, Long Island Sound, and Cape Cod Bay (Musick et al. 1994; Morreale et al. 1989; Danton and Prescott 1988; Frazier et al. 2007). There are historical summer sightings and strandings of Kemp's ridley turtles from Massachusetts into the Gulf of Maine (Lazell 1980). Occasionally, individuals can be carried by the Gulf Stream as far as northern Europe, although those individuals are considered lost to the breeding population. Virtually all sighting records of Kemp's ridley turtles off the northeastern U.S. were in summer off the coast of New Jersey (Fig. C-4a *in* DoN 2005). There are 60 OBIS sighting records off the coast of New Jersey, some within the proposed survey area (SEFSC 1992 *in* IOC 2013).

Seabirds

Two ESA-listed seabird species could occur in or near the Project area: the ***Threatened*** piping plover and the ***Endangered*** roseate tern. General information on the taxonomy, ecology, distribution and movements, and acoustic capabilities of seabird families are given in § 3.5.1 of the PEIS.

(1) Piping Plover (*Charadrius melodus*)

The Atlantic Coast Population of the piping plover is listed as ***Threatened*** under the U.S. ESA, and the species is listed as ***Near Threatened*** on the IUCN Red List of Threatened Species (IUCN 2013). It breeds on coastal beaches from Newfoundland to North Carolina during March–August and it winters along the Atlantic Coast from North Carolina south, along the Gulf Coast, and in the Caribbean (USFWS 1996). Its marine nesting habitat consists of sandy beaches, sandflats, and barrier islands (Birdlife International 2013). Feeding areas include intertidal portions of ocean beaches, mudflats, sandflats, and shorelines of coastal ponds, lagoons, or salt marshes (USFWS 1996). Wintering plovers are generally found on barrier islands, along sandy peninsulas, and near coastal inlets (USFWS 1996).

Because it is strictly coastal, the piping plover likely would not be encountered at the proposed survey site.

(2) Roseate Tern (*Sterna dougallii*)

The Northeast Population of the roseate tern is listed as ***Endangered*** under the U.S. ESA, and the species is listed as ***Near Threatened*** on the IUCN Red List of Threatened Species (IUCN 2013). It breeds on islands along the northeast coast of the U.S from New York to Maine and north into Canada, and historically as far south as Virginia (USFWS 1998, 2010). It is thought to migrate beginning in mid September through the eastern Caribbean and along the north coast of South America, and to winter mainly on the east coast of Brazil (USFWS 2010). During the breeding season, roseate terns forage over shallow coastal waters, especially in water depths <5 m, sometimes near the colony and at other times at distances of over 30 km. They usually forage over shallow bays, tidal inlets and channels, tide rips, and sandbars (USFWS 2010).

Because of its distribution during the breeding season, the roseate tern likely would not be encountered at the proposed survey site.

Fish, Essential Fish Habitat, and Habitat Areas of Particular Concern

(1) ESA-Listed Fish and Invertebrate Species

There are two fish species listed under the ESA as ***Endangered*** that could occur in the study area: the New York Bight distinct population segment (DPS) of the Atlantic sturgeon, and the shortnose sturgeon. There are three species that are candidates for ESA listing: the cusk, the Northwest Atlantic and Gulf of Mexico DPS of the dusky shark, and the great hammerhead shark. There are no listed or candidate invertebrate species.

Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*)

Five DPSs of the Atlantic sturgeon are listed under the U.S. ESA, one as ***Threatened*** and four as ***Endangered***, including the New York Bight DPS, and the species is listed as ***Critically Endangered*** on the IUCN Red List of Threatened Species (IUCN 2013). It is a long-lived, late maturing (11–21 years in the Hudson River), anadromous fish. Spawning adults migrate upriver in spring, beginning in April–May in the mid Atlantic. The New York Bight DPS primarily uses the Delaware and Hudson rivers for spawning. Following spawning, males can remain in the river or lower estuary until fall, and females usually exit the rivers within 4–6 weeks. Juveniles move downstream and inhabit brackish waters for a few months before moving into nearshore coastal waters (NOAA 2012b).

Shortnose Sturgeon (*Acipenser brevirostrum*)

The shortnose sturgeon is listed as ***Endangered*** throughout its range under the U.S. ESA and ***Vulnerable*** on the IUCN Red List of Threatened Species (IUCN 2013). It is an anadromous species that spawns in coastal rivers along the east coast of North America from Canada to Florida. The shortnose sturgeon prefers the nearshore marine, estuarine, and riverine habitats of large river systems, and apparently does not make long-distance offshore migrations (NOAA 2013d).

Cusk (*Brosme brosme*)

The cusk is an ESA ***Candidate Species*** throughout its range, and has not been assessed for the IUCN Red List. In the Northwest Atlantic, it occurs from New Jersey north to the Strait of Belle Isle and the Grand Banks of Newfoundland and rarely to southern Greenland. It is a solitary, benthic species found in rocky, hard bottom areas to a depth of 100 m. In U.S waters, it occurs primarily in deep water of the central Gulf of Maine (NOAA 2013e).

Dusky Shark (*Carcharhinus obscurus*)

The Northwest Atlantic and Gulf of Mexico DPS of the dusky shark is an ESA ***Candidate Species***, and the species is listed as ***Vulnerable*** on the IUCN Red List of Threatened Species (IUCN 2013). It is a coastal-pelagic species that inhabits warm temperate and tropical waters throughout the world. In the Northwest Atlantic, it is found from southern Massachusetts and Georges Bank to Florida and the northern Gulf of Mexico. The dusky shark occurs in both inshore and offshore waters, although it avoids areas of low salinity from the surface to depths of 575 m. Along U.S. coasts, it undertakes long temperature-related migrations, moving north in summer and south in fall (NMFS 2013b).

Great Hammerhead Shark (*Carcharhinus mokarran*)

The great hammerhead shark is an ESA ***Candidate Species***, and has not been assessed for the IUCN Red List. It is a highly migratory species found in coastal, warm temperate and tropical waters throughout the World, usually in coastal waters and over continental shelves, but also adjacent deep waters. Along the U.S. east coast, the great hammerhead shark can be found in waters off Massachusetts, although it is rare north of North Carolina, and south to Florida and the Gulf of Mexico (NOAA 2013f).

(2) Essential Fish Habitat (EFH)

EFH is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity". "Waters" include aquatic areas and their associated physical, chemical, and biological properties that are used by fish. "Substrate" includes sediment, hard bottom, structures underlying the waters, and associated biological communities (NMFS 2013c). The entire eastern sea-board from the coast to the limits of the EEZ is EFH for one or more species or life stage for which EFH has been designated.

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) and the New England Fishery Management Council (NEFMC). The Highly Migratory Division of the National Marine Fisheries Service in Silver Spring, MD, manages highly migratory species (sharks, swordfish, billfish, and tunas).

The life stages and associated habitats for those species with EFH in the survey area are described in Table 4.

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

	Life stage[1] and habitat[2]				
Species	E	L/N	J	A	SA
Atlantic cod *Gadus morhua*				B	B
Black sea bass *Centropristis striata*	P	P	D	D	D
Bluefish *Pomatomus saltatrix*	P	P	P	P	P
Butterfish *Peprilus triacanthus*	P	P	P	P	P
Atlantic herring *Clupea harengus*			P	P	B
Atlantic mackerel *Scomber scombrus*	P	P	P	P	P
Red hake *Urophycis chuss*	P	P	B		
Silver hake *Merluccius bilinearis*	P	P	B		
Scup *Stenotomus chrysops*			D	D	
Monkfish *Lophius americanus*	P	P	B	B	B
Ocean pout *Macrozoarces americanus*	B	B	B	B	B
Summer flounder *Paralichthys dentatus*	P	P	B	B	B
Windowpane flounder *Scophthalmus acquosus*	P	P		B	B
Winter flounder *Pleuronectes americanus*	B	D/P	B	B	B
Witch flounder *Glyptocephalus cynoglossus*	P	P			B
Yellowtail flounder *Limanda ferruginea*	P				
Albacore tuna *Thunnus alalunga*			P		
Bigeye tuna *Thunnus obesus*				P	
Bluefin tuna *Thunnus thynnus*			P		
Skipjack tuna *Katsuwonus pelamis*				P	
Yellowfin tuna *Thunnus albacres*			P		
Little skate *Leucoraja erinacea*			B	B	
Winter skate *Leucoraja ocellata*			B		
Basking shark *Cetorhinus maximus*			P	P	
Blue shark *Prionace glauca*		P	P	P	
Dusky shark *Carcharhinus obscurus*		P	P	P	
Common thresher shark *Alopias vulpinus*		P	P	P	
Sandbar shark *Carcharhinus plumbeus*		B	B	B	
Scalloped hammerhead shark *Sphyrna lewini*			P	P	
Shortfin mako shark *Isurus oxyrinchus*		P	P	P	
Smooth (spiny) dogfish *Squalus acanthias*		P	P	P	
Sand tiger shark *Carcharias taurus*		P	P		
Tiger shark *Galeocerdo cuvier*			P	P	
White shark *Carcharodon carcharias*		P	P	P	
Atlantic sea scallop *Placopecten magellanicus*	B	P	B	B	B
Atlantic surfclam *Spisula solidissima*	P	P	B	B	B
Ocean quahog *Arctica islandica*	P	P	B	B	B
Northern shortfin squid *Illex illecebrosus*	P	P	D/P	D/P	D/P
Longfin inshore squid *Loligo pealeii*	B	P	D/P	D/P	D/P

Source: NOAA 2012c

[1] E = eggs; L/N = larvae for bony fish and invertebrates, neonate for sharks; J = juvenile; A = adult; SA = spawning adult

[2] P = pelagic; D = demersal; B = benthic

Two EFH areas located to the northeast of the proposed survey area, the Lydonia and Oceanographer canyons, were previously protected from fishing. Bottom trawling was prohibited in these areas because of the presence of *Loligo* squid eggs, under the Fisheries Management Plan for Atlantic mackerel, butterfish, and *Illex* and *Loligo* squid. This protection was valid as of 31 July 2008 for up to three years, after which it was to be subject to review for the possibility of extension (NOAA 2008).

(3) Habitat Areas of Particular Concern

Habitat Areas of Particular Concern (HAPC) are subsets of EFH that provide important ecological functions and/or are especially vulnerable to degradation, and are designated by Fishery Management Councils. All four life stages of summer flounder have EFH within the proposed survey area, whereas HAPC have only been designated for the juvenile and adult EFH: demersal waters over the continental shelf, from the coast to the limits of the EEZ, from the Gulf of Maine to Cape Hatteras, North Carolina (NOAA 2012c). Specifically, the HAPC include "all native species of macroalgae, seagrasses, and freshwater and tidal macrophytes in any size bed, as well as loose aggregations, within adult and juvenile EFH. If native species of submerged aquatic vegetation are eliminated then exotic species should be protected because of functional value, however, all efforts should be made to restore native species" (NOAA 2012c). No other HAPC have been designated for those species with EFH within the proposed survey area.

Fisheries

Commercial and recreational fisheries data are collected by NMFS, including species, gear type and landings mass and value, all of which are reported by state of landing (NOAA 2013g). Fisheries data from 2008 to 2012 (and 2013 where available) were used in the analysis of New Jersey's commercial and recreational fisheries near the proposed study area. The latest year's available data are considered preliminary.

(1) Commercial Fisheries

The average annual catch weights and values, fishing season, and gear types for major commercial species are summarized in Table 5. In the waters off New Jersey, commercial fishery catches are dominated by menhaden, various shellfish, and squid. Menhaden accounted for 33% of the catch weight, followed by Atlantic surf clam (17%), ocean quahog (8%), sea scallop (8%), northern shortfin squid (7%), shellfish (6%), and blue crab (4%). Numerous other fish and invertebrate species accounted for the remaining proportion of catch weight. In 2010 (the only such dataset available in NOAA 2013g), most finfish by weight (68.8%) were caught within 5.6 km from shore; that catch was almost all (98.1%) accounted for by menhaden. Fish dominating the offshore (5.6–370 km from shore) finfish catch by weight were American mackerel (20.1% of total finfish weight), American herring (17.7%), skates (12.8%), and summer flounder (8.8%). Most finfish by value (73.3%) were caught between 5.6 and 370 km from shore; dominant fish by value were summer flounder (25.7% of total finfish value), goosefish/anglerfish (15.2%), yellowfin tuna (6.8%), and bigeye tuna (6.4%). Most shellfish and squid were captured between 5.6 and 370 km from shore, both by weight (73.6% of total shellfish and squid catch) and value (89.1%).

During 2002–2006 (the last year reported), commercial catch has only been landed by U.S. and Canadian vessels in the EEZ along the U.S east coast, with the vast majority of the catch (>99%) taken by U.S. vessels (Sea Around Us Project 2011). Typical commercial fishing vessels in the New Jersey area include trawlers, gill netters, lobster/crab boats, dredgers, longliners, and purse seiners.

(2) Recreational Fisheries

In 2012, marine recreational fishers caught over 6 million fish for harvest or bait, and >23.7 million fish in catch and release programs in New Jersey waters. These catches were taken by over 1.1 million recreational fishers during more than 5.02 million trips. The majority of the trips (91%) occurred within 5.6 km from shore. The periods with the most boat-based trips (including charter, party, and private/rental boats) were July–August (1.2 million trips or 40% of total), followed by September–October (802,626 or 27%), and May–June (709,913 or 24%). The same was true for shore-based trips

Table 5. Commercial fishery catches for major marine species for New Jersey waters by weight, value, season, and gear type, averaged from 2008 to 2012.

Species	Average annual landings (mt)	% total	Average annual landings (1000$)	% total	Fishing season (peak season)	Gear Type: Fixed	Gear Type: Mobile
Menhaden	25,255	34	4,905	3	Year-round (May–Oct)	Gill nets, pots, traps, pound nets	Dip nets, trawls, dredge, purse seines
Atlantic surf clam	13,090	18	17,910	11	Year-round	N/A	Dredge, tongs, grabs
Ocean quahog	6,473	9	8,686	5	Mar–Dec (spring–fall)	N/A	Dredge
Sea scallop	6,116	8	108,730	65	Year-round (Mar–Oct)	Gill nets, pots, traps, pound nets	Dredge, trawls
Northern shortfin squid	5,109	7	3,883	2	Aug - Oct	N/A	Trawls
Shellfish	4,329	6	1,757	1	Year-round (May–Oct)	Gill nets, long lines, pots and traps, pound nets, weirs	Trawls, cast nets, dip nets, diving, dredge, fyke net, hand lines, seines
Blue crab	2,924	4	7,639	5	Year-round (May–Oct)	Lines trot with bait, pots, traps	Dredge, hand lines, trawls
Atlantic herring	2,528	3	608	<1	Year-round (Jan–Feb)	N/A	Trawls
Atlantic mackerel	2,404	3	919	1	Fall–spring (Jan–Apr)	Gill nets	Trawls
Longfin squid	1,401	2	2,977	2	Year-round (Feb–Mar; Sep–Nov)	N/A	Dredge, trawls
Monkfish (Goosefish)	1,170	2	3,346	2	Year-round (Oct–Mar; May–Jun)	Gill nets, pots, traps	Dredge, trawls
Skate	1,054	1	693	<1	Year-round (Nov–Jan; May–Jun)	Gill nets	Dredge, trawls
Summer flounder	962	1	4,457	3	Year-round	Gill nets	Dredge, hand lines, trawls
Scup	617	1	782	<1	Year-round (Jan–Apr)	Gill nets, pots, traps	Dredge, trawls
Spiny dogfish shark	511	1	239	<1	Fall–spring (Nov–Jan; May)	Gill nets	Trawls
Bluefish	475	1	498	<1	Year-round (spring–summer)	Gill nets	Dredge, hand lines, trawls
Total	74,418	100	168,028	100			

Source: NOAA 2013g

(from beaches, marshes, docks, and/or piers; DoN 2005), with the most trips in July–August (712,135 or 34%), then September–October (552,726 or 27%), and May–June (542,049 or 26%).

In 2004, there were eight recreational fishing tournaments around New Jersey between May and November, all of which were within 150 km (~80 nm) from shore (DoN 2005). Of the 'hotspots' (popular fishing sites commonly visited by recreational anglers) mapped by DoN (2005), most are to the north or south of the proposed survey area; however, there are several hotspots located within or very near the northwestern corner of the survey area. In 2014, as of April 2014, 11 tournaments were scheduled for central New Jersey ports of call (Table 6). No detailed information about locations is given in the sources cited.

In 2012, at least 85 species of fish were targeted by recreational fishers off New Jersey. Species with 2012 recreational catch numbers exceeding one million include summer flounder (27% of total catch), black sea bass (15%), bluefish (11%), Atlantic croaker (5%), and spot (4%). Other notable species or species groups representing at least 1% each of the total catch included unidentified sea robin, smooth dogfish, weakfish, striped sea robin, northern sea robin, white perch, northern puffer, unidentified skate, striped bass, tautog, oyster toadfish, scup, Atlantic menhaden, hickory shad, unidentified shark, clearnose skate, spiny dogfish, and cunner. All of these species/species groups were predominantly caught within 5.6 km from shore (~60% of total catch for black sea bass and skates/rays; ~90% for all others).

Table 6. Fishing tournaments off New Jersey, June–mid August 2014.

Dates	Tournament name	Port/ waters	Marine species/groups targeted	Source
1 Feb–14 Dec	Kayak Wars	Statewide/ all legal	Barred sand/calico/spotted bay/white sea bass; bonefish; bonito; cabezon; California barracuda; coho/king/pink salmon; corvina; dorado (mahi mahi); greenling; halibut; leopard/mako/ sevengill/thresher shark; lingcod; opaleye; rock sole; rockfish; saltwater perch; sanddab; sculpin; sheepshead; spiny dogfish; starry flounder; sturgeon; cutthroat trout; whitefish; yellowtail	1
1 Apr–30 Nov	Jersey Shore Beach N Boat Fishing Tournament	Beach Haven/out to 20 n.mi.	Black drum; bluefish; fluke; northern kingfish; sea/striped bass; tog; weakfish	1
1 May–30 Nov	Manasquan River MTC Monthly and Mako Tournament	Brielle/N/A	White/blue marlin; pelagic sharks; bigeye/albacore/yellowfin tuna	2
Spring–Fall	Annual Striper Derby – Spring Lake Live Liners Fishing Club	Spring Lake/ any NJ waters	Striped bass	1
6 Jun–27 Jul	Manasquan River Marlin & Tuna Club Bluefin Tournament	Manasquan/ Atlantic Ocean	Bluefin tuna	1
27 Jun–6 Jul	Manasquan River Marlin & Tuna Club Jack Meyer Trolling Tournament	Manasquan/ Atlantic Ocean	Unlisted	1
3–7 Jul	Manasquan River MTC Jack Meyer Memorial Tournament	Brielle/ N/A	White/blue marlin; bigeye/ albacore/yellowfin tuna	2
4 Jul	World Cup Blue Marlin Championship	Statewide/ offshore	Blue marlin	1
12–13 Jul	Manasquan River Marlin & Tuna Club Ladies & Juniors	Manasquan/ Atlantic Ocean	Mako shark	1
23–26 Jul	Beach Haven Marlin & Tuna Club White Marlin Invitational	Beach Haven/ offshore	White marlin	1, 3
31 Jul–3 Aug	Manasquan River Marlin & Tuna Club Fluke Tournament	Manasquan/ Atlantic Ocean	Mako shark	1

Sources: 1: American Fishing Contests (2014); 2: NOAA (2014); 3: InTheBite (2014)

Recreational SCUBA Diving

Wreck diving is a popular recreation in the waters off New Jersey. A search for shipwrecks in New Jersey waters was made using NOAA's automated wreck and obstruction information system (NOAA 2014). Results of the search are plotted in Figure 2 together with the survey lines. There are over 900 shipwrecks/obstructions in New Jersey waters, most (58%) of which are listed by NOAA (2014) as unidentified. Only two shipwrecks, both known dive sites, are in or near the survey area (Fig. 2): the *Lillian* (Galiano 2009; Fisherman's Headquarters 2014; NOAA 2014) and the *Maurice Tracy* (DiveBuddy 2014).

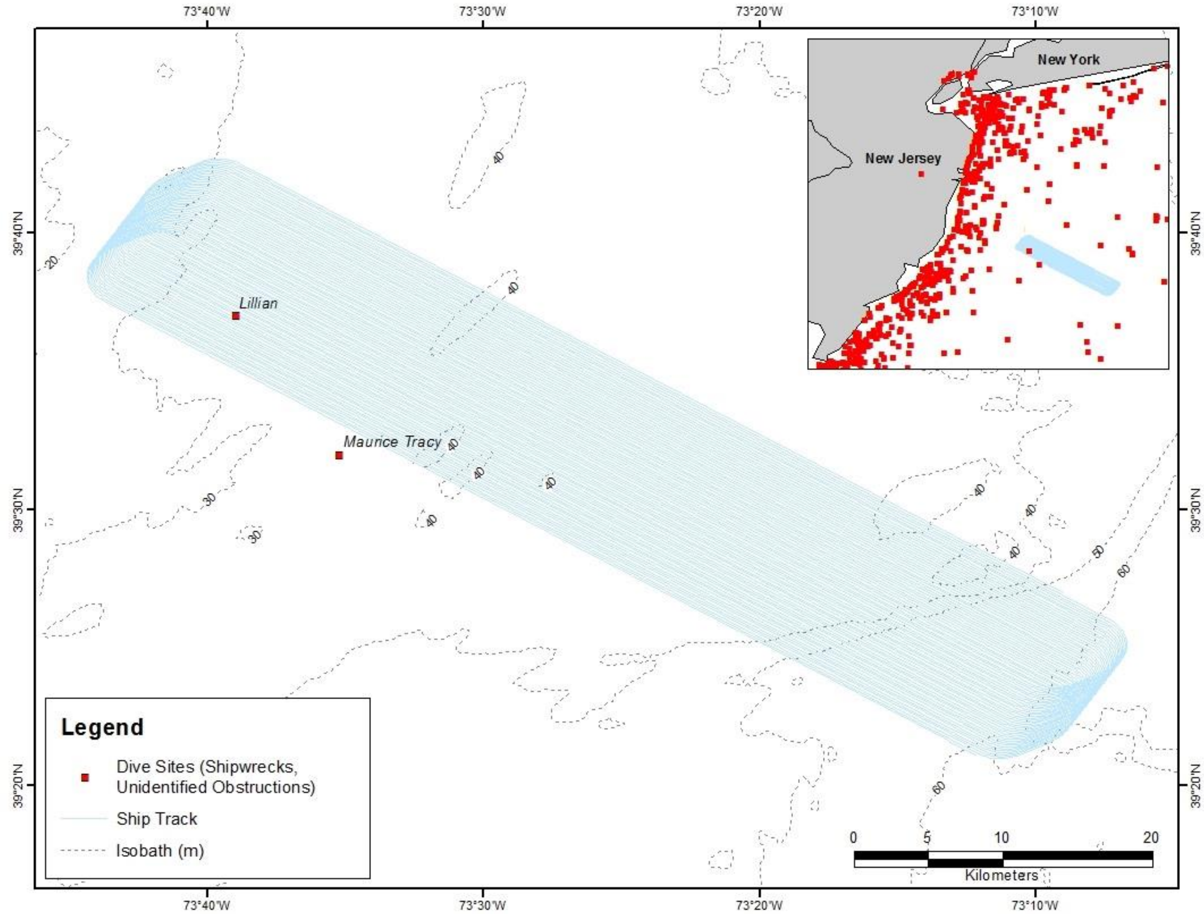

Figure 2. Potential dive sites (shipwrecks or unidentified obstructions) in New Jersey waters. Source: NOAA (2014).

IV. Environmental Consequences

Proposed Action

The PEIS presented analyses of potential impacts from acoustic sources in general terms and for specific analysis areas. The proposed survey and effects analysis differ from those in the NW Atlantic DAA presented in the PEIS in that different sources were used, the survey areas covered a different range of depths, and different modeling methods were used. The following section includes site-specific details of the proposed survey, summary effects information from the PEIS, and updates to the effects information from recent literature. Additional effects literature is given in the NMFS EA (Appendix E), and is incorporated into this Final EA by reference as if fully set forth herein.

(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, and reference to recent literature that has become available since the PEIS was released in 2011. A more comprehensive review of the relevant background information, as well as information on the hearing abilities of marine mammals and sea turtles, appears in § 3.4.4.3, § 3.6.4.3, § 3.7.4.3, and Appendix E of the PEIS.

Estimates of the numbers of marine mammals that could be affected by the proposed seismic survey scheduled to occur during July–mid August 2014 are provided in (e) below, along with a description of the rationale for NSF's estimates of the numbers of individuals exposed to received sound levels ≥160 dB re 1 µPa_{rms}. Although the PEIS included modeling for the NW Atlantic DAA, it was done for a different energy source level and survey parameters (e.g., survey water depths and source tow depth), modeling methods were different from those used by L-DEO (see PEIS, Appendix B, for further modeling details regarding the NW Atlantic DAA). Acoustic modeling for the proposed action was conducted by L-DEO, consistent with past EAs and determined to be acceptable by NMFS to use in the calculation of estimated takes under the MMPA (e.g., NMFS 2013d,e).

(a) Summary of Potential Effects of Airgun Sounds

As noted in the PEIS (§ 3.4.4.3, § 3.6.4.3, and § 3.7.4.3), 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). 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. Recent research has shown that sound exposure can cause cochlear neural degeneration, even when threshold shifts and hair cell damage are reversible (Liberman 2013). These findings have raised some doubts as to whether TTS should continue to be considered a non-injurious effect. Although the possibility cannot be entirely excluded, it is unlikely that the project would result in any cases of temporary or permanent hearing impairment, or any significant non-auditory physical or physiological effects. If marine mammals encounter the 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 whales 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 very 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, 2013), and this weaker reverberation presumably reduces the detection range of calls and other natural sounds to some degree. Guerra et al. (2013) reported that ambient noise levels between seismic pulses were elevated because 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. (2013) reported that airgun sounds could reduce the communication range of blue and fin whales 2000 km from the seismic source. Klinck et al. (2012) also found reverberation effects between airgun pulses. 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 seismic pulses (e.g., Nieukirk et al. 2012). 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). 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. 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), 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. 2013). 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). 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 humpbacks, gray whales, bowheads, 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 boat; 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. Studies examining the behavioral responses of humpback whales to airguns are currently underway off eastern Australia (Cato et al. 2011, 2012, 2013).

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). On their summer feeding grounds in southeast Alaska, there was no clear evidence of avoidance, despite the possibility of subtle effects, at received levels up to 172 re 1 μPa on an approximate rms basis (Malme et al. 1985). 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 fecal hormone metabolites decreased in North Atlantic right whales with a 6-dB decrease in underwater noise from vessels. Wright et al. (2011) also reported that sound could be a potential source of stress for marine mammals.

Results from *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). However, more recent research on bowhead whales corroborates earlier evidence that, during the summer feeding season, bowheads are not as sensitive to seismic sources (e.g., Miller et al. 2005). Nonetheless, Robertson et al. (2013) showed that bowheads on their summer feeding grounds showed subtle but statistically significant changes in surfacing–respiration–dive cycles during exposure to seismic sounds, including shorter surfacing intervals, shorter dives, and decreased number of blows per surface interval.

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) reported that calling rates in 2007 declined significantly where received SPLs from airgun sounds were 116–129 dB re 1 µPa. Thus, bowhead whales in the Beaufort Sea apparently decrease their calling rates in response to seismic operations, although movement out of the area could also contribute to the lower call detection rate (Blackwell et al. 2013).

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.

Reactions of migrating and feeding (but not wintering) *gray whales* to seismic surveys have been studied. Off St. Lawrence Island in the northern Bering Sea, it was estimated, based on small sample sizes, that 50% of feeding gray whales stopped feeding at an average received pressure level of 173 dB re 1 μPa on an (approximate) rms basis, and that 10% of feeding whales interrupted feeding at received levels of 163 dB re 1 μPa_{rms} (Malme et al. 1986, 1988). Those findings were generally consistent with the results of experiments conducted on larger numbers of gray whales that were migrating along the California coast (Malme et al. 1984; Malme and Miles 1985), and western Pacific gray whales feeding off Sakhalin Island, Russia (e.g., Gailey et al. 2007; Johnson et al. 2007; Yazvenko et al. 2007a,b).

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 off the U.K. from 1997 to 2000 suggest that, during times of good sightability, sighting rates for mysticetes (mainly fin and sei whales) were similar when large arrays of airguns were shooting vs. silent, although there was localized avoidance (Stone and Tasker 2006). Singing fin whales in the Mediterranean moved away from an operating airgun array, and their song notes had lower bandwidths during periods with versus 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).

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. The western Pacific gray whale population did not seem affected by a seismic survey in its feeding ground during a previous year, and 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 marine mammal 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). 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.

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* (*Monodon monoceros*) 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).

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), but foraging behavior can be altered upon exposure to airgun sound (e.g., Miller et al. 2009). 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). However, 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). In any event, it is likely that most beaked whales would also show strong avoidance of an approaching seismic vessel, although this has not been documented explicitly.

The limited available data suggest that *harbor porpoises* show stronger avoidance of seismic operations than do Dall's porpoises. 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 $\mu Pa^2 \cdot s$); however, animals returned to the area within a few hours. The apparent tendency for greater responsiveness in the harbor porpoise is consistent with their 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, which tend to be less responsive than the more responsive cetaceans.

Sea Turtles

The limited available data indicate that sea turtles will hear airgun sounds and sometimes exhibit localized avoidance (see PEIS, § 3.4.4.3). 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 are likely to have the greatest impact. 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 year.

***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. 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, although there is recent evidence that auditory effects in a given animal are not a simple function of received acoustic energy. Frequency, duration of the exposure and occurrence of gaps within the exposure can also influence the auditory effect (Finneran and Schlundt 2010, 2011; Finneran et al. 2010a,b; Finneran 2012; Ketten 2012; Finneran and Schlundt 2011, 2013; Kastelein et al. 2013a).

The assumption that, in marine mammals, the occurrence and magnitude of TTS is a function of cumulative acoustic energy (SEL) is probably an oversimplification (Finneran 2012). 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. Kastelein et al. (2012a,b; 2013b) also reported that the equal-energy model is not valid for predicting TTS in harbor porpoises or harbor seals.

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). Schlundt et al. (2013) reported that the potential for seismic surveys using airguns to cause auditory effects on dolphins could be lower than previously thought. Based on behavioral tests, Finneran et al. (2011) and Schlundt et al. (2013) reported no measurable TTS in bottlenose dolphins after exposure to 10 impulses from a seismic airgun with a cumulative SEL of ~195 dB re 1 $\mu Pa^2 \cdot s$; results from auditory evoked potential measurements were more variable (Schlundt et al. 2013).

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. 2013a). Popov et al. (2013b) also 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). Therefore, Supin et al. (2013) reported that SEL may not be a valid metric for examining fatiguing sounds on beluga whales. Similarly, Nachtigall and Supin (2013) reported that false killer whales are able to change their hearing sensation levels when exposed to loud sounds, such as warning signals or echolocation sounds.

It is inappropriate to assume that onset of TTS occurs at similar received levels in all cetaceans (*cf.* Southall et al. 2007). Some cetaceans could incur TTS at lower sound exposures than are necessary to elicit TTS in the beluga or bottlenose dolphin. Based on the best available information, Southall et al. (2007) recommended a TTS threshold for exposure to single or multiple pulses of 183 dB re 1 $\mu Pa^2 \cdot s$. Tougaard et al. (2013) proposed a TTS criterion of 165 dB re 1 $\mu Pa^2 \cdot s$ for porpoises based on data from two recent studies. 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 closest point of approach 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 likelihood 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).

Current NMFS policy regarding exposure of marine mammals to high-level sounds is that cetaceans and pinnipeds should not be exposed to impulsive sounds with received levels ≥180 dB and 190 dB re 1 μPa_{rms}, respectively (NMFS 2000). These criteria have been used in establishing the exclusion (shut-down) zones planned for the proposed seismic survey. However, those criteria were established before there was any information about minimum received levels of sounds necessary to cause auditory impairment in marine mammals.

Recommendations for science-based noise exposure criteria for marine mammals, frequency-weighting procedures, and related matters were published by Southall et al. (2007). Those recommendations were never formally adopted by NMFS for use in regulatory processes and during mitigation programs associated with seismic surveys, although some aspects of the recommendations have been taken into account in certain environmental impact statements and small-take authorizations. In December 2013, NOAA made available for public comment new draft guidance for assessing the effects of anthropogenic sound on marine mammals (NOAA 2013a), taking at least some of the Southall et al. recommendations into account. The new acoustic guidance and procedures could account for the now-available scientific data on marine mammal TTS, the expected offset between the TTS and PTS thresholds, differences in the acoustic frequencies to which different marine mammal groups are sensitive (e.g., M-weighting or generalized frequency weightings for various groups of marine mammals, allowing for their functional bandwidths), and other relevant factors. At the time of preparation of this Final EA, the date of release of the final guidelines and how they would be implemented are unknown.

Nowacek et al. (2013) 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 § II and § IV[2], below). 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.

Non-auditory physical effects could 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. It is possible that some marine mammal species (i.e., beaked whales) could be especially susceptible to injury and/or stranding when exposed to strong transient sounds.

There is no definitive evidence that any of these effects occur even for marine mammals in close proximity to large arrays of airguns. However, 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. Additionally, a few cases of strandings in the general area where a seismic survey was ongoing have led to speculation concerning a possible link between seismic surveys and strandings (e.g., Castellote and Llorens 2013).

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 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 vs. 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. 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 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. However, exposure duration during the proposed survey 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 PSVOs stationed on the *Langseth* would also watch for sea turtles, and airgun operations would be shut down if a turtle enters the designated EZ.

(b) Possible Effects of Other Acoustic Sources

The Kongsberg EM 122 MBES, Knudsen Chirp 3260 SBP, and Teledyne OS75 75-kHz ADCP would be operated from the source vessel during the proposed survey, but not during transits. Information about this equipment was provided in § 2.2.3.1 of the PEIS (MBES, SBP) or § II of this Final EA (ADCP). A review of the anticipated potential effects (or lack thereof) of MBESs, SBPs, and pingers on marine mammals and sea turtles appears in § 3.4.4.3, § 3.6.4.3, § 3.7.4.3, and Appendix E of the PEIS.

There has been some recent attention given to the effects of MBES on marine mammals, as a result of a report issued in September 2013 by an IWC independent scientific review panel (ISRP) linking the operation of a MBES to a mass stranding of melon-headed whales (*Peponocephala electra*; Southall et al. 2013) off Madagascar. During May–June 2008, ~100 melon-headed whales entered and stranded in the Loza Lagoon system in northwest Madagascar at the same time that a 12-kHz MBES survey was being conducted ~65 km away off the coast. In conducting a retrospective review of available information on the event, an independent scientific review panel concluded that the Kongsberg EM 120 MBES was the most plausible behavioral trigger for the animals initially entering the lagoon system and eventually stranding. The independent scientific review panel, however, identified that an unequivocal conclusion on causality of the event was not possible because of the lack of information about the event and a number of potentially contributing factors. Additionally, the independent review panel report indicated that this incident was likely the result of a complicated confluence of environmental, social, and other factors that have a very low probability of occurring again in the future, but recommended that the potential be considered in environmental planning. The proposed survey design and environmental context of the proposed survey are quite different from the mass melon-headed whale stranding described by the ISRP. It should be noted that this event is the first known marine mammal mass stranding closely associated with the operation of a MBES. It is noted that leading scientific experts knowledgeable about MBES have expressed concerns about the independent scientific review panel analyses and findings (Bernstein 2013).

There is no available information on marine mammal behavioral response to MBES sounds (Southall et al. 2013) or sea turtle responses to MBES systems. Much of the literature on marine mammal response to sonars relates to the types of sonars used in naval operations, including Low-Frequency Active (LFA) sonars (e.g., Miller et al. 2012; Sivle et al. 2012) and Mid-Frequency Active (MFA) sonars (e.g., Tyack et al. 2011; Melcón et al. 2012; Miller et al. 2012; DeRuiter et al. 2013a,b; Goldbogen et al. 2013). However, the MBES sounds are quite different from naval sonars. Ping duration of the MBES is very short relative to naval sonars. Also, at any given location, an individual marine mammal would be in the beam of the MBES for much less time given the generally downward orientation of the beam and its narrow fore-aft beamwidth; naval sonars often use near-horizontally-directed sound. In addition, naval sonars have higher duty cycles. These factors would all reduce the sound energy received from the MBES relative to that from naval sonars.

Risch et al. (2012) found a reduction in humpback whale song in the Stellwagen Bank National Marine Sanctuary during Ocean Acoustic Waveguide Remote Sensing (OAWRS) activities that were carried out approximately 200 km away. The OAWRS used three frequency-modulated (FM) pulses centered at frequencies of 415, 734, and 949 Hz with received levels in the sanctuary 88–110 dB re 1 µPa. Deng et al (2014) measured the spectral properties of pulses transmitted by three 200-kHz echo sounders, and found that they generated weaker sounds at frequencies below the center frequency (90–130 kHz). These sounds are within the hearing range of some marine mammals, and the authors suggested that they could be strong enough to elicit behavioural responses within close proximity to the sources, although they would be well below potentially harmful levels.

Despite the aforementioned information that has recently become available, this Final EA is in agreement with the assessment presented in § 3.4.7, 3.6.7, and 3.7.7 of the PEIS that operation of MBESs, SBPs, and pingers is not likely to impact mysticetes or odontocetes, and is not expected to affect sea turtles, (1) given the lower acoustic exposures relative to airguns and (2) because the intermittent and/or narrow downward-directed nature of these sounds would result in no more than one or two brief ping exposures of any individual marine mammal or sea turtle given the movement and speed of the vessel. Also, for sea turtles, the associated frequency ranges are above their known hearing range.

(c) Other Possible Effects of Seismic Surveys

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.

Vessel noise from the *Langseth* could affect marine animals in the proposed survey area. Sounds produced by large vessels generally dominate ambient noise at frequencies from 20 to 300 Hz (Richardson et al. 1995). 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; Hatch et al. 2012). 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; Castellote et al. 2012; Melcón et al. 2012: Tyack and Janik 2013).

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 survey 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).

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. Some dolphin species approach moving vessels to ride the bow or stern waves (Williams et al. 1992). 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 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. Information on vessel strikes is reviewed in § 3.4.4.4 and § 3.6.4.4 of the PEIS. The 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. There has been no history of marine mammal vessel strikes with the R/V *Langseth*, or its predecessor, R/V *Maurice Ewing*.

Entanglement of sea turtles in seismic gear is also a concern. There have been reports of turtles being trapped and killed between the gaps in tail-buoys offshore from West Africa (Weir 2007); however, these tailbuoys are significantly different than those used on the *Langseth*. In April 2011, a dead olive ridley turtle was found in a deflector foil of the seismic gear on the R/V *Langseth* during equipment recovery at the conclusion of a survey off Costa Rica, where sea turtles were numerous. Such incidents are possible, but this is the first case of sea turtle entanglement in seismic gear for the R/V *Langseth*, which has been conducting seismic surveys since 2008, or for R/V *Maurice Ewing*, during 2003–2007. Towing the hydrophone streamer or other equipment during the proposed survey is not expected to significantly interfere with sea turtle movements, including migration, because sea turtles are not expected to be abundant in the survey area.

(d) Mitigation Measures

Several mitigation measures are built into the proposed seismic survey as an integral part of the planned activities. These measures include the following: ramp ups; typically two, however a minimum of one dedicated observer maintaining a visual watch during all daytime airgun operations; two observers for 30 min before and during ramp ups during the day and at night; PAM during the day and night to complement visual monitoring (unless the system and back-up systems are damaged during operations); and power downs (or if necessary shut downs) when mammals or turtles are detected in or about to enter designated EZ. These mitigation measures are described in § 2.4.4.1 of the PEIS and summarized earlier in this document, in § II(3). The fact that the 4 or 8-airgun subarray, because of its design, would 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.

(e) Potential Numbers of Cetaceans Exposed to Received Sound Levels ≥160 dB

All anticipated takes would be "takes by harassment" as described in § I, involving temporary changes in behavior. The mitigation measures to be applied would minimize the possibility of injurious takes. (However, as noted earlier and in the PEIS, there is no specific information demonstrating that injurious "takes" would occur even in the absence of the planned mitigation measures.) In the sections below, we describe methods to estimate the number of potential exposures to sound levels >160 dB re 1 μPa_{rms}, and present estimates of the numbers of marine mammals that could be affected during the proposed seismic program. The estimates are based on consideration of the number of marine mammals that could be disturbed appreciably by ~4900 km of seismic surveys off the coast of New Jersey. The main sources of distributional and numerical data used in deriving the estimates are described in the next subsection.

Basis for Estimating Exposure.—The estimates are based on a consideration of the number of marine mammals that could be within the area around the operating airgun array where the received levels (RLs) of sound >160 dB re 1 μPa_{rms} are predicted to occur (see Table 1). The estimated numbers are based on the densities (numbers per unit area) of marine mammals expected to occur in the area 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 are likely to overestimate the numbers actually exposed to the specified level of sounds. The overestimation is expected to be particularly large when dealing with the higher sound-level criteria, e.g., 180 dB re 1 μPa_{rms}, as animals are more likely to move away before RL reaches 180 dB than they are to move away before it reaches (for example) 160 dB re 1 μPa_{rms}. Likewise, they are less likely to approach within the ≥180 dB re 1 μPa_{rms} radius than they are to approach within the considerably larger ≥160 dB radius.

We used densities calculated from the U.S. Navy's "OPAREA Density Estimates" (NODE) database (DoN 2007). The cetacean density estimates are based on the NMFS-NEFSC aerial surveys conducted between 1998 and 2004; all surveys from New Jersey to Maine were conducted in summer (June–August). Density estimates were derived using density surface modeling of the existing line-transect data, which uses sea surface temperature, chlorophyll *a*, depth, longitude, and latitude to allow extrapolation to areas/seasons where survey data were not collected. For some species, there were not enough sightings to be able to produce a density surface, so densities were estimated using traditional line-transect analysis. The models and analyses have been incorporated into a web-based Geographic Information System (GIS) developed by Duke University's Department of Defense Strategic Environmental Research and Development Program (SERDP) team in close collaboration with the NMFS SERDP team (Read et al. 2009). We used the GIS to obtain densities in a polygon the size of the survey area for the 19 cetacean species in the model. The GIS provides minimum, mean, and maximum estimates for four seasons, and we have used the mean estimates for summer. Mean densities were used because the minimum and maximum estimates are for points within the polygon, whereas the mean estimate is for the entire polygon.

The estimated numbers of individuals potentially exposed presented below 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 density estimates calculated as described above and the estimates of the number of different individual marine mammals that potentially could be exposed to ≥160 dB re 1 μPa_{rms} during the seismic survey if no animals moved away from the survey vessel. The *Requested Take Authorization* is given in the far right column of Table 7. For species for which densities were not available but for which there were sighting records near the survey area, we have included a *Requested Take Authorization* for the mean group size for the species from Palka (2012).

It should be noted that the following estimates of exposures to various sound levels assume that the proposed survey would be completed; in fact, the ensonified areas calculated using the planned number of line-kilometers ***have been increased by 25%*** to accommodate lines that may need to be repeated, equipment testing, etc. As is typical during offshore ship surveys, inclement weather and equipment malfunctions are likely to cause delays and may limit the number of useful line-kilometers of seismic operations that can be undertaken. Also, any marine mammal sightings within or near the designated EZ would result in the shut down of seismic operations as a mitigation measure. Thus, the following estimates of the numbers of marine mammals potentially exposed to 160-dB re 1 μPa_{rms} sounds are precautionary and probably overestimate the actual numbers of marine mammals that could be involved. These estimates assume that there would be no weather, equipment, or mitigation delays, which is highly unlikely. In the NMFs EA and IHA, an additional 25% was added to account for the turnover of marine mammals in the survey area.

Consideration should be given to the hypothesis that delphinids are less responsive to airgun sounds than are mysticetes, as referenced in both the PEIS and "Summary of Potential Airgun Effects" of this document. The 160-dB (rms) criterion currently applied by NMFS, on which the following estimates are based, was developed based primarily on data from gray and bowhead whales. The estimates of "takes by harassment" of delphinids given below are thus considered precautionary. As noted previously,

TABLE 7. Densities and estimates of the possible numbers of individuals that could be exposed to ≥160 dB re 1 µPa_{rms} during the proposed seismic survey in the northwest Atlantic off New Jersey during July–mid August 2014. The proposed sound source consists of an 8-airgun subarray with a total discharge volume of ~1400 in^3. Species in italics are listed under the ESA as endangered. The column of numbers in boldface shows the numbers of Level B "takes" for which authorization is requested.

Species	Reported Density (#/1000 km^2) Read et al. (2009)[1]	Correction Factor[2]	Estimated Density (#/1000 km^2)	Ensonified Area (km^2)	Calculated Take[3]	% of Regional Pop'n[4]	Requested Level B Take Authorization
Mysticetes							
North Atlantic right whale	*0*		*0*	2502	*0*	*0*	***0***
Humpback whale	*0*		*0*	2502	*0*	*0.01*	***1[5]***
Minke whale	0		0	2502	0	0	**0**
Sei whale	*0.161*		*0.161*	2502	*0*	*0.01*	***1[5]***
Fin whale	*0.002*		*0.002*	2502	*0*	*<0.01*	***1[5]***
Blue whale	*0*		*0*	2502	*0*	*0*	***0***
Odontocetes							
Sperm whale	*7.06*		*7.06*	2502	*18*	*0.13*	***18***
Pygmy/dwarf sperm whale	0.001		0.001	2502	0	0.05	**2[5]**
Beaked whales[6]	0.124		0.124	2502	0	0.02	**3[5]**
Rough-toothed dolphin	0		0	2502	0	0	**0**
Bottlenose dolphin	111.3		111.3	2502	279	0.32	**279**
Pantropical spotted dolphin	0		0	2502	0	0	**0**
Atlantic spotted dolphin	36.11		36.11	2502	90	0.20	**90**
Spinner dolphin[7]	0		0	2502	0	0	**0**
Striped dolphin	0		0	2502	0	0.08	**46[5]**
Short-beaked common dolphin	0		0	2502	0	0.01	**18[5]**
White-beaked dolphin[7]	0		0	2502	0	0	**0**
Atlantic white-sided dolphin	0		0	2502	0	0.03	**15[5]**
Risso's dolphin	13.60		13.60	2502	34	0.19	**34**
Pygmy killer whale[7]	0		0	2502	0	N/A	**0**
False killer whale[7]	0		0	2502	0	N/A	**0**
Killer whale [7]	0		0	2502	0	N/A	**0**
Pilot whale	0.184		0.184	2502	0	<0.01	**9[5]**
Harbor porpoise	0		0	2502	0	0	**0**

[1] Densities are the mean values for the survey area, calculated from the SERDP model of Read et al. (2009)
[2] No correction factors were applied for these calculations
[3] Calculated take is estimated density (reported density x correction factor) multiplied by the 160-dB ensonified area (including the 25% contingency)
[4] Requested takes expressed as percentages of the larger regional populations, where available, for species that are at least partly pelagic; where not available (most odontocetes–see Table 3), Draft 2013 SAR population estimates were used; N/A means not available
[5] Requested take authorization was increased to group size from Palka (2012) for species for which densities were zero but that have been sighted near the proposed survey area
[6] May include Cuvier's, True's, Gervais', Sowerby's, or Blainville's beaked whales, or the northern bottlenose whale
[7] Atlantic waters not included in the SERDP model of Read et al. (2009)

in December 2013, NOAA made available for public comment new draft guidance for assessing the effects of anthropogenic sound on marine mammals (NOAA 2013a), although at the time of preparation of this Final EA, the date of release of the final guidelines and how they would be implemented are unknown. Available data suggest that the current use of a 160-dB criterion may be improved upon, as behavioral response may not occur for some percentage of odontocetes and mysticetes exposed to received levels >160 dB, while other individuals or groups may respond in a manner considered as taken to sound levels <160 dB (NMFS 2013a). 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 2013a).

Potential Number of Marine Mammals Exposed.—The number of different individuals that could be exposed to airgun sounds with received levels ≥160 dB re 1 μPa_{rms} on one or more occasions can be estimated by considering the total marine area that would be within the 160-dB radius around the operating seismic source on at least one occasion, along with the expected density of animals in the area. The number of possible exposures (including repeated exposures of the same individuals) can be estimated by considering the total marine area that would be within the 160-dB radius around the operating airguns, including areas of overlap. During the proposed survey, the transect lines are closely spaced relative to the 160-dB distance. Thus, the area including overlap is 38.3 times the area excluding overlap, so a marine mammal that stayed in the survey area during the entire survey could be exposed ~38 times, on average. However, it is unlikely that a particular animal would stay in the area during the entire survey. The numbers of different individuals potentially exposed to ≥160 dB re 1 μPa_{rms} were calculated by multiplying the expected species density times the anticipated area to be ensonified to that level during airgun operations excluding overlap. The area expected to be ensonified was determined by entering the planned survey lines into a MapInfo GIS, using the GIS to identify the relevant areas by "drawing" the applicable 160-dB buffer (see Table 1) around each seismic line, and then calculating the total area within the buffers.

Applying the approach described above, ~2002 km^2 (~2502 km^2 including the 25% contingency) would be within the 160-dB isopleth on one or more occasions during the proposed survey. Because this approach does not allow for turnover in the mammal populations in the area during the course of the survey, the actual number of individuals exposed may be underestimated, although the conservative (i.e., probably overestimated) line-kilometer distances used to calculate the area may offset this. Also, the approach assumes that no cetaceans would move away or toward the trackline as the *Langseth* approaches in response to increasing sound levels before the levels reach 160 dB. Another way of interpreting the estimates that follow is that they represent the number of individuals that are expected (in the absence of a seismic program) to occur in the waters that would be exposed to ≥160 dB re 1 μPa_{rms}.

The estimate of the number of individual cetaceans that could be exposed to seismic sounds with received levels ≥160 dB re 1 μPa_{rms} during the proposed survey is 421 (Table 7). That total includes 18 cetaceans listed as ***Endangered*** under the ESA, all sperm whales (0.13% of the regional population). Most (96%) of the cetaceans potentially exposed are delphinids; the bottlenose dolphin, Atlantic spotted dolphin, and Risso's dolphin are estimated to be the most common delphinid species in the area, with estimates of 279 (0.32% of the regional population), 90 (0.20%), and 34 (0.19%) exposed to ≥160 dB re 1 μPa_{rms}, respectively.

As part of the IHA process, NMFS reviewed the take estimates presented in Table 7 (Table 6 in the Draft EA). As part of NMFS's analyses process, however, they revised the take calculations for most species based upon the best available density information from SERDP SDSS and other sources and most recent population estimates from the 2014 SAR. These included some additional takes for blue, fin, humpback, minke, sei, and north Atlantic right whales; beaked whales; harbor porpoise; and gray, harbor, and harp seals, and other species. The IHA issued by NOAA therefore included slightly different estimates of the possible numbers of marine mammals exposed to sound levels ≥160 dB re 1 mPa during the proposed seismic survey than those presented in Table 7. For all but two of the species for which take has been issued, the takes remain less than 1% of the species' regional population or stock. Additionally, in the Biological Opinion, a different methodology to analyze for multiple exposures of endangered species was presented. NMFS does not provide specific guidance or requirements for IHA Applicants or for Section 7 ESA consultation for the development of take estimates and multiple exposure analysis, therefore variation in methodologies and calculations are likely to occur. The analysis presented in the NSF Final EA, however, is a methodology that has been used successfully for past NSF seismic surveys to generate take estimates and multiple exposures for the MMPA and ESA processes. Although NSF did not, and has not historically, estimated take for sea turtles, the Biological Opinion and ITS included analysis and take estimates for sea turtles (Appendix C). NSF and LDEO would adhere to the requirements of the Incidental Take Statement (ITS) and the IHA and associated take levels issued.

(f) Conclusions for Marine Mammals and Sea Turtles

The proposed seismic project would involve towing a 4 or 8-airgun subarray, with a total discharge volume of 700 in^3 or 1400 in^3, respectively, that introduces 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".

Cetaceans.**—**In § 3.6.7 and 3.7.7, the 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 mysticete and odontocete species in the NW Atlantic DAA; that Level A effects were highly unlikely; and that operations were unlikely to adversely affect ESA-listed species. The information from recent literature summarized in sections (a) to (c) above complements, and does not affect the outcome of the effects assessment as presented in the PEIS.

In this analysis, 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 estimates are likely overestimates of the actual number of animals that would be exposed to and would react to the seismic sounds. The reasons for that conclusion are outlined above. 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 cetaceans would be anticipated from the proposed activities. In decades of seismic surveys carried out by the *Langseth* and its predecessor, the R/V *Ewing*, Protected Species Observers (PSOs) and other crew members have seen no seismic sound-related marine mammal injuries or mortality. NMFS has issued an IHA, therefore, the proposed activity meets the criteria that the proposed activities, "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." In the Biological Opinion, NMFS has determined that the level of incidental take is not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat**.** The issuance of the IHA and the Biological Opinion further verifies that significant impacts would not be anticipated from the proposed activities.

Sea Turtles.**—**In § 3.4.7, the 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. Five species of sea turtle**—**the leatherback, loggerhead, green, hawksbill, and Kemp's ridley**—**could be encountered in the proposed survey area. Only foraging or migrating individuals would occur. Given the proposed activities, no significant impacts on sea turtles would be anticipated. In decades of seismic surveys carried out by the *Langseth* and its predecessor, the R/V *Ewing*, Protected Species Observers (PSOs) and other crew members have seen no seismic sound-related sea turtle injuries or mortality. In the Biological

Opinion, NMFS has determined that the level of incidental take is not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat**.** The Biological Opinion further verifies that significant impacts would not be anticipated from the proposed activities.

(2) Direct Effects on Invertebrates, Fish, Fisheries, and EFH and Their Significance

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. Relevant new studies on the effects of sound on marine invertebrates, fish, and fisheries that have been published since the release of the PEIS are summarized below.

(a) Effects of Sound on Fish and Invertebrates

Morley et al. (2013) considered invertebrates important when examining the impacts of anthropogenic noise. Although their review focused on terrestrial invertebrates, they noted that invertebrates, because of their short life cycle, can provide model systems for evaluating the effects of noise on individual fitness and physiology, thereby providing data that can be used to draw stronger, ecologically valid conclusions.

Solé et al. (2013) exposed four cephalopod species to low-frequency sound (50–400 Hz sweeps) 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 the shore crab *Carcinus maenas* was initially exposed to ship-noise playbacks, it consumed more oxygen, indicating a higher metabolic rate and potentially more stress; however, there were no changes in physiological responses to repeated exposure (Wale et al. 2013). Heavier crabs were more responsive than lighter crab (Wale et al. 2013). Celi et al. (2013) exposed red swamp crayfish (*Procambarus clarkia*) to linear sweeps with a frequency range of 0.1 to 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.

Fewtrell and McCauley (2012) exposed squid (*Sepioteuthis australis*), 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 squid and 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, and squid were seen to discharge ink or change their swimming pattern or vertical position in the water column.

Significant developmental delays and body abnormalities in scallop larvae exposed to seismic pulses were reported by de Soto et al. (2013). Their 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. Other studies conducted in the field have shown no effects on Dungeness crab larvae or snow crab embryos (Pearson et al. 1994; DFOC 2004 *in* NSF PEIS). Moreover, a major annual scallop-spawning period occurs in the Mid-Atlantic Bight during late summer to fall (August–October), although MacDonald and Thompson (1988 in NMFS 2004) reported scallop spawning off New Jersey during September–November. The timing of the proposed survey would not coincide with the time when scallops are spawning.

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 3D 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 prior to 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, which reduced the impacts of seismic sounds on the fish communities by exposing them to relatively low SELs (<187 dB re 1 $\mu Pa^2 \cdot s$).

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 temporary threshold shift (TTS) in any of the fish examined, even though the cumulative SELs had reached 190 dB re 1 $\mu Pa^2 \cdot s$.

Two spawning stocks that migrate inshore/offshore off New Jersey are the summer flounder and black sea bass. Summer flounder normally inhabit shallow coastal and estuarine waters in summer and move offshore in 60–150 m depth in fall and winter. They spawn in fall and winter (September–December) (MAFMC 1988), after the proposed seismic survey period. Black sea bass normally inhabit shallow waters in summer and move offshore and south in 75–165 m depth in fall and winter (MAFMC 1996). Spawning in the Middle Atlantic Bight population occurs primarily on the inner continental shelf from May to July during inshore migrations (NMFS 1999), largely before the survey's proposed timing. Therefore, spawning of at least two important species would not be affected to any great degree.

(b) 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. 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 their 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 fish activity, whereas longline catches decreased overall (Løkkeborg et al. 2012).

(c) Conclusions for Invertebrates, Fish and Fisheries

This newly available information does not affect the outcome of the effects assessment as presented in 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 and associated EFH. The PEIS also concluded that seismic surveys could cause temporary, localized reduced fish catch to some species, but that effects on commercial and recreation fisheries were not significant.

Most commercial fish catches by weight (almost all menhaden) and most recreational fishing trips off the coast of New Jersey (91% in 2012) occur in waters within 5.6 km from shore, although the highest-value fish (e.g., flounder and tuna) are caught offshore. The closest distance between the proposed survey and shore is >25 km, so interactions between the proposed survey and recreational and some commercial fisheries would be relatively limited. Also, most of the recreational fishery "hotspots" described in § III are to the north or south of the proposed survey area; however, there are several hotspots located within or very near the northwestern corner of the survey area. Two possible conflicts are the *Langseth*'s streamer entangling with fixed fishing gear and temporary displacement of fishers within the survey area, although it is relatively small (12 x 50 km). Fishing activities could occur within the survey area; however, a safe distance would need to be kept from the *Langseth* and the towed seismic equipment. Conflicts would be avoided and, therefore, impacts would be negligible, through communication with the fishing community and publication of a Notice to Mariners about operations in the area.

Survey activities are proposed to take place ~25–85 km (~14–46 n.mi.) off the coast of New Jersey. The area of the proposed survey is relatively small, ~600 km^2 (~324 n.mi.^{2}). If we were to make a comparison of that survey area to blocks in New York City, it would essentially be equivalent to an area of 8 by 22 city blocks. The overall area of NJ marine waters from shore to the EEZ encompasses ~210,768 km^2 (~113,805 n.mi.^{2}). Thus the proposed survey area represents less than one half percent (0.28%) of the area of waters from the NJ shore to the EEZ (600 km^2/210,768 km^2). The survey area plus the largest mitigation zone (8.15 km) would represent less than one percent (0.88%) of the area of waters from the NJ shore to the EEZ (1159 km^2/210,768 km^2). The seismic survey is proposed to take place for ~30 days within the July to mid-August timeframe in 2014, not over the entire time that would be allowable under the IHA. As noted previously, fishing activities would not be precluded from operating in the proposed survey area. Any impacts to fish species would occur very close to the survey vessel and would be temporary.

Given the proposed activities, no significant impacts on marine invertebrates, marine fish, their EFH, and their fisheries would be anticipated. In decades of seismic surveys carried out by the *Langseth* and its predecessor, the R/V *Ewing*, Protected Species Observers (PSOs) and other crew members have seen no seismic sound-related fish or invertebrate injuries or mortality. Furthermore, past seismic surveys in the proposed survey area (2002, 1998, 1996, 1990) did not result in noticeable effects on commercial or recreational fish catches, based on a review of multi-year NMFS fish catch data in the months when seismic surveys were undertaken.

NSF consulted with the NMFS Greater Atlantic Regional Fisheries Office under the Magnuson-Stevens Act for EFH (see below "Coordination with Other Agencies and Processes" for further details). The NMFS Greater Atlantic Regional Fisheries Office concluded that the proposed activities may at some level adversely affect EFH, however, no specific conservation measures were identified for the proposed activities.

(3) Direct Effects on Seabirds and Their Significance

Effects of seismic sound and other aspects of seismic operations (collisions, entanglement, and ingestion) on seabirds are discussed in § 3.5.4 of the PEIS. The 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, no significant impacts on seabirds would be anticipated. In decades of seismic surveys carried out by the *Langseth* and its predecessor, the R/V *Ewing*, Protected Species Observers (PSOs) and other crew members have seen no seismic sound-related seabird injuries or mortality. Furthermore, NSF received concurrence from USFWS that the proposed activities "may affect" but "are not likely to adversely affect" species under their jurisdiction (Appendix F).

(4) Indirect Effects on Marine Mammals, Sea Turtles, and Their Significance

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

During the proposed seismic survey, only a small fraction of the available habitat would be ensonified at any given time. Disturbance to fish species and invertebrates would be short-term, and fish would return to their pre-disturbance behavior once the seismic activity ceased. Thus, the proposed survey would have little impact on the abilities of marine mammals or sea turtles to feed in the area where seismic work is planned. No other indirect effects on other species would be anticipated.

(5) Direct Effects on Recreational SCUBA Divers and Dive Sites and Their Significance

No significant impacts on dive sites, including shipwrecks, would be anticipated. Airgun sounds would have no effects on solid structures. The only potential effects could be temporary displacement of fish and invertebrates from the structures.

Significant impacts on, or conflicts with, divers or diving activities would be avoided through communication with the diving community before and during the survey and publication of a Notice to Mariners about operations in the area. In particular, dive operators with dives scheduled on the shipwrecks *Lillian* and *Maurice Tracy* during the survey would be contacted directly. Those dive sites represent only a very small percentage of the recreational dive sites in New Jersey waters.

(6) Cumulative Effects

The results of the cumulative impacts analysis in the PEIS indicated that there would not be any significant cumulative effects to marine resources from the proposed NSF-funded marine seismic research. However, the 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 survey that may result in cumulative impacts to environmental resources." Here we focus on activities that could impact animals specifically in the proposed survey area (research activities, vessel traffic, and commercial fisheries).

Additionally, the NMFS EA Cumulative Effects Section on Climate Change is incorporated into this Final EA by reference as if fully set forth herein.

(a) Past and future research activities in the area

Most recently, as part of the Integrated Ocean Drilling Program (IODP), the riserless drilling vessel *JOIDES Resolution* conducted scientific research and drilling on Expedition 313, New Jersey Shallow Shelf, at several sites off New Jersey during 30 April–17 July 2008. In the more distant past, there have been other scientific drilling activities in the vicinity. There have also been numerous prior seismic surveys, all of which were 2-D, ranging from poor quality, low resolution data collected in 1979 to the most recent, excellent quality, high resolution but shallow penetration data from 2002. These include surveys with a 6-airgun, 1350-in^3 array in 1990; with a single, 45-in^3 GI Gun in 1996 and 1998; and with two 45-in^3 GI Guns in 2002. No seismic sound-related marine mammal injuries or mortality, or impacts to fish and seabirds were observed by crew or scientists during these past seismic surveys in the proposed survey area. Other scientific research activities may be conducted in this region in the future; however, no other marine geophysical surveys are proposed at this specific site using the *Langseth* in the foreseeable future. At the present time, the proponents of the survey are not aware of other similar research activities planned to occur in the proposed survey area during the July–mid August 2014 timeframe, but research activities planned by other entities are possible, although unlikely.

In 2014, the *Langseth* may also support an NSF-proposed 2-D seismic survey off the coast of North Carolina to study the U.S. mid-Atlantic margin. That cruise would last ~38 days and cover ~4900 km of track lines. Additionally, the *Langseth* may conduct 2-D seismic surveys for ~3 weeks in each of 2014 and 2015 for the USGS in support of the delineation of the U.S. Extended Continental Shelf (ECS) along the east coast. Separate EAs are being prepared for those activities, and neither project would overlap with the proposed survey area.

(b) Vessel traffic

Based on data available through the Automated Mutual-Assistance Vessel Rescue (AMVER) system managed by the U.S. Coast Guard, 15–49 commercial vessels per month travelled through the proposed survey area during the months of June and July from 2008 to 2013, and for each month in 2012 and 2013 (2013 data are available for January–June). Over 50 commercial vessels per month were recorded during this time closer to shore (particularly around New York City), to the immediate west and northwest of the proposed survey area (USCG 2013).

Live vessel traffic information is available from MarineTraffic (2013), including vessel names, types, flags, positions, and destinations. Various types of vessels were in the general vicinity of the proposed survey area when MarineTraffic (2013) was accessed on 16 and 21 September 2013, including fishing vessels (17), pleasure craft (3), tug/towing vessels (8), cargo vessels (9), and fishery patrol and passenger vessels (1 of each). All but the cargo vessels were U.S.A.-flagged.

The total transit distance (~5200 km) by L-DEO's vessel *Langseth* would be minimal relative to total transit length for vessels operating in the proposed survey area during July – mid August. Thus, the projected increases in vessel traffic attributable to implementation of the proposed activities would constitute only a negligible portion of the total existing vessel traffic in the analysis area, and only a negligible increase in overall ship disturbance effects on marine mammals.

(c) Marine Mammal Disease

As discussed in § III, since July 2013, an unusually high number of dead or dying bottlenose dolphins have washed up on the mid-Atlantic coast from New York to Florida. NOAA noted that the triggers for disease outbreaks are unknown, but that contaminants and injuries may reduce the fitness of dolphin populations by stressing the immune system. Morbillivirus outbreaks can also be triggered by a drop in the immunity of bottlenose dolphin populations if they have not been exposed to the disease over time, and natural immunity wanes (NOAA 2013b). The last morbillivirus mortality event occurred in 1987–1988, when more than 740 bottlenose dolphins died along the mid-Atlantic coast from New Jersey to Florida (NOAA 2013b). During that mortality event, fungal, bacterial, and mixed bacterial and fungal pneumonias were common in the lungs of 79 dolphins that were examined, and the frequent occurrence of the fungal and bacterial infections in dolphins that also were infected by morbillivirus was consistent with morbillivirus-induced immunosuppression resulting in secondary infections (Lipscomb et al. 1994). Dr. Teri Knowles of NOAA noted that if the current outbreak evolves like the one in 1987–1988, "we're looking at mortality being higher and morbillivirus traveling southwards and continuing until May 2014." She also speculated that environmental factors, such as heavy metal pollution and sea surface temperature changes, could also play a role in the current outbreak (National Geographic Daily News 2013). It seems unlikely that the short-term behavioral disturbance that could be caused by the proposed seismic survey, especially for dolphins, would contribute to the development or continuation of a morbillivirus outbreak. Although NSF has contacted the NMFS Greater Atlantic Regional Fisheries Office Marine Mammal Response Coordinator, strandings from the proposed activities would not be anticipated. Therefore, the proposed activities would not be anticipated to increase the level of coordination necessary for stranding networks and associated budgets or impact the NJ Animal Health Diagnostic Laboratory budget, which has been involved with funding efforts related to the recent bottlenose dolphin morbillivirus mortality event.

(d) Fisheries

The commercial and recreational 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 removal of prey items, noise, potential entanglement (Reeves et al. 2003), and the direct and indirect removal of prey items. In U.S. waters, numerous cetaceans (mostly delphinids) and pinnipeds suffer serious injury or mortality each year from fisheries; for example, for the species assessed by Waring et al. (2013), average annual fishery-related mortality during 2006–2010 in U.S. Atlantic waters included 164 common dolphins, 212 Atlantic white-sided dolphins, 791 harbor porpoises, and 1466 harbor, gray, and harp seals. There may be some localized avoidance by marine mammals of fishing vessels near the proposed seismic survey area. L-DEO's operations in the proposed survey area are also limited (duration of ~1 month), and the combination of L-DEO's operations with the existing commercial and recreational fishing operations is expected to produce only a negligible increase in overall disturbance effects on marine mammals and sea turtles.

(e) Military Activity

The proposed survey is located within the U.S. Navy's Atlantic City Range Complex (ACRC). The Boston, Narragansett Bay, and Atlantic City range complexes are collectively referred to as the Northeast Range Complexes. The types of activities that could occur in the ACRC would include the use of active sonar, gunnery events with both inert and explosive rounds, bombing events with both inert and explosive bombs, and other similar events. The ACRC includes special use airspace, Warning Area W-107. The ACRC is an active area, but there is typically relatively limited activity that occurs there. There has only been limited activity in the past, and as of August 2013, there was nothing forecast for the next few months. L-DEO and NSF are coordinating, and would continue to coordinate, with the U.S. Navy to ensure there would be no conflicts.

(f) Oil and Gas Activities

Oil and gas activities are managed by BOEM. If BOEM were interested in oil and gas development activities in the survey area, BOEM would need to prepare the appropriate analyses under NEPA, followed by other consultation processes under such federal statutes as the MMPA, ESA, EFH, and CZMA. The proposed survey site is outside of the BOEM Atlantic Outer Continental Shelf Proposed Geological and Geophysical (G&G) Activities in the Mid-Atlantic and South Atlantic Planning Areas (BOEM 2014). The current BOEM mid-Atlantic and South Atlantic activities would be the preliminary surveys that are necessary for BOEM and industry to determine resource potential, and to provide siting information for renewable energy and marine minerals activities; lease sales in those areas have not yet been considered. The final BOEM Record of Decision for the proposed action has not yet been issued. Proposed BOEM activities, if they did go forward, are not projected to begin until 2017.

Whereas it is theoretically possible that the oil and gas industry may be interested in the architecture of the passive margin area in the survey region for application to other locations (Appendix B, page C-15), there are no known interests for G&G activities, including oil and gas exploration, in or around the proposed survey site. The proposed seismic survey is not related to nor would it lead to offshore drilling; the proposed activities would evaluate sea level change as described in the Draft EA and there are no additional activities proposed beyond those by the PIs or NSF (i.e., there are no proposed oil and gas exploration activities associated with the proposed activities). In fact, the proposed survey activities are only imaging approximately one kilometer below the seafloor, which would be a shallower depth than would be necessary for oil and gas industry interests. Thus, the proposed activities would not be useful for oil and gas exploration in the proposed survey area.

Seismic surveys in support of research activities have occurred in the survey area in the recent past (2002, 1998, 1996, 1990). Additionally, NJDEP conducted a seismic survey (boomer/sparker source) in 1985 off the coast of New Jersey (Waldner and Hall 1991). Oil and gas activities in the proposed survey area have not resulted from these similar research seismic surveys. Therefore, it would not be logical to assume that the proposed research seismic survey would result in oil and gas development.

Given the potential distance from any future BOEM G&G activities in the region and separation in time with the proposed activities, no cumulative effects would be anticipated.

(7) Unavoidable Impacts

Unavoidable impacts to the species of marine mammals, sea turtles, seabirds, fish, and invertebrates occurring in the proposed survey 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, would be a temporary phenomenon that does not involve injury, and would be 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, sea turtles, seabirds, fish, and invertebrates or on the populations to which they belong. Effects on recruitment or survival would be expected to be (at most) negligible.

(8) Public Involvement and Coordination with Other Agencies and Processes

NSF posted the Draft Environmental Assessment (Draft EA) on the NSF website for a 30 day public comment period from 3 February to 3 March 3, 2014, but received no comments during the open comment period. As noted below, public comments were received during the NMFS IHA process, and although not received as part of the NSF NEPA process, NSF considered the responses with respect to the information included in the Draft EA. The public comments received for the IHA process are included in Appendix G and are summarized in the NMFS EA (Appendix E). After consideration of public comments received during the NMFS IHA public comment period and discussions during MMPA and ESA consultations with NMFS, refinements to the information about fisheries were made in this NSF Final EA, and additional material was included, such as summary of scientific literature published since the PEIS issued in 2011 and information regarding shipwrecks and SCUBA diving. The new information included in this NSF Final EA, however, did not alter the overall conclusions of the Draft EA and remained consistent with the PEIS. This Final EA was prepared by LGL on behalf of L-DEO and NSF pursuant to NEPA. Potential impacts to endangered species and critical habitat were also assessed in the document; therefore, it was used to coordinate and support other consultations with Federal agencies as required and noted below.

Endangered Species Act (ESA)

NSF engaged in formal consultation with NMFS and informal consultation with USFWS pursuant to Section 7 of the ESA. NSF received concurrence from USFWS that the proposed activities "may affect" but "are not likely to adversely affect" species under their jurisdiction (Appendix F). Mitigation measures would include power-downs/shut-downs for foraging endangered or threatened seabirds. NMFS issued a Biological Opinion and an Incidental Take Statement (Appendix C) on 1 July 2014 for the proposed activities and consultation was concluded. For operational purposes and coordination with monitoring and mitigation measures required under the IHA, the Exclusion Zone for sea turtles and foraging seabirds would be expanded to the 177db isopleth.

Marine Mammal Protection Act (MMPA)

L-DEO submitted to NMFS an IHA pursuant to the MMPA. NMFS issued in the Federal Register a Notice of Intent to issue an IHA for the survey and 30-day public comment period. In response to public comment request, NMFS extended the public comment period an additional 30 days, for a total of 60 days. As noted above, public comments were received as part of the IHA process (Appendix G) and, although not received as part of the NSF NEPA process, NSF considered the responses with respect to the information included in the Draft EA. NMFS prepared a separate EA for its federal action of issuing an IHA; NMFS's EA (Appendix E) is hereby incorporated by reference in this NSF Final EA as appropriate and where indicated. NMFS issued an IHA on 1 July 2014 (Appendix D). The IHA stipulated monitoring and mitigation measures, including additional mitigation measures beyond those proposed in the NSF Draft EA and IHA Application, such as an expanded Exclusion Zone (177dB isopleth) and a one minute shot interval for the 40 in^3 mitigation airgun. NSF and LDEO would adhere to the IHA requirements for the proposed action.

NMFS Marine Mammal Stranding Program

Although marine mammal strandings were not anticipated as a result of the proposed activities, during ESA Section 7 and MMPA consultation with NMFS it was recommended that the NMFS Greater Atlantic Regional Fisheries Office Marine Mammal Response Coordinator be contacted regarding the proposed activity. Both NMFS and NSF made contact with that coordinator. Should any marine mammal strandings occur during the survey, per the IHA, NMFS and the NMFS Greater Atlantic Regional Fisheries Office Marine Mammal Response Coordinator would be contacted.

Magnuson Stevens Act - Essential Fish Habitat (EFH)

The Magnuson Stevens Act requires that a Federal action agency consult with NMFS for actions that "may adversely affect" EFH. Although adverse effects on EFH, including a reduction in quantity or quality of EFH, were not anticipated by the proposed activities, NSF contacted the EFH Regional Coordinator of the NOAA Greater Atlantic Regional Fisheries Office regarding the proposed activities. The EFH Regional Coordinator concluded in a letter dated 18 June 2014, however, that some level of adverse effects to EFH may occur as a result of the proposed activities (Appendix H). Additional research and monitoring to gain a better understanding of the potential effects that seismic surveys may have on EFH, federal managed species, their prey, and other NOAA trust resources was recommended for future NSF activities. No project-specific EFH conservation recommendations were provided, however, and consultation was concluded.

Coastal Zone Management Act (CZMA)

Per the requirements of the CZMA, NSF reviewed the New Jersey Coastal Management Program (CMP) Federal Consistency Listings and determined that the proposed activity was unlisted. NSF contacted NOAA's Office of Ocean and Coastal Resource Management (OCRM) to discuss CZMA implications regarding the proposed project. NSF, OCRM, and the New Jersey Department of Environmental Protection (NJDEP) engaged in several conversations regarding the proposed activity. On 20 May, OCRM received by email NJDEP's request for approval to review the NSF assistance to Rutgers as an unlisted activity under Subpart F and for OCRM to concur that the operation of the vessel was subject to Subpart C (Appendix I). OCRM submitted a letter to NSF requesting information about the proposed project (Appendix J). NSF provided a response to OCRM per request, also noting NSF's position that the proposed activities were applicable to Supbart F and that the NJDEP request to review was untimely (Appendix K). NSF further set forth its position that the operation of the vessel was pursuant to a cooperative agreement that had been approved years ago, and, thus, the time for consistency review had passed. In response to the NJDEP request, OCRM concluded in its letter dated 18 June 2014 that the proposed project falls under Subpart F, not Subpart C, of the regulations implementing CZMA and determined that the NJDEP request to review the project under Subpart F was untimely (Appendix L). No further action is required by NSF or the PIs under CZMA.

Alternative Action: Another Time

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 (~35 days in July–mid August) are the dates when the personnel and equipment essential to meet the overall project objectives are available; if the date of the cruise were changed, it is likely that the *Langseth* would not be available and, thus, the purpose and need of the proposed activities could not be met. 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 on the *Langseth* for 2014 and beyond.

The weather in the mid-Atlantic Ocean was taken into consideration when planning the proposed activities. The mid-Atlantic Ocean off New Jersey can be challenging to operate during certain times of year, precluding the ability to safely tow seismic gear. Whereas conducting the survey at an alternative time is a viable alternative if the *Langseth*, personnel, and essential equipment were available, because of the weather conditions, it would not be viable to conduct a seismic survey in winter months off the coast of New Jersey.

Marine mammals and sea turtles are expected to be found throughout the proposed survey area and throughout the time during which the project would occur. 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. Some migratory species are expected to be farther north at the time of the survey, so the survey timing is beneficial for those species (see § III, above). In particular, migration of the North Atlantic right whale occurs mostly between November and April, and the survey is timed to avoid those months. Accordingly, the alternative action would likely result in either a failure to meet the purpose and need of the proposed activities or it would raise the risk of causing impacts to species such as the North Atlantic right whale.

No Action Alternative

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. Research that would contribute to the understanding of the response of nearshore environments to changes in elevation of global sea level would be lost and greater understanding of Earth processes would not be gained. The "No Action" alternative could also, in some circumstances, result in significant delay of other studies that would be planned on the *Langseth* for 2014 and beyond, depending on the timing of the decision. Not conducting this cruise (no action) would result in less data and support for the academic institutions involved. Data collection would be an essential first step for a much greater effort to analyze and report information for the significant topics indicated. The field effort would provide material for years of analyses involving multiple professors, students, and technicians. The lost opportunity to collect valuable scientific information would be compounded by lost opportunities for support of research infrastructure, training, and professional career growth. The research goals and objectives cannot be achieved using existing scientific data. Existing seismic profiles occur at intervals too coarse to achieve the proposed scientific goals of this project. Both the larger spacing and the limitations inherent in processing 2-D seismic data preclude identification of key features of the past margin such as river or delta channels and shoreline adjustments. Only dense and 3-D seismic acquisition and processing can provide continuity of imaging to enable confident identification of these features, whose distributions are expected to evolve throughout the time period recorded in the sediments targeted. The no Action Alternative would not meet the purpose and need for the proposed activities.

V. LIST OF PREPARERS

LGL Ltd., environmental research associates

William E. Cross, M.Sc., King City, Ont.*
Meike Holst, M.Sc., Sidney, B.C.*
Sarah Penney, M.Sc., St. John's, Nfld.*
Mark Fitzgerald, B.Sc., King City, Ont.
William R. Koski, M.Sc., King City, Ont.
W. John Richardson, Ph.D., King City, Ont.

Lamont Doherty Earth Observatory

Helene Carton, Ph.D., Palisades, NY

National Science Foundation

Holly E. Smith, M.A., Arlington, VA

* Principal preparers of this specific document. Others listed above contributed to a lesser extent, or contributed substantially to previous related documents from which material has been excerpted.

VI. LITERATURE CITED

Aguilar, A. 1986. A review of old Basque whaling and its effect on the right whales of the North Atlantic. **Rep. Int. Whal. Comm. Spec. Iss**. 10:191-199.

Aguilar-Soto, N., M. Johnson, P.T. Madsen, P.L. Tyack, A. Bocconcelli, and J.F. Borsani. 2006. Does intense ship noise disrupt foraging in deep-diving Cuvier's beaked whales (*Ziphius cavirostris*)? **Mar. Mamm. Sci.** 22(3):690-699.

American Fishing Contests. 2014. American Fishing Contests. Accessed in April 2014 at http://www.americanfishingcontests.com/Contest/List.aspx?Rank=Month&Month=6&State=NJ&Page=1.

Baker, C.S. and L.M. Herman. 1989. Behavioral responses of summering humpback whales to vessel traffic: experimental and opportunistic observations. NPS-NR-TRS-89-01. Rep. from Kewalo Basin Mar. Mamm. Lab., Univ. Hawaii, Honolulu, HI, for U.S. Natl. Park Serv., Anchorage, AK. 50 p. NTIS PB90-198409.

Baker, C.S., L.M. Herman, B.G. Bays, and W.F. Stifel. 1982. The impact of vessel traffic on the behavior of humpback whales in southeast Alaska. Rep. from Kewalo Basin Mar. Mamm. Lab., Honolulu, HI, for U.S. Natl. Mar. Fish. Serv., Seattle, WA. 78 p.

Baker, C.S., L.M. Herman, B.G. Bays, and G.B. Bauer. 1983. The impact of vessel traffic on the behavior of humpback whales in southeast Alaska: 1982 season. Rep. from Kewalo Basin Mar. Mamm. Lab., Honolulu, HI, for U.S. Nat. Mar. Mamm. Lab., Seattle, WA. 30 p. + fig., tables.

Barry, S.B., A.C. Cucknell and N. Clark. 2012. A direct comparison of bottlenose dolphin and common dolphin behaviour during seismic surveys when airguns are and are not being utilised. p. 273-276 *In*: A.N. Popper and A. Hawkins (eds.), The effects of noise on aquatic life. Springer, New York, NY. 695 p.

Beaudin Ring, J. 2002. Right whale sightings and trackline data for the mid Atlantic by month, 1974–2002. Mid-Atlantic sightings archive. Accessed at http://www.nero.noaa.gov/shipstrike/doc/Historical%20sightings.htm on 3 September 2013.

Bernard, H.J. and S.B. Reilly. 1999. Pilot whales *Globicephala* Lesson, 1828. p. 245-279 *In*: S.H. Ridgway and R. Harrison (eds.), Handbook of marine mammals, Vol. 6: The second book of dolphins and the porpoises. Academic Press, San Diego, CA. 486 p.

Bernstein, L. 2013. The Washington Post: Health, Science, and Environment. Panel links underwater mapping sonar to whale stranding for first time. Published 6 October 2013. Accessed in April 2014 at http://www.washingtonpost.com/national/health-science/panel-links-underwater-mapping-sonar-to-whale-stranding-for-first-time/2013/10/06/52510204-2e8e-11e3-bbed-a8a60c601153_story.html.

BirdLife International. 2013. Species factsheet: *Charadrius melodus*. Accessed on 5 September 2013 at http://www.birdlife.org/datazone/speciesfactsheet.php?id=3127.

Blackwell, S.B., C.S. Nations, T.L. McDonald, C.R. Greene, Jr., A.M. Thode, M. Guerra, and A.M. Macrander. 2013. Effects of airgun sounds on bowhead whale calling rates in the Alaskan Beaufort Sea. **Mar. Mamm. Sci.** DOI: 10.1111/mms.12001.

BOEM (Bureau of Ocean Energy Management). 2014. Atlantic OCS proposed geological and geophysical activities: Mid-Atlantic and South Atlantic Planning Areas. Final Programmatic Environmental Impact Statement. U.S. Department of the Interior. Prepared under GSA Task Order No. M11PD00013 by CSA Ocean Sciences Inc. February 2014.

Breitzke, M. and T. Bohlen. 2010. Modelling sound propagation in the Southern Ocean to estimate the acoustic impact of seismic research surveys on marine mammals. **Geophys. J. Int.** 181(2):818-846.

Bui, S., F. Oppedal, Ø.J. Korsøen, D. Sonny, and T. Dempster. 2013. Group behavioural responses of Atlantic salmon (*Salmo salar* L.) to light, infrasound and sound stimuli. **PLoS ONE** 8(5):e63696. doi:10.1371/journal.pone.0063696.

Carwardine, M. 1995. Whales, dolphins and porpoises. Dorling Kindersley Publishing, Inc., New York, NY. 256 p.

Castelao, R., S. Glenn, O. Schofield, R. Chant, J. Wilkin, and J. Kohut. 2008. Seasonal evolution of hydrographic fields in the central Middle Atlantic Bight from glider observations. **Geophys. Res. Lett.** 35. doi:10.1029/2007GL032335.

Castellote, M. and C. Llorens. 2013. Review of the effects of offshore seismic surveys in cetaceans: are mass strandings a possibility? Abstr. 3rd Int. Conf. Effects of Noise on Aquatic Life, Budapest, Hungary, August 2013.

Castellote, M., C.W. Clark, and M.O. Lammers. 2012. Acoustic and behavioural changes by fin whales (*Balaenoptera physalus*) in response to shipping and airgun noise. **Biol. Conserv**. 147(1):115-122.

Cato, D.H., M.J. Noad, R.A. Dunlop, R.D. McCauley, C.P. Salgado Kent, N.J. Gales, H. Kniest, J. Noad, and D. Paton. 2011. Behavioral response of Australian humpback whales to seismic surveys. **J. Acoust. Soc. Am.** 129(4):2396.

Cato, D.H., M.J. Noad, R.A. Dunlop, R.D. McCauley, N.J. Gales, C.P. Salgado Kent, H. Kniest, D. Paton, K.C.S. Jenner, J. Noad, A.L. Maggi, I.M. Parnum, and A.J. Duncan. 2012. Project BRAHSS: Behavioural response of Australian humpback whales to Seismic surveys. Proc. Austral. Acoust. Soc., 21–23 Nov. 2012, Fremantle, Australia. 7 p.

Cato, D.H., M. Noad, R. Dunlop, R.D. McCauley, H. Kniest, D. Paton, C.P. Salgado Kent, and C.S. Jenner. 2013. Behavioral responses of humpback whales to seismic air guns. Proc. Meet. Acoust. 19(010052).

Cattanach, K.L., J. Sigurjónsson, S.T. Buckland, and T. Gunnlaugsson. 1993. Sei whale abundance in the North Atlantic, estimated from NASS-87 and NASS-89 data. **Rep. Int. Whal. Comm.** 43:315-321.

Celi, M., F. Filiciotto, D. Parrinello, G. Buscaino, M.A. Damiano, A. Cuttitta, S. D'Angelo, S. Mazzola, and M. Vazzana. 2013. Physiological and agonistic behavioural response of *Procambarus clarkii* to an acoustic stimulus. **J. Exp. Biol.** 216:709-718.

Cerchio, S., S. Strindberg, T. Collins, C. Bennett, and H. Rosenbaum. 2014. Seismic surveys negatively affect humpback whale singing activity off northern Angola. PLoS ONE 9(3):e86464. doi:10.1371/journal.pone.0086464.

CetaceanHabitat. 2013. Directory of cetacean protected areas around the world. Accessed on 30 August 2013 at http://www.cetaceanhabitat.org/launch_intro.php.

CETAP (Cetacean and Turtle Assessment Program). 1982. A characterization of marine mammals and turtles in the mid- and north Atlantic areas of the USA outer continental shelf. Cetacean and Turtle Assessment Program, University of Rhode Island. Final Report #AA51-CT8-48 to the Bureau of Land Management, Washington, DC. 538 p.

Clapham, P.J., L.S. Baraff, C.A. Carlson, M.A. Christian, D.K. Mattila, C.A. Mayo, M.A. Murphy, and S. Pittman. 1993. Seasonal occurrence and annual return of humpback whales, *Megaptera novaeangliae*, in the southern Gulf of Maine. **Can. J. Zool.** 71:440-443.

Clark, C.W. 1995. Application of U.S. Navy underwater hydrophone arrays for scientific research on whales. **Rep. Int. Whal. Comm.** 45:210-212.

Clark, C.W. and G.C. Gagnon. 2006. Considering the temporal and spatial scales of noise exposures from seismic surveys on baleen whales. Working Pap. SC/58/E9. Int. Whal. Comm., Cambridge, U.K. 9 p.

Clark, C.W., W.T. Ellison, B.L. Southall, L. Hatch, S.M. Van Parijs, A. Frankel, and D. Ponirakis. 2009. Acoustic masking in marine ecosystems: intuitions, analysis, and implication. **Mar. Ecol. Prog. Ser.** 395:201-222.

Cole T., A. Glass, P.K. Hamilton, P. Duley, M. Niemeyer, C. Christman, R.M. Pace III, and T. Fraiser. 2009. Potential mating ground for North Atlantic right whales off the Northeast USA. Abstr. 18th Bienn. Conf. Biol. Mar. Mamm., Québec City, 12–16 Oct. 2009. 58 p.

Danton, C. and R. Prescott. 1988. Kemp's ridley in Cape Cod Bay, Massachusetts–1987 field research. p. 17-18 *In*: B.A. Schroeder (compiler), Proc. 8th Ann. Worksh. Sea Turtle Conserv. Biol. NOAA Tech. Memo. NMFS-SEFC-214. 123 p.

Deng, Z.D., B.L. Southall, T.J. Carlson, J. Xu, J.J. Martinez, M.A. Weiland, and J.M. Ingraham. 2014. 200 kHz commercial sonar systems generate lower frequency side lobes audible to some marine mammals. PLoS ONE 9(4): e95315. doi:10.1371/journal.pone.0095315.

DeRuiter, S.L., I.L. Boyd, D.E. Claridge, C.W. Clark, C. Gagnon, B.L. Southall, and P.L. Tyack. 2013a. Delphinid whistle production and call matching during playback of simulated military sonar. **Mar. Mamm. Sci.** 29(2):E46-E59.

DeRuiter, S.L., B.L. Southall, J. Calambokidis, W.M.X. Zimmer, D. Sadykova, E.A. Falcone, A.S. Friedlaender, J.E. Joseph, D. Moretti, G.S. Schorr, L. Thomas, and P.L. Tyack. 2013b. First direct measurements of behavioural responses by Cuvier's beaked whales to mid-frequency active sonar. **Biol. Lett.** 9:20130223. http://dx.doi.org/10.1098/rsbl.2013.0223.

de Soto, N.A, Delorme, N., Atkins, J., Howard, S., William, J., and M. Johnson. Anthropogenic noise causes body malformations and delays development in marine larvae. Sci. Rep. 3:2831. doi: 10.1038/srep02831.

Diebold, J.B., M. Tolstoy, L. Doermann, S.L. Nooner, S.C. Webb, and T.J. Crone. 2010. R/V Marcus G. Langseth seismic source: modeling and calibration. **Geochem. Geophys. Geosyst.** 11(12), Q12012, doi:10.1029/2010GC003126. 20 p.

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

DoN (Department of the Navy). 2005. Marine resource assessment for the Northeast Operating Areas: Atlantic City, Narragansett Bay, and Boston. Rep. from GeoMarine Inc., Newport News, VA, for Naval Facilities Engineering Command, Atlantic; Norfolk, VA. Contract No. N62470-02-D-9997, Task Order No. 0018. 556 p.

DoN (Department of Navy). 2007. Navy OPAREA density estimates (NODE) for the Northeast OPAREAs: Boston, Narragansett Bay, and Atlantic City. Rep. from GeoMarine Inc., Plano, TX, for Department of the Navy, Naval Facilities Engineering Command, Atlantic, Norfolk, VA. Contract N62470-02-D-9997, Task Order 0045.

Eckert, K.L. 1995a. Leatherback sea turtle, *Dermochelys coriacea*. p. 37-75 *In*: Plotkin, P.T. (ed.), National Marine Fisheries Service and U.S. Fish and Wildlife Service status reviews of sea turtles listed under the Endangered Species Act of 1973. Nat. Mar. Fish. Serv., Silver Spring, MD. 139 p.

Eckert, K.L. 1995b. Hawksbill sea turtle, *Eretmochelys imbricata*. p. 76-108 *In*: Plotkin, P.T. (ed.), National Marine Fisheries Service and U.S. Fish and Wildlife Service status reviews of sea turtles listed under the Endangered Species Act of 197. Nat. Mar. Fish. Serv., Silver Spring, MD. 139 p.

Ellison, W.T., B.L. Southall, C.W. Clark and A.S. Frankel. 2012. A new context-based approach to assess marine mammal behavioral responses to anthropogenic sounds. **Conserv. Biol.** 26(1):21-28.

Engel, M.H., M.C.C. Marcondes, C.C.A. Martins, F.O. Luna, R.P. Lima, and A. Campos. 2004. Are seismic surveys responsible for cetacean strandings? An unusual mortality of adult humpback whales in Abrolhos Bank, northeastern coast of Brazil. Working Pap. SC/56/E28, Int. Whal. Comm., Cambridge, U.K.

Environment News Service. 2013. U.S. east coast dolphin die-off triggers investigation. Accessed on 17 September 2013 at http://ens-newswire.com/2013/08/08/u-s-east-coast-dolphin-die-off-triggers-investigation.

Fewtrell, J.L. and R.D. McCauley. 2012. Impact of airgun noise on the behaviour of marine fish and squid. **Mar. Poll. Bull.** 64(5):984-993.

Figley, B. 2005. Artificial reef management plan for New Jersey. State of New Jersey, Department of Environmental Protection. 115 p. Accessed at http://www.njfishandwildlife.org/pdf/2005/reefplan05.pdf on 6 November 2013.

Finneran, J.J. 2012. Auditory effects of underwater noise in odontocetes. p. 197-202 *In*: A.N. Popper and A. Hawkins (eds.), The effects of noise on aquatic life. Springer, New York, NY. 695 p.

Finneran, J.J. and C.E. Schlundt. 2010. Frequency-dependent and longitudinal changes in noise-induced hearing loss in a bottlenose dolphin (*Tursiops truncatus*) (L). **J. Acoust. Soc. Am.** 128(2):567-570.

Finneran, J.J. and C.E. Schlundt. 2011. Noise-induced temporary threshold shift in marine mammals. **J. Acoust. Soc. Am.** 129(4):2432. [supplemented by oral presentation at the ASA meeting, Seattle, WA, May 2011].

Finneran, J.J. and C.E. Schlundt. 2013. Effects of fatiguing tone frequency on temporary threshold shift in bottlenose dolphins (*Tursiops truncates*). **J. Acoust. Soc. Am.** 133(3):1819-1826.

Finneran, J.J., C.E. Schlundt, D.A. Carder, J.A. Clark, J.A. Young, J.B. Gaspin, and S.H. Ridgway. 2000. Auditory and behavioral responses of bottlenose dolphins (*Tursiops truncatus*) and beluga whale (*Delphinapterus leucas*) to impulsive sounds resembling distant signatures of underwater explosions. **J. Acoust. Soc. Am.** 108(1):417-431.

Finneran, J.J., C.E. Schlundt, R. Dear, D.A. Carder, and S.H. Ridgway. 2002. Temporary shift in masked hearing thresholds in odontocetes after exposure to single underwater impulses from a seismic watergun. **J. Acoust. Soc. Am.** 111(6):2929-2940.

Finneran, J.J., D.A. Carder, C.E. Schlundt, and S.H. Ridgway. 2005. Temporary threshold shift in bottlenose dolphins (*Tursiops truncatus*) exposed to mid-frequency tones. **J. Acoust. Soc. Am.** 118(4):2696-2705.

Finneran, J.J., D.A. Carder, C.E. Schlundt, and R.L. Dear. 2010a. Growth and recovery of temporary threshold shift (TTS) at 3 kHz in bottlenose dolphins (*Tursiops truncatus*). **J. Acoust. Soc. Am.** 127(5):3256-3266.

Finneran, J.J., D.A. Carder, C.E. Schlundt and R.L. Dear. 2010b. Temporary threshold shift in a bottlenose dolphin (*Tursiops truncatus*) exposed to intermittent tones. **J. Acoust. Soc. Am.** 127(5):3267-3272.

Finneran, J.J., J.S. Trickey, B.K. Branstetter, C.E. Schlundt, and K. Jenkins. 2011. Auditory effects of multiple underwater impulses on bottlenose dolphins (*Tursiops truncatus*). **J. Acoust. Soc. Am.** 130(4):2561.

Frazier, J., R. Arauz, J. Chevalier, A. Formia, J. Fretey, M.H. Godfrey, R. Márquez-M., B. Pandav, and K. Shanker. 2007. Human–turtle interactions at sea. p. 253-295 *In*: P.T. Plotkin (ed.), Biology and conservation of ridley sea turtles. The Johns Hopkins University Press, Baltimore, MD. 356 p.

Gailey, G., B. Würsig, and T.L. McDonald. 2007. Abundance, behavior, and movement patterns of western gray whales in relation to a 3-D seismic survey, northeast Sakhalin Island, Russia. **Environ. Monit. Assess.** 134(1-3):75-91.

Gaskin, D.E. 1982. The ecology of whales and dolphins. Heineman Educational Books Ltd., London, U.K. 459 p.

Gaskin, D.E. 1984. The harbor porpoise *Phocoena phocoena* (L.): regional populations, status, and information on direct and indirect catches. **Rep. Int. Whal. Comm.** 34:569-586.

Gaskin, D.E. 1987. Updated status of the right whale, *Eubalaena glacialis*, in Canada. **Can Field-Nat** 101:295-309.

Gaskin, D.E. 1992. The status of the harbour porpoise. **Can. Field Nat.** 106(1):36-54.

Gedamke, J. 2011. Ocean basin scale loss of whale communication space: potential impacts of a distant seismic survey. p. 105-106 *In*: Abstr. 19th Bienn. Conf. Biol. Mar. Mamm., Tampa, FL, 27 Nov.–2 Dec. 2011. 344 p.

Gedamke, J., N. Gales, and S. Frydman. 2011. Assessing risk of baleen whale hearing loss from seismic surveys: the effects of uncertainty and individual variation. **J. Acoust. Soc. Am.** 129(1):496-506.

Glenn, S., R. Arnone, T. Bergmann, W.P. Bissett, M. Crowley, J. Cullen, J. Gryzmski, D. Haidvogel, J. Kohut, M. Moline, M. Oliver, C. Orrico, R. Sherrell, T. Song, A. Weidemann, R. Chant, and O. Schofield. 2004. Biogeochemical impact of summertime coastal upwelling on the New Jersey Shelf. **J. Geophys. Res.** 109:doi:10.1029/2003JC002265.

GMI (Geo-Marine Inc.). 2010. Ocean/wind power ecological baseline studies, January 2008–December 2009. Final Report. Department of Environmental Protection, Office of Science, Trenton, NJ. Accessed on 13 September at www.nj.gov/dep/dsr/ocean-wind/report.htm.

Goldbogen, J.A., B.L. Southall, S.L. DeRuiter, J. Calambokidis, A.S. Friedlaender, E.L. Hazen, E. Falcone, G. Schorr, A. Douglas, D.J. Moretti, C. Kyburg, M.F. McKenna, and P.L. Tyack. 2013. Blue whales respond to simulated mid-frequency military sonar. **Proc. R. Soc. B.** 280:20130657. http://dx.doi.org/10.1098/rspb.2013.0657.

Gordon, J., D. Gillespie, J. Potter, A. Frantzis, M.P. Simmonds, R. Swift, and D. Thompson. 2004. A review of the effects of seismic surveys on marine mammals. **Mar. Technol. Soc. J.** 37(4):16-34.

Götz, T. and V.M. Janik. 2013. Acoustic deterrent devices to prevent pinniped depredation: efficiency, conservation concerns and possible solutions. **Mar. Ecol. Prog. Ser.** 492:285-302.

Gray, H. and K. Van Waerebeek. 2011. Postural instability and akinesia in a pantropical spotted dolphin, *Stenella attenuata*, in proximity to operating airguns of a geophysical seismic vessel. **J. Nature Conserv.** 19(6): 363-367.

Guerra, M., A.M. Thode, S.B. Blackwell and M. Macrander. 2011. Quantifying seismic survey reverberation off the Alaskan North Slope. **J. Acoust. Soc. Am.** 130(5):3046-3058.

Guerra, M., P.J. Dugan, D.W. Ponirakis, M. Popescu, Y. Shiu, C.W. Clark. 2013. High-resolution analysis of seismic airgun impulses and their reverberant field as contributors to an acoustic environment. Abstr. 3rd Int. Conf. Effects of Noise on Aquatic Life, Budapest, Hungary, August 2013.

Hamilton, P.K. and C.A. Mayo. 1990. Population characteristics of right whales (*Eubalaena glacialis*) observed in Cape Cod and Massachusetts Bays, 1978–86. **Rep. Int. Whal. Comm. Spec. Iss.** 12:203-208.

Handegard, N.O., T.V. Tronstad, and J.M. Hovem. 2013. Evaluating the effect of seismic surveys on fish—the efficacy of different exposure metrics to explain disturbance. **Can. J. Fish. Aquat.** Sci. 70:1271-1277.

Hastie, G.D., C. Donovan, T. Götz, and V.M. Janik. 2014. Behavioral responses of grey seals (*Halichoerus grypus*) to high frequency sonar. **Mar. Poll. Bull.** 79:205-210.

Hastings, M.C. and J. Miksis-Olds. 2012. Shipboard assessment of hearing sensitivity of tropical fishes immediately after exposure to seismic air gun emissions at Scott Reef. p. 239-243 *In:* A.N. Popper and A. Hawkins (eds.), The effects of noise on aquatic life, Springer, New York, NY. 695 p.

Hatch, L.T., C.W. Clark, S.M. Van Parijs, A.S. Frankel, and D.W. Ponirakis. 2012. **Conserv. Biol.** 26(6):983-994.

Hawkes, L.A., A.C. Broderick, M.S. Coyne, M.H. Godfrey, and B.J. Godley. 2007. Only some like it hot–quantifying the environmental niche of the loggerhead sea turtle. **Divers. Distrib.** 13:447-457.

Heide-Jørgensen, M.P., R.G. Hansen, S. Fossette, N.J. Nielsen, M.V. Jensen, and P. Hegelund. 2013a. Monitoring abundance and hunting of narwhals in Melville Bay during seismic surveys. Preliminary report from the Greenland Institute of Natural Resources. 59 p.

Heide-Jørgensen, M.P., R.G. Hansen, K. Westdal, R.R. Reeves, and A. Mosbech. 2013b. Narwhals and seismic exploration: is seismic noise increasing the risk of ice entrapments? **Biol. Conserv.** 158:50-54.

Hovem, J.M., T.V. Tronstad, H.E. Karlsen, and S. Løkkeborg. 2012. Modeling propagation of seismic airgun sounds and the effects on fish behaviour. **IEEE J. Ocean. Eng.** 37(4):576-588.

Hoyt, E. 2005. Marine protected areas for whales, dolphins and porpoises: a world handbook for cetacean habitat conservation. Earthscan, Sterling, VA. 492 p.

InTheBite. 2014. Tournaments. InTheBite: The professionals' sportfishing magazine. Accessed in April 2014 at http://www.inthebite.com/tournaments/.

IOC (Intergovernmental Oceanographic Commission of UNESCO). 2013. The Ocean Biogeographic Information System. Accessed on 9 September 2013 at http://www.iobis.org.

IUCN. 2013. IUCN Red list of threatened species. Version 2013.1. Accessed on 5 September 2013 at http://www.iucnredlist.org.

IWC. 2007. Report of the standing working group on environmental concerns. Annex K to Report of the Scientific Committee. **J. Cetac. Res. Manage**. 9(Suppl.):227-260.

IWC. 2013. Whale population estimates: population table. Last updated 09/01/09. Accessed on 9 September 2013 at http://iwc.int/estimate.htm.

James, M.C., C.A. Ottensmeyer, and R.A. Myers. 2005. Identification of high-use habitat and threats to leatherback sea turtles in northern waters: new directions for conservation. **Ecol. Lett.** 8:195-201.

Jaquet, N. 1996. How spatial and temporal scales influence understanding of sperm whale distribution: a review. **Mamm. Rev.** 26:51-65.

Jefferson, T.A., M.A. Webber, and R.L. Pitman. 2008. Marine mammals of the world: a comprehensive guide to their identification. Elsevier, London, U.K. 573 p.

Jefferson, T.A., C.R. Weir, R.C. Anderson, L.T. Balance, R.D. Kenney, and J.J. Kiszka. 2013. Global distribution of Risso's dolphin *Grampus griseus*: a review and critical evaluation. **Mamm. Rev.** doi:10.1111/mam.12008.

Jensen, F.H., L. Bejder, M. Wahlberg, N. Aguilar Soto, M. Johnson, and P.T. Madsen. 2009. Vessel noise effects on delphinid communication. **Mar. Ecol. Prog. Ser.** 395:161-175.

Johnson, S.R., W.J. Richardson, S.B. Yazvenko, S.A. Blokhin, G. Gailey, M.R. Jenkerson, S.K. Meier, H.R. Melton, M.W. Newcomer, A.S. Perlov, S.A. Rutenko, B. Würsig, C.R. Martin, and D.E. Egging. 2007. A western gray whale mitigation and monitoring program for a 3-D seismic survey, Sakhalin Island, Russia. **Environ. Monit. Assess.** 134(1-3):1-19.

Kastak, D. and C. Reichmuth. 2007. Onset, growth, and recovery of in-air temporary threshold shift in a California sea lion (*Zalophus californianus*). **J. Acoust. Soc. Am.** 122(5):2916-2924.

Kastak, D., J. Mulsow, A. Ghoul, and C. Reichmuth. 2008. Noise-induced permanent threshold shift in a harbor seal. **J. Acoust. Soc. Am.** 123(5):2986.

Kastelein, R., R. Gransier, L. Hoek, and J. Olthuis. 2012a. Temporary threshold shifts and recovery in a harbor porpoise (*Phocoena phocoena*) after octave-band noise at 4 kHz. **J. Acoust. Soc. Am.** 132(5):3525-3537.

Kastelein, R.A., R., Gransier, L. Hoek, A. Macleod, and J.M. Terhune. 2012b. Hearing threshold shifts and recovery in harbor seals (*Phoca vitulina*) after octave-band noise exposure at 4 kHz. **J. Acoust. Soc. Am.** 132(4):2745-2761.

Kastelein, R.A., R. Gransier, L. Hoek, and M. Rambags. 2013a. Hearing frequency thresholds of a harbour porpoise (*Phocoena phocoena*) temporarily affected by a continuous 1.5 kHz tone. **J. Acoust. Soc. Am.** 134(3):2286-2292.

Kastelein, R., R. Gransier, and L. Hoek. 2013b. Comparative temporary threshold shifts in a harbour porpoise and harbour seal, and severe shift in a seal (L). **J. Acoust. Soc. Am.** 134(1):13-16.

Kasuya, T. 1986. Distribution and behavior of Baird's beaked whales off the Pacific coast of Japan. **Sci. Rep. Whales Res. Inst.** 37:61-83.

Katona, S.K., J.A. Beard, P.E. Girton, and F. Wenzel. 1988. Killer whales (*Orcinus orca*) from the Bay of Fundy to the Equator, including the Gulf of Mexico. **Rit Fiskideildar** 11:205-224.

Kenney, R.D., H.E. Winn, and M.C. Macaulay. 1995. Cetaceans in the Great South Channel, 1979–1989: right whale (*Eubalaena glacialis*). **Cont. Shelf Res.** 15:385-414.

Kenney, R.D., C.A. Mayo, and H.E. Winn. 2001. Migration and foraging strategies at varying spatial scales in western North Atlantic right whales: a review of hypotheses. **J. Cetac. Res. Manage**. **Spec. Iss.** 2:251-260.

Ketten, D.R. 2012. Marine mammal auditory system noise impacts: evidence and incidence. p. 207-212 *In*: A.N. Popper and A. Hawkins (eds.), The effects of noise on aquatic life. Springer, New York, NY. 695 p.

Klinck, H., S.L. Nieukirk, D.K. Mellinger, K. Klinck, H. Matsumoto, and R.P. Dziak. 2012. Seasonal presence of cetaceans and ambient noise levels in polar waters of the North Atlantic. **J. Acoust. Soc. Am.** 132(3):EL176-EL181.

Knowlton, A.R., J. Sigurjónsson, J.N. Ciano, and S.D. Kraus. 1992. Long-distance movements of North Atlantic right whales (*Eubalaena glacialis*). **Mar. Mamm. Sci.** 8(4):397-405.

Knowlton, A.R., J.B. Ring, and B. Russell. 2002. Right whale sightings and survey effort in the mid Atlantic region: migratory corridor, time frame, and proximity to port entrances. Final Rep. to National Marine Fisheries Ship Strike Working Group. 25 p.

Kraus, S.D., J.H. Prescott, A.R. Knowlton, and G.S. Stone. 1986. Migration and calving of right whales (*Eubalaena glacialis*) in the western North Atlantic. **Rep. Int. Whal. Comm. Spec. Iss.** 10:139-144.

Krieger, K.J. and B.L. Wing. 1984. Hydroacoustic surveys and identification of humpback whale forage in Glacier Bay, Stephens Passage, and Frederick Sound, southeastern Alaska, summer 1983. NOAA Tech. Memo. NMFS F/NWC-66. U.S. Natl. Mar. Fish. Serv., Auke Bay, AK. 60 p. NTIS PB85-183887.

Krieger, K.J. and B.L. Wing. 1986. Hydroacoustic monitoring of prey to determine humpback whale movements. NOAA Tech. Memo. NMFS F/NWC-98. U.S. Natl. Mar. Fish. Serv., Auke Bay, AK. 63 p. NTIS PB86-204054.

Laws, R. 2012. Cetacean hearing-damage zones around a seismic source. p. 473-476 *In*: A.N. Popper and A. Hawkins (eds.), The effects of noise on aquatic life. Springer, New York, NY. 695 p.

Lazell, J.D. 1980. New England waters: critical habitat for marine turtles. **Copeia** 1980:290-295.

Leatherwood, S., D.K. Caldwell, and H.E. Winn. 1976. Whales, dolphins, and porpoises of the western North Atlantic. A guide to their identification. NOAA Tech. Rep. NMFS Circ. 396. U.S. Dep. Comm., Washington, DC. 176 p.

Lenhardt, M. 2002. Sea turtle auditory behavior. **J. Acoust. Soc. Amer**. 112(5, Pt. 2):2314 (Abstr.).

Le Prell, C.G. 2012. Noise-induced hearing loss: from animal models to human trials. p. 191-195 *In*: A.N. Popper and A. Hawkins (eds.), The effects of noise on aquatic life. Springer, New York, NY. 695 p.

Liberman, C. 2013. New perspectives on noise damage. Abstr. 3rd Int. Conf. Effects of Noise on Aquatic Life, Budapest, Hungary, August 2013.

Lien J., R. Sears, G.B. Stenson, P.W. Jones, and I-Hsun Ni. 1989. Right whale, (*Eubalaena glacialis*), sightings in waters off Newfoundland and Labrador and the Gulf of St. Lawrence, 1978–1987. **Can. Field-Nat.** 103:91-93.

Lipscomb, T.P, F.Y. Schulman, D. Moffett, and S. Kennedy. 1994. Morbilliviral disease in Atlantic bottlenose dolphins (*Tursiops truncatus*) from the 1987–1988 epizootic. **J. Wildl. Dis.** 30(4):567-571.

Løkkeborg, S., E. Ona, A. Vold, and A. Salthaug. 2012. Sounds from seismic air guns: Gear- and species-specific effects on catch rates and fish distribution. **Can. J. Fish. Aquat. Sci.** 69:1278-1291.

Lusseau, D. and L. Bejder. 2007. The long-term consequences of short-term responses to disturbance experience from whalewatching impact assessment. **Int. J. Comp. Psych.** 20(2-3):228-236.

MacGillivray, A.O., R. Racca, and Z. Li. 2014. Marine mammal audibility of selected shallow-water survey sources. **J. Acoust. Soc. Am.** 135(1):EL35-EL40.

MacLeod, C.D., W.F. Perrin, R. Pitman, J. Barlow, L.T. Ballance, A. D'Amico, T. Gerrodette, G. Joyce, K.D. Mullin, D. Palka, and G.T. Waring. 2006. Known and inferred distributions of beaked whale species (Cetacea: Ziphiidae). **J. Cetac. Res. Manage.** 7(3):271-286.

MAFMC (Mid-Atlantic Fishery Management Council). 1988. Fisheries Management Plan for the summer flounder fishery. Mid-Atlantic Fishery Management Council in cooperation with the National Marine Fisheries Service, the New England Fishery Management Council, and the South Atlantic Fishery Management Council. 157 p. + app.

MAFMC (Mid-Atlantic Fishery Management Council). 1996. Amendment 9 to the summer flounder Fisheries Management Plan and Final Environmental Impact Statement for the black sea bass fishery. Mid-Atlantic Fishery Management Council in cooperation with the Atlantic States Marine Fisheries Commission, the National Marine Fisheries Service, the New England Fishery Management Council, and the South Atlantic Fishery Management Council. 152 p. + app.

Malme, C.I. and P.R. Miles. 1985. Behavioral responses of marine mammals (gray whales) to seismic discharges. p. 253-280 *In:* G.D. Greene, F.R. Engelhard, and R.J. Paterson (eds.), Proc. Workshop on Effects of Explosives Use in the Marine Environment, Jan. 1985, Halifax, NS. Tech. Rep. 5. Can. Oil & Gas Lands Admin., Environ. Prot. Br., Ottawa, Ont. 398 p.

Malme, C.I., P.R. Miles, C.W. Clark, P. Tyack, and J.E. Bird. 1984. Investigations of the potential effects of underwater noise from petroleum industry activities on migrating gray whale behavior/Phase II: January 1984 migration. BBN Rep. 5586. Rep. from Bolt Beranek & Newman Inc., Cambridge, MA, for MMS, Alaska OCS Region, Anchorage, AK. NTIS PB86-218377.

Malme, C.I., P.R. Miles, P. Tyack, C.W. Clark, and J.E. Bird. 1985. Investigation of the potential effects of underwater noise from petroleum industry activities on feeding humpback whale behavior. BBN Rep. 5851; OCS Study MMS 85-0019. Rep. from BBN Labs Inc., Cambridge, MA, for MMS, Anchorage, AK. NTIS PB86-218385.

Malme, C.I., B. Würsig, J.E. Bird, and P. Tyack. 1986. Behavioral responses of gray whales to industrial noise: feeding observations and predictive modeling. BBN Rep. 6265. OCS Study MMS 88-0048. Outer Contin. Shelf Environ. Assess. Progr., Final Rep. Princ. Invest., NOAA, Anchorage 56(1988): 393-600. NTIS PB88-249008.

Malme, C.I., B. Würsig, B., J.E. Bird, and P. Tyack. 1988. Observations of feeding gray whale responses to controlled industrial noise exposure. p. 55-73 *In:* W.M. Sackinger, M.O. Jeffries, J.L. Imm, and S.D. Treacy (eds.), Port and Ocean Engineering Under Arctic Conditions. Vol. II. Symposium on Noise and Marine Mammals. Univ. Alaska Fairbanks, Fairbanks, AK. 111 p.

MarineTraffic. 2013. Live Ships Map–AIS–Vessel Traffic and Positions. Accessed on 25 September at http://www.marinetraffic.com/ais/default.aspx?centerx=30&centery=25&zoom=2&level1=140.

Mass.Gov. 2013. Massachusetts ocean management planning areas and Massachusetts ocean sanctuaries. Accessed on 16 September 2013 at http://www.mass.gov/eea/docs/czm/oceans/ocean-planning-map.pdf.

McCauley, R.D., M.-N. Jenner, C. Jenner, K.A. McCabe, and J. Murdoch. 1998. The response of humpback whales (*Megaptera novaeangliae*) to offshore seismic survey noise: preliminary results of observations about a working seismic vessel and experimental exposures. **APPEA J.** 38:692-707.

McCauley, R.D., J. Fewtrell, A.J. Duncan, C. Jenner, M.-N. Jenner, J.D. Penrose, R.I.T. Prince, A. Adhitya, J. Murdoch, and K. McCabe. 2000. Marine seismic surveys: Analysis of airgun signals; and effects of air gun exposure on humpback whales, sea turtles, fishes and squid. Rep. from Centre for Marine Science and Technology, Curtin Univ., Perth, Western Australia, for Australian Petrol. Produc. & Explor. Association, Sydney, NSW. 188 p.

McDonald, T.L., W.J. Richardson, K.H. Kim, and S.B. Blackwell. 2010. Distribution of calling bowhead whales exposed to underwater sounds from Northstar and distant seismic surveys, 2009. p. 6-1 to 6-38 *In*: W.J. Richardson (ed.), Monitoring of industrial sounds, seals, and bowhead whales near BP's Northstar oil development, Alaskan Beaufort Sea: Comprehensive report for 2005–2009. LGL Rep. P1133-6. Rep. from LGL Alaska Res. Assoc. Inc. (Anchorage, AK), Greeneridge Sciences Inc. (Santa Barbara, CA), WEST Inc. (Cheyenne, WY) and Applied Sociocult. Res. (Anchorage, AK) for BP Explor. (Alaska) Inc., Anchorage, AK. 265 p.

McDonald, T.L., W.J. Richardson, K.H. Kim, S.B. Blackwell, and B. Streever. 2011. Distribution of calling bowhead whales exposed to multiple anthropogenic sound sources and comments on analytical methods. p. 199 *In*: Abstr. 19th Bienn. Conf. Biol. Mar. Mamm., Tampa, FL, 27 Nov.–2 Dec. 2011. 344 p.

Mead, J.G. 1986. Twentieth-century records of right whales (*Eubalaena glacialis*) in the northwest Atlantic Ocean. **Rep. Int. Whal. Comm. Spec. Iss.** 10:109-120.

Mead, J.G. 1989. Beaked whales of the genus *Mesoplodon*. p. 349-430 *In*: S.H. Ridgway and R.J. Harrison (eds.), Handbook of marine mammals, Vol. 4: River dolphins and the larger toothed whales. Academic Press, San Diego, CA. 442 p.

Melcón, M.L., A.J. Cummins, S.M. Kerosky, L.K. Roche, S.M. Wiggins, and J.A. Hildebrand. 2012. Blue whales response to anthropogenic noise. **PLoS ONE** 7(2):e32681. doi:10.1371/journal.pone.0032681.

Miller, G.W., R.E. Elliott, W.R. Koski, V.D. Moulton, and W.J. Richardson. 1999. Whales. p. 5-1 to 5-109 *In:* W.J. Richardson (ed.), Marine mammal and acoustical monitoring of Western Geophysical's open-water seismic program in the Alaskan Beaufort Sea, 1998. LGL Rep. TA2230-3. Rep. from LGL Ltd., King City, Ont., and Greeneridge Sciences Inc., Santa Barbara, CA, for Western Geophysical, Houston, TX, and Nat. Mar. Fish. Serv., Anchorage, AK, and Silver Spring, MD. 390 p.

Miller, G.W., V.D. Moulton, R.A. Davis, M. Holst, P. Millman, A. MacGillivray, and D. Hannay. 2005. Monitoring seismic effects on marine mammals—southeastern Beaufort Sea, 2001-2002. p. 511-542 *In:* S.L. Armsworthy, P.J. Cranford, and K. Lee (eds.), Offshore oil and gas environmental effects monitoring/approaches and technologies. Battelle Press, Columbus, OH.

Miller, I. and E. Cripps. 2013. Three dimensional marine seismic survey has no measureable effect on species richness or abundance of a coral reef associated fish community. **Mar. Poll. Bull**. 77:63-70.

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

Miller, P.J.O., P.H. Kvadsheim, F.P.A. Lam, P.J. Wensveen, R. Antunes, A.C. Alves, F. Visser, L. Kleivane, P.L. Tyack, and L.D. Sivle. 2012. The severity of behavioral changes observed during experimental exposures of killer (*Orcinus orca*), long-finned pilot (*Globicephala melas*), and sperm whales (*Physeter macrocephalus*) to naval sonar. **Aquat. Mamm.** 38:362-401.

Mitchell, E. and D.G. Chapman. 1977. Preliminary assessment of stocks of northwest Atlantic sei whales (*Balaenoptera borealis*). **Rep. Int. Whal. Comm. Spec. Iss.** 1:117-120.

Miyazaki, N. and W.F. Perrin. 1994. Rough-toothed dolphin *Steno bredanensis* (Lesson, 1828). p. 1-21 *In*: S.H. Ridgway and R.J. Harrison (eds.), Handbook of marine mammals, Vol. 5: The first book of dolphins. Academic Press, San Diego, CA. 416 p.

Mizroch, S.A., D.W. Rice, and J.M. Breiwick. 1984. The blue whale, *Balaenoptera musculus*. **Mar. Fish. Rev.** 46(4)15-19.

Moein, S.E., J.A. Musick, J.A. Keinath, D.E. Barnard, M. Lenhardt, and R. George. 1994. Evaluation of seismic sources for repelling sea turtles from hopper dredges. Rep. from Virginia Inst. Mar. Sci., Gloucester Point, VA, for U.S. Army Corps of Engineers. 33 p.

Moore, M.J., B. Rubinstein, S.A. Norman, and T. Lipscomb. 2004. A note on the most northerly record of Gervais' beaked whale from the western North Atlantic Ocean. **J. Cetac. Res. Manage.** 6(3):279-281.

Morano, J.L., A.N. Rice, J.T. Tielens, B.J. Estabrook, A. Murray, B.L. Roberts, and C.W. Clark. 2012. Acoustically detected year-round presence of right whales in an urbanized migration corridor. **Conserv. Biol.** 26(4):698-707.

Morley, E.L., G. Jones, and A.N. Radford. 2013. The importance of invertebrates when considering the impacts of anthropogenic noise. **Proc. R. Soc. B** 281, 20132683. http://dx.doi.org/10.1098/rspb.2013.2683.

Morreale, S., A. Meylan, and B. Baumann. 1989. Sea turtles in Long Island Sound, New York: an historical perspective. p. 121-122 *In*: S.A. Eckert, K.L. Eckert, and T.H. Richardson (compilers), Proc. 9th Ann. Worksh. Sea Turtle Conserv. Biol. NOAA Tech. Memo. NMFS-SEFC-232. 306 p.

Morreale, S.J., P.T. Plotkin, D.J. Shaver, and H.J. Kalb. 2007. Adult migration and habitat utilization: ridley turtles in their element. p. 213-229 *In*: P.T. Plotkin (ed.), Biology and conservation of ridley sea turtles. The Johns Hopkins University Press, Baltimore, MD. 356 p.

Moulton, V.D. and M. Holst. 2010. Effects of seismic survey sound on cetaceans in the Northwest Atlantic. Environ. Stud. Res. Funds Rep. 182. St. John's, Nfld. 28 p. Available at http://www.esrfunds.org/pdf/182.pdf.

Musick, J.A. and C.J. Limpus. 1997. Habitat utilization and migration in juvenile sea turtles. p. 137-163 *In*: P.L. Lutz and J.A. Musick (eds.), The biology of sea turtles. CRC Press, Boca Raton, FL. 432 p.

Musick, J.A., D.E. Barnard, and J.A. Keinath. 1994. Aerial estimates of seasonal distribution and abundance of sea turtles near the Cape Hatteras faunal barrier. p. 121-122 *In*: B.A. Schroeder and B.E. Witherington (compilers), Proc. 13th Ann. Symp. Sea Turtle Biol. Conserv. NOAA Tech. Mem. NMFS-SEFSC-341. 281 p.

Mussoline, S.E., D. Risch, L.T. Hatch, M.T. Weinrich, D.N. Wiley, M.A. Thompson, P.J. Corkeron, and S.M. Van Parijs. 2012. Seasonal and diel variation in North Atlantic right whale up-calls: implications for management and conservation in the northwestern Atlantic Ocean. **Endang. Species Res.** 17(1):17-26.

Nachtigall, P.E. and A.Y. Supin. 2013. Hearing sensation changes when a warning predicts a loud sound in the false killer whale. Abstr. 3rd Int. Conf. Effects of Noise on Aquatic Life, Budapest, Hungary, August 2013.

National Geographic Daily News. 2013. What's killing bottlenose dolphins? Experts discover cause. 13 August 2013. Accessed on 22 November 2013 at http://news.nationalgeographic.com/news/2013/08/130827-dolphin-deaths-virus-outbreak-ocean-animals-science/.

NEFSC (Northeast Fisheries Science Center). 2012. North Atlantic right whale sighting advisory system. Accessed on 11 September 2013 at http://www.nefsc.noaa.gov/psb/surveys/SAS.html.

NEFSC (Northeast Fisheries Science Center). 2013a. Ecology of the northeast U.S. continentals shelf: Oceanography. Accessed at http://www.nefsc.noaa.gov/ecosys/ecology/Oceanography/ on 6 November 2013.

NEFSC (Northeast Fisheries Science Center). 2013b. Interactive North Atlantic right whale sightings map. Accessed on 22 August 2013 at http://www.nefsc.noaa.gov/psb/surveys.

New, L.F., J. Harwood, L. Thomas, C. Donovan, J.S. Clark, G. Hastie, P.M. Thompson, B. Cheney, L. Scott-Hayward, and D. Lusseau. 2013. Modelling the biological significance of behavioural change in coastal bottlenose dolphins in response to disturbance. **Function. Ecol.** 27:314-322.

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

NMFS (National Marine Fisheries Service). 1994. Designated critical habitat, northern right whale. **Fed. Regist.** (59, 3 June 1994): 28793.

NMFS (National Marine Fisheries Service). 1999. Essential Fish Habitat source document: black sea bass, *Centropristis striata*, life history and habitat characteristics. NOAA Tech. Memo. NMFS-NE-143. 42 p. Accessed at http://www.nefsc.noaa.gov/publications/tm/tm143/tm143.pdf in June 2014.

NMFS (National Marine Fisheries Service). 2000. Small takes of marine mammals incidental to specified activities: marine seismic-reflection data collection in southern California/Notice of receipt of application. **Fed. Regist.** 65(60, 28 Mar.):16374-16379.

NMFS (National Marine Fisheries Service). 2001. Small takes of marine mammals incidental to specified activities: oil and gas exploration drilling activities in the Beaufort Sea/Notice of issuance of an incidental harassment authorization. **Fed. Regist.** 66(26, 7 Feb.):9291-9298.

NMFS (National Marine Fisheries Service). 2004. Essential Fish Habitat source document: sea scallop, *Placopecten magellanicus*, life history and habitat characteristics. 2nd edit. NOAA Tech. Memo. NMFS-NE-189. 21 p. Accessed at http://www.nefsc.noaa.gov/publications/tm/tm189/tm189.pdf in June 2014.

NMFS (National Marine Fisheries Service). 2005. Recovery plan for the North Atlantic right whale (*Eubalaena glacialis*). Nat. Mar. Fish. Serv., Silver Spring, MD. 137 p.

NMFS (National Marine Fisheries Service). 2008. Endangered fish and wildlife; Final Rule to implement speed restrictions to reduce the threat of ship collisions with North Atlantic right whales. **Fed. Regist.** 73(198, 10 Oct.):60173-60191.

NMFS (National Marine Fisheries Service). 2010. Endangered fish and wildlife and designated Critical Habitat for the endangered North Atlantic right whale. **Fed. Regist.** 75:(193, 6 Oct.):61690-61691.

NMFS (National Marine Fisheries Service). 2013a. Effects of oil and gas activities in the Arctic Ocean: Supplemental draft environmental impact statement. U.S. Depart. Commerce, NOAA, NMFS, Office of Protected Resources. Accessed at http://www.nmfs.noaa.gov/pr/permits/eis/arctic.htm on 21 September 2013.

NMFS (National Marine Fisheries Service). 2013b. Endangered and threatened wildlife; 90-Day finding on petitions to list the dusky shark as Threatened or Endangered under the Endangered Species Act. **Fed. Regist.** 78 (96, 17 May):29100-29110.

NMFS (National Marine Fisheries Service). 2013c. NOAA Fisheries Service, Southeast Regional Office. Habitat Conservation Division. Essential fish Habitat: frequently asked questions. Accessed at http://sero.nmfs.noaa.gov/hcd/efh_faq.htm#Q2 on 24 September 2012.

NMFS (National Marine Fisheries Service). 2013d. Takes of marine mammals incidental to specified activities; marine geophysical survey on the Mid-Atlantic Ridge in the Atlantic Ocean, April 2013, through June 2013. Notice; issuance of an incidental harassment authorization. **Fed. Regist.** 78 (72, 15 Apr.):22239-22251.

NMFS (National Marine Fisheries Service). 2013e. Takes of marine mammals incidental to specified activities; marine geophysical survey in the northeast Atlantic Ocean, June to July 2013. Notice; issuance of an incidental harassment authorization. **Fed. Regist.** 78 (109, 6 Jun.):34069-34083.

NMFS and USFWS (National Marine Fisheries Service and U.S. Fish and Wildlife Service). 2007. Green sea turtle (*Chelonia mydas*) 5-year review: summary and evaluation. NMFS Office of Protected Resources, Silver Spring, MD, and USFWS Southeast Region, Jacksonville Ecological Services Field Office, Jacksonville, FL. 105 p.

NMFS and USFWS (National Marine Fisheries Service and U.S. Fish and Wildlife Service). 2013a. Leatherback turtle (*Dermochelys coriacea*) 5-year review: summary and evaluation. NMFS Office of Protected Resources, Silver Spring, MD, and USFWS Southeast Region, Jacksonville Ecological Services Field Office, Jacksonville, FL. 89 p.

NMFS and USFWS (National Marine Fisheries Service and U.S. Fish and Wildlife Service). 2013b. Hawksbill turtle (*Eretmochelys imbricata*) 5-year review: summary and evaluation. NMFS Office of Protected Resources, Silver Spring, MD, and USFWS Southeast Region, Jacksonville Ecological Services Field Office, Jacksonville, FL. 91 p.

NOAA (National Oceanic and Atmospheric Administration). 2006. NOAA recommends new east coast ship traffic routes to reduce collisions with endangered whales. Press Release. Nat. Ocean. Atmos. Admin., Silver Spring, MD, 17 November.

NOAA (National Oceanic and Atmospheric Administration). 2007. NOAA & coast guard help shift Boston ship traffic lane to reduce risk of collisions with whales. Press Release. Nat. Ocean. Atmos. Admin., Silver Spring, MD, 28 June.

NOAA (National Oceanic and Atmospheric Administration). 2008. Fisheries of the northeastern United States: Atlantic mackerel, squid, and butterfish fisheries; Amendment 9. **Fed. Regist.** 73(127, 1 Jul.):37382-37388.

NOAA (National Oceanic and Atmospheric Administration). 2010a. Guide to the Atlantic large whale take reduction plan. Accessed at http://www.nero.noaa.gov/whaletrp/plan/ALWTRPGuide.pdf on 13 September 2013.

NOAA (National Oceanic and Atmospheric Administration). 2010b. Harbor porpoise take reduction plan: Mid-Atlantic. Accessed on 13 September 2013 at http://www.nero.noaa.gov/prot_res/porptrp/doc/HPTRPMidAtlanticGuide_Feb%202010.pdf

NOAA (National Oceanic and Atmospheric Administration). 2012a. North Atlantic right whale (*Eubalaena glacialis*) 5-year review: summary and evaluation. NOAA Fisheries Service, Northeast Regional Office, Gloucester, MA. 34 p. Accessed on 13 September 2013 at http://www.nmfs.noaa.gov/pr/pdfs/species/narightwhale_5yearreview.pdf.

NOAA (National Oceanic and Atmospheric Administration). 2012b. Office of Protected Resources: Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*). Accessed on 9 September 2013 at http://www.nmfs.noaa.gov/pr/species/fish/atlanticsturgeon.htm.

NOAA (National Oceanic and Atmospheric Administration). 2012c. NOAA Habitat Conservation, Habitat Protection. EFH text descriptions and GIS data inventory. Accessed on 23 September at http://www.habitat.noaa.gov/protection/efh/newInv/index.html.

NOAA (National Oceanic & Atmospheric Administration). 2013a. Draft guidance for assessing the effects of anthropogenic sound on marine mammals/Acoustic threshold levels for onset of permanent and temporary threshold shifts. Draft: 23 Dec. 2013. 76 p. Accessed in January 2014 at http://www.nmfs.noaa.gov/pr/acoustics/draft_acoustic_guidance_2013.pdf.

NOAA (National Oceanic and Atmospheric Administration). 2013b. Reducing ship strikes to North Atlantic right whales. Accessed on 13 September 2013 at http://www.nmfs.noaa.gov/pr/shipstrike.

NOAA (National Oceanic and Atmospheric Administration). 2013c. 2013 bottlenose dolphin unusual mortality event in the mid-Atlantic. Accessed on 12 December 2013, 2 April 2014, and 23 April 2014 at http://www.nmfs.noaa.gov/pr/health/mmume/midatldolphins2013.html.

NOAA (National Oceanic and Atmospheric Administration). 2013d. Office of Protected Resources: Shortnose sturgeon (*Acipenser brevirostrum*). Accessed on 9 September 2013 at http://www.nmfs.noaa.gov/pr/species/fish/shortnosesturgeon.htm.

NOAA (National Oceanic and Atmospheric Administration). 2013e. Office of Protected Resources: Cusk (*Brosme brosme*). Accessed on 9 September 2013 at http://www.nmfs.noaa.gov/pr/species/fish/cusk.htm.

NOAA (National Oceanic and Atmospheric Administration). 2013f. Office of Protected Resources: Great hammerhead shark (*Sphyrna mokarran*). Accessed on 9 September 2013 at http://www.nmfs.noaa.gov/pr/species/fish/greathammerheadshark.htm.

NOAA (National Oceanic and Atmospheric Administration). 2013g. NOAA Office of Science and Technology, National Marine Fisheries Service. Accessed on 25 September at http://www.st.nmfs.noaa.gov/index.

NOAA (National Oceanic and Atmospheric Association). 2014. 2014 registered tournaments for Atlantic highly migratory species as of 13 March 2014. Accessed in April 2014 at http://www.nmfs.noaa.gov/sfa/hms/Tournaments/2014_registered_hms_tournaments.pdf.

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

Nowacek, D.P., K. Bröker, G. Donovan, G. Gailey, R. Racca, R.R. Reeves, A.I. Vedenev, D.W. Weller, and B.L. Southall. 2013. Responsible practices for minimizing and monitoring environmental impacts of marine seismic surveys with an emphasis on marine mammals. **Aquat. Mamm.** 39(4):356-377.

NRC (National Research Council). 2005. Marine mammal populations and ocean noise/Determining when noise causes biologically significant effects. U.S. Nat. Res. Counc., Ocean Studies Board, Committee on characterizing biologically significant marine mammal behavior (Wartzok, D.W., J. Altmann, W. Au, K. Ralls, A. Starfield, and P.L. Tyack). Nat. Acad. Press, Washington, DC. 126 p.

NSF (National Science Foundation). 2012. Record of Decision for marine seismic research funded by the National Science Foundation. June 2012. 41 p. Accessed at http://www.nsf.gov/geo/oce/envcomp/rod-marine-seismic-research-june2012.pdf on 23 September 2013.

NSF and USGS (National Science Foundation and U.S. Geological Survey). 2011. 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. Accessed on 23 September 2013 at http://www.nsf.gov/geo/oce/envcomp/usgs-nsf-marine-seismic-research/nsf-usgs-final-eis-oeis-with-appendices.pdf.

Odell, D.K. and K.M. McClune. 1999. False killer whale *Pseudorca crassidens* (Owen, 1846). p. 213-243 *In*: S.H. Ridgway and R. Harrison (eds.), Handbook of marine mammals, Vol. 6: The second book of dolphins and the porpoises. Academic Press, San Diego, CA. 486 p.

Olson, P.A. 2009. Pilot whales. p. 847-852 *In*: W.F. Perrin, B. Würsig and J.G.M. Thewissen (eds.), Encyclopedia of marine mammals, 2nd edit. Academic Press, San Diego, CA. 1316 p.

Palka, D.L. 2006. Summer abundance estimates of cetaceans in U.S. North Atlantic Navy Operating Areas. Northeast Fish. Sci. Center Ref. Doc. 06-03. Northeast Fish. Sci. Center, Nat. Mar. Fish. Serv., Woods Hole, MA. 41 p.

Palka, D. 2012. Cetacean abundance estimates in U.S. northwestern Atlantic Ocean waters from summer 2011 line transect survey. Northeast Fish. Sci. Cent. Ref. Doc. 12-29. Northeast Fish. Sci. Center, Nat. Mar. Fish. Serv., Woods Hole, MA. 37 p.

Palsbøll, P.J., J. Allen, T.H. Anderson, M. Berube, P.J. Clapham, T.P. Feddersen, N.A. Friday, P.S. Hammond, H. Jorgensen, S.K. Katona, F. Larsen, J. Lien, D.K. Mattila, F.B. Nygaard, J. Robbins, R. Sponer, R. Sears, J. Sigurjonsson, T.G. Smith, P.T. Stevick, G.A. Vikingsson, and N. Oien. 2001. Stock structure and composition of the North Atlantic humpback whale, *Megaptera novaeangliae*. Working Pap. SC/53/NAH11. Int. Whal. Comm., Cambridge, U.K.

Parks, S.E. M. Johnson, D. Nowacek, and P.L. Tyack. 2011. Individual right whales call louder in increased environmental noise. **Biol. Lett.** 7(1):33-35.

Parks, S.E., M.P. Johnson, D.P. Nowacek, and P.L. Tyack. 2012. Changes in vocal behaviour of North Atlantic right whales in increased noise. p. 317-320 *In*: A.N. Popper and A. Hawkins (eds.), The effects of noise on aquatic life. Springer, New York, NY. 695 p.

Patrician, M.R., I.S. Biedron, H.C. Esch, F.W. Wenzel, L.A. Cooper, P.K. Hamilton, A.H. Glass, and M.F. Baumgartner. 2009. Evidence of a North Atlantic right whale calf (*Eubalaena glacialis*) born in northeastern U.S. waters. **Mar. Mamm. Sci.** 25(2):462-477.

Payne, R. 1978. Behavior and vocalizations of humpback whales (*Megaptera* sp.). *In*: K.S Norris and R.R. Reeves (eds.), Report on a workshop on problems related to humpback whales (*Megaptera novaeangliae*) in Hawaii. MCC-77/03. Rep. from Sea Life Inc., Makapuu Pt., HI, for U.S. Mar. Mamm. Comm., Washington, DC.

Payne, R. S. and S. McVay. 1971. Songs of humpback whales. **Science** 173(3997):585-597.

Peña, H., N.O. Handegard, and E. Ona. 2013. Feeding herring schools do not react to seismic air gun surveys. ICES J. Mar. Sci. doi:10.1093/icesjms/fst079.

Perrin, W.F., D.K. Caldwell, and M.C. Caldwell. 1994. Atlantic spotted dolphin *Stenella frontalis* (G. Cuvier, 1829). p. 173-190 *In*: S.H. Ridgway and R.J. Harrison (eds.), Handbook of marine mammals, Vol. 5: The first book of dolphins. Academic Press, San Diego, CA. 416 p.

Pierson, M.O., J.P. Wagner, V. Langford, P. Birnie, and M.L. Tasker. 1998. Protection from, and mitigation of, the potential effects of seismic exploration on marine mammals. Chapter 7 *In*: M.L. Tasker and C. Weir (eds.), Proc. Seismic Mar. Mamm. Worksh., London, U.K., 23–25 June 1998.

Pike, D.G., G.A. Víkingsson, T. Gunnlaugsson, and N. Øien. 2009. A note on the distribution and abundance of blue whales (*Balaenoptera musculus*) in the central and northeast North Atlantic. **NAMMCO Sci. Publ.** 7:19-29.

Pirotta, E., R. Milor, N. Quick, D. Moretti, N. Di Marzio, P. Tyack, I. Boyd, and G. Hastie. 2012. Vessel noise affects beaked whale behavior: results of a dedicated acoustic response study. **PLoS ONE** 7(8):e42535. doi:10.1371/journal.pone.0042535.

Plotkin, P. 2003. Adult migrations and habitat use. p. 225-241 *In*: P.L. Lutz, J.A. Musick, and J. Wyneken (eds.), The biology of sea turtles, Vol. II. CRC Press, New York, NY. 455 p.

Popov, V.V., A.Y. Supin, D. Wang, K. Wang, L. Dong, and S. Wang. 2011. Noise-induced temporary threshold shift and recovery in Yangtze finless porpoises *Neophocaena phocaenoides asiaeorientalis*. **J. Acoust. Soc. Am.** 130(1):574-584.

Popov, V.V., A.Y. Supin, V.V. Rozhnov, D.I. Nechaev, E.V. Sysuyeva, V.O. Klishin, M.G. Pletenko, and M.B. Tarakanov. 2013a. Hearing threshold shifts and recovery after noise exposure in beluga whales, *Delphinapterus leucas*. **J. Exp. Biol.** 216:1587-1596.

Popov, V., A. Supin, D. Nechaev, and E.V. Sysueva. 2013. Temporary threshold shifts in naïve and experienced belugas: learning to dampen effects of fatiguing sounds? Abstr. 3rd Int. Conf. Effects of Noise on Aquatic Life, Budapest, Hungary, August 2013.

Read, A.J., P.N. Halpin, L.B. Crowder, B.D. Best, and E. Fujioka (eds.). 2009. OBIS-SEAMAP: Mapping marine mammals, birds and turtles. World Wide Web electronic publication. Accessed on 20 August 2013 at http://seamap.env.duke.edu/prod/serdp/serdp_map.php.

Reeves, R.R. 2001. Overview of catch history, historic abundance and distribution of right whales in the western North Atlantic and in Cintra Bay, West Africa**. J. Cetac. Res. Manage.** Spec. Iss. 2:187-192.

Reeves, R.R. and E. Mitchell. 1986. American pelagic whaling for right whales in the North Atlantic. **Rep. Int. Whal. Comm**. Spec. Iss. 10:221-254.

Reeves, R.R., E. Mitchell, and H. Whitehead. 1993. Status of the northern bottlenose whale, *Hyperoodon ampullatus*. **Can. Field-Nat.** 107:490-508.

Reeves, R.R., C. Smeenk, C.C. Kinze, R.L. Brownell, Jr., and J. Lien. 1999a. White-beaked dolphin *Lagenorhynchus albirostris* (Gray, 1846). p. 1-30 *In*: S.H. Ridgeway and R. Harrison (eds.), Handbook of marine mammals, Vol. 6: The second handbook of dolphins and the porpoises. Academic Press, San Diego, CA. 486 p.

Reeves, R.R., C. Smeenk, R.L. Brownell, Jr., and C.C. Kinze. 1999b. Atlantic white-sided dolphin *Lagenorhynchus acutus* (Gray, 1828). p. 31-58 *In*: S.H. Ridgeway and R. Harrison (eds.), Handbook of marine mammals, Vol. 6: The second handbook of dolphins and the porpoises. Academic Press, San Diego, CA. 486 p.

Rice, D.W. 1998. Marine mammals of the world, systematics and distribution. Spec. Publ. 4. Soc. Mar. Mammal., Allen Press, Lawrence, KS. 231 p.

Richardson, W.J., C.R. Greene, Jr., C.I. Malme, and D.H. Thomson. 1995. Marine mammals and noise. Academic Press, San Diego. 576 p.

Richardson, W.J., G.W. Miller, and C.R. Greene, Jr. 1999. Displacement of migrating bowhead whales by sounds from seismic surveys in shallow waters of the Beaufort Sea. **J. Acoust. Soc. Am.** 106(4, Pt. 2):2281 (Abstract).

Risch, D., P.J. Corkeron, W.T. Ellison and S.M. Van Parijs. 2012. Changes in humpback whale song occurrence in response to an acoustic source 200 km away. **PLoS One** 7:e29741.

Robertson, F.C., W.R. Koski, T.A. Thomas, W.J. Richardson, B. Würsig, and A.W. Trites. 2013. Seismic operations have variable effects on dive-cycle behavior of bowhead whales in the Beaufort Sea. **Endang. Species Res.** 21:143-160.

Rolland, R.M., S.E. Parks, K.E. Hunt, M. Castellote, P.J. Corkeron, D.P. Nowacek, S.K. Water and S.D. Kraus. 2012. Evidence that ship noise increases stress in right whales. **Proc. R. Soc. B** 279:2363-2368.

Salden, D.R. 1993. Effects of research boat approaches on humpback whale behavior off Maui, Hawaii, 1989–1993. p. 94 *In*: Abstr. 10th Bienn. Conf. Biol. Mar. Mamm., Galveston, TX, Nov. 1993. 130 p.

Schlundt, C.E., J.J. Finneran, B.K. Branstetter, J.S. Trickey, and K. Jenkins. 2013. Auditory effects of multiple impulses from a seismic air gun on bottlenose dolphins (*Tursiops truncatus*). Abstr. 3rd Int. Conf. Effects of Noise on Aquatic Life, Budapest, Hungary, August 2013.

Sea Around Us Project. 2011. Fisheries, ecosystems, and biodiversity. EEZ waters of United States, East Coast. Accessed on 17 September 2013 at http://www.seaaroundus.org/eez/851.aspx.

Sea Around Us Project. 2013. LME: Northeast U.S. continental shelf. Accessed on 6 November 2013 at http://www.seaaroundus.org/lme/7.aspx.

Sears, R. and W.F Perrin. 2000. Blue whale. p. 120-124 *In*: W.F. Perrin, B. Würsig, and J.G.M. Thewissen (eds.), Encyclopedia of marine mammals, 2nd edit. Academic Press, San Diego, CA. 1316 p.

Selzer, L.A. and P.M. Payne. 1988. The distribution of white-sided (*Lagenorhynchus acutus*) and common dolphins (*Delphinus delphis*) vs. environmental features of the continental shelf of the northeastern United States. **Mar. Mamm. Sci.** 4:141-153.

Sivle, L.D., P.H. Kvadsheim, A. Fahlman, F.P.A. Lam, P.L. Tyack, and P.J.O. Miller. 2012. Changes in dive behavior during naval sonar exposure in killer whales, long-finned pilot whales, and sperm whales. **Front. Physiol.** 3(400). doi:10.3389/fphys.2012.00400.

Simard, Y., F. Samaran, and N. Roy. 2005. Measurement of whale and seismic sounds in the Scotian Gully and adjacent canyons in July 2003. p. 97-115 *In*: K. Lee, H. Bain, and C.V. Hurley (eds.), Acoustic monitoring and marine mammal surveys in The Gully and outer Scotian Shelf before and during active seismic surveys. Environ. Stud. Res. Funds Rep. 151. 154 p. (Published 2007).

Solé, M., M. Lenoir, M. Durfort, M. López-Bejar, A. Lombarte, M. van der Schaaer, and M. André. 2013. Does exposure to noise from human activities compromise sensory information from cephalopod statocysts? **Deep-Sea Res. II** 95:160-181.

Southall, B.L., A.E. Bowles, W.T. Ellison, J.J. Finneran, R.L. Gentry, C.R. Greene Jr., D. Kastak, D.R. Ketten, J.H. Miller, P.E. Nachtigall, W.J. Richardson, J.A. Thomas, and P.L. Tyack. 2007. Marine mammal noise exposure criteria: initial scientific recommendations. **Aquat. Mamm.** 33(4):411-522.

Southall, B.L., T. Rowles, F. Gulland, R.W. Baird, and P.D. Jepson. 2013. Final report of the Independent Scientific Review Panel investigating potential contributing factors to a 2008 mass stranding of melon-headed whales (*Peponocephala electra*) in Antsohihy, Madagascar. Accessed in April 2014 at http://iwc.int/2008-mass-stranding-in-madagascar.

Spotila, J.R. 2004. Sea turtles: a complete guide to their biology, behavior, and conservation. The Johns Hopkins University Press, Baltimore, MD. 227 p.

Steimle, F.W. and C. Zetlin. 2000. Reef habitats in the Middle Atlantic Bight: abundance, distribution, associated biological communities, and fishery resource use. **Mar. Fish. Rev.** 62(2):24-42.

Stone, C.J. and M.L. Tasker. 2006. The effects of seismic airguns on cetaceans in U.K waters. **J. Cetac. Res. Manage.** 8(3):255-263.

Supin, A., V. Popov, D. Nechaev, and E.V. Sysueva. 2013. Sound exposure level: is it a convenient metric to characterize fatiguing sounds? A study in beluga whales. Abstr. 3rd Int. Conf. Effects of Noise on Aquatic Life, Budapest, Hungary, August 2013.

Thompson, P.M., K.L. Brookes, I.M. Graham, T.R. Barton, K. Needham, G. Bradbury, and N.D. Merchant. 2013. Short-term disturbance by a commercial two-dimensional seismic survey does not lead to long-term displacement of harbour porpoises. **Proc. Royal Soc. B** 280: 20132001.

Tougaard, J., A.J. Wright, and P.T. Madsen. 2013. Noise exposure criteria for harbour porpoises. Abstr. 3rd Int. Conf. Effects of Noise on Aquatic Life, Budapest, Hungary, August 2013.

Tyack, P.L. and V.M. Janik. 2013. Effects of noise on acoustic signal production in marine mammals. p. 251-271 *In:* Animal communication and noise. Springer, Berlin, Heidelberg, Germany.

Tyack, P.L., W.M.X. Zimmer, D. Moretti, B.L. Southall, D.E. Claridge, J.W. Durban, C.W. Clark, A. D'Amico, N. DiMarzio, S. Jarvis, E. McCarthy, R. Morrissey, J. Ward, and I.L. Boyd. 2011. Beaked whales respond to simulated and actual navy sonar. **PLoS One**:6(e17009).

UNEP-WCMC (United Nations Environment Programme-World Conservation Monitoring Centre). 2012. Convention on International Trade in Endangered Species of Wild Flora and Fauna. Appendices I, II, and III. Valid from 12 June 2013. Accessed in August 2013 at http://www.cites.org/eng/app/2013/E-Appendices-2013-06-12.pdf.

USCG (U.S. Coast Guard). 1999. Mandatory ship reporting systems. **Fed. Regist.** 64(104, 1 June):29229-29235.

USCG (U.S. Coast Guard). 2001. Mandatory ship reporting systems–Final rule. **Fed. Regist.** 66(224, 20 Nov.):58066-58070.

USCG (U.S. Coast Guard). 2013. AMVER density plot display. USCG, U.S. Department of Homeland Security. Accessed on 25 September at http://www.amver.com/density.asp.

USFWS (U.S. Fish and Wildlife Service). 1996. Piping plover *(Charadrius melodus)* Atlantic Coast Population revised recovery plan. Accessed on 5 September at http://ecos.fws.gov/docs/recovery_plan/960502.pdf.

USFWS (U.S. Fish and Wildlife Service). 1998. Roseate tern *Sterna dougallii*: Northeastern Population recovery plan, first update. Accessed on 5 September at http://ecos.fws.gov/docs/recovery_plan/981105.pdf.

USFWS (U.S. Fish and Wildlife Service). 2010. Caribbean roseate tern and North Atlantic roseate tern (*Sterna dougallii dougallii*) 5-year review: summary and evaluation. Accessed on 5 September at http://ecos.fws.gov/docs/five_year_review/doc3588.pdf.

Vigness-Raposa, K.J., R.D. Kenney, M.L. Gonzalez, and P.V. August. 2010. Spatial patterns of humpback whale (*Megaptera novaeangliae*) sightings and survey effort: insight into North Atlantic population structure. **Mar. Mamm. Sci.** 26(1):161-175.

Waldner, J.S. and D.W. Hall. 1991. A marine seismic survey to delineate Tertiary and Quaternary stratigraphy of coastal plain sediments offshore of Atlantic City, New Jersey. New Jersey Geological Survey Geological Survey Rep. GSR 26. New Jersey Department of Environmental Protection. 15 p.

Wale, M.A., S.D. Simpson, and A.N. Radford. 2013. Size-dependent physiological responses of shore crabs to single and repeated playback of ship noise. **Biol. Lett.** 9:20121194. http://dx.doi.org/10.1098/rsbl.2012.1194.

Ward-Geiger, L.I., G.K. Silber, R.D. Baumstark, and T.L. Pulfer. 2005. Characterization of ship traffic in right whale Critical Habitat. **Coast. Manage.** 33:263-278.

Waring, G.T., C.P. Fairfield, C.M. Ruhsam, and M. Sano. 1992. Cetaceans associated with Gulf Stream features off the Northeastern U.S.A. shelf. **ICES C.M.** 1992/N:12.

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

Waring, G.T., E. Josephson, K. Maze-Foley, and P.E. Rosel (eds.) 2010. U.S. Atlantic and Gulf of Mexico marine mammal stock assessments–2010. NOAA Tech. Memo. NMFS-NE-219. 591 p.

Waring, G.T., E. Josephson, K. Maze-Foley, and P.E Rozel (eds.). 2013. Draft U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments–2013. 543 p. Accessed on 28 November 2013 at http://www.nmfs.noaa.gov/pr/sars/pdf/ao2013_draft.pdf.

Wartzok, D., A.N. Popper, J. Gordon, and J. Merrill. 2004. Factors affecting the responses of marine mammals to acoustic disturbance. **Mar. Technol. Soc. J.** 37(4):6-15.

Weilgart, L.S. 2007. A brief review of known effects of noise on marine mammals. **Int. J. Comp. Psychol.** 20:159-168.

Weinrich, M.T., R.D. Kenney, and P.K. Hamilton. 2000. Right whales (*Eubalaena glacialis*) on Jeffreys Ledge: a habitat of unrecognized importance? **Mar. Mamm. Sci.** 16:326-337.

Weir, C.R. 2007. Observations of marine turtles in relation to seismic airgun sound off Angola. **Mar. Turtle Newsl.** 116:17-20.

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

Wenzel, F., D.K. Mattila, and P.J. Clapham. 1988. *Balaenoptera musculus* in the Gulf of Maine. **Mar. Mamm. Sci.** 4(2):172-175.

Westgate, A.J., A.J. Read, T.M. Cox, T.D. Schofield, B.R. Whitaker, and K.E. Anderson. 1998. Monitoring a rehabilitated harbor porpoise using satellite telemetry. **Mar. Mamm. Sci.** 14(3):599-604.

Whitehead, H. 2002. Estimates of the current global population size and historical trajectory for sperm whales. **Mar. Ecol. Prog. Ser.** 242:295-304.

Whitt, A.D., K. Dudzinski, and J.R. Laliberté. 2013. North Atlantic right whale distribution and seasonal occurrence in nearshore waters off New Jersey, U.S.A., and implications for management. **Endang. Species Res.** 20:59-69.

Williams, T.M, W.A. Friedl, M.L. Fong, R.M. Yamada, P. Sideivy, and J.E. Haun. 1992. Travel at low energetic cost by swimming and wave-riding bottlenose dolphins. **Nature** 355(6363):821-823.

Winn, H.E., C.A. Price, and P.W. Sorensen. 1986. The distributional biology of the right whale (*Eubalaena glacialis*) in the western North Atlantic. **Rep. Int. Whal. Comm. Spec. Iss.** 10:129-138.

Wittekind, D., J. Tougaard, P. Stilz, M. Dähne, K. Lucke, C.W. Clark, S. von Benda-Beckmann, M. Ainslie, and U. Siebert. 2013. Development of a model to assess masking potential for marine mammals by the use of airguns in Antarctic waters. Abstr. 3rd Int. Conf. Effects of Noise on Aquatic Life, Budapest, Hungary, August 2013.

Wright, A.J. 2014. Reducing impacts of human ocean noise on cetaceans: knowledge gap analysis and recommendations. 98 p. World Wildlife Fund Global Arctic Programme, Ottawa, Canada.

Wright, A.J., T. Deak, and E.C.M. Parsons. 2011. Size matters: management of stress responses and chronic stress in beaked whales and other marine mammals may require larger exclusion zones. **Mar. Poll. Bull.** 63(1-4):5-9.

Würsig, B., S.K. Lynn, T.A. Jefferson, and K.D. Mullin. 1998. Behaviour of cetaceans in the northern Gulf of Mexico relative to survey ships and aircraft. **Aquat. Mamm.** 24(1):41-50.

Würsig, B., T.A. Jefferson, and D.J. Schmidly. 2000. The marine mammals of the Gulf of Mexico. Texas A&M University Press, College Station, TX. 232 p.

Yazvenko, S.B., T.L. McDonald, S.A. Blokhin, S.R. Johnson, S.K. Meier, H.R. Melton, M.W. Newcomer, R.M. Nielson, V.L. Vladimirov, and P.W. Wainwright. 2007a. Distribution and abundance of western gray whales during a seismic survey near Sakhalin Island, Russia. **Environ. Monit. Assess.** 134(1-3):45-73.

Yazvenko, S. B., T.L. McDonald, S.A. Blokhin, S.R. Johnson, H.R. Melton, and M.W. Newcomer. 2007b. Feeding activity of western gray whales during a seismic survey near Sakhalin Island, Russia. **Environ. Monit. Assess.** 134(1-3):93-106.

APPENDIX A:

ACOUSTIC MODELING OF SEISMIC ACOUSTIC SOURCES AND SCALING FACTORS FOR SHALLOW WATER[4]

For the proposed survey off New Jersey, a smaller energy source than the full airgun array available on the R/V *Langseth* would be sufficient to collect the desired geophysical data. Previously conducted calibration studies of the *Langseth*'s airgun arrays, however, can still inform the modeling process used to develop mitigation radii for the currently proposed survey.

Acoustic Source Description

This 3-D seismic data acquisition project would use two airgun subarrays that would be fired alternately as the ship progresses along track (one subarray would be towed on the port side and the other on the starboard side). Each airgun subarray would consist of either four airguns (total volume 700 in^3) or eight airguns (total volume 1400 in^3). These two possible subarray configurations would use subsets of the linear arrays or "strings" composed of Bolt 1500LL and Bolt 1900LLX airguns that are carried by the R/V *Langseth* (Figure A1). For the 700-in^3 source, four airguns in one string would be fired simultaneously, and the other six airguns on the string would be inactive. For the 1400-in^3 source, two strings would be used, with the same four active airguns on each string and the same six inactive airguns on each string. The subarray tow depth would be either 4.5 m (desired tow depth) or 6 m (in case of weather degradation). The subarray would be fired roughly every 5.4 s. At each shot, a brief (~0.1 s) pulse of sound would be emitted, with silence in the intervening periods. This signal attenuates as it moves away from the source, decreasing in amplitude and increasing in signal duration.

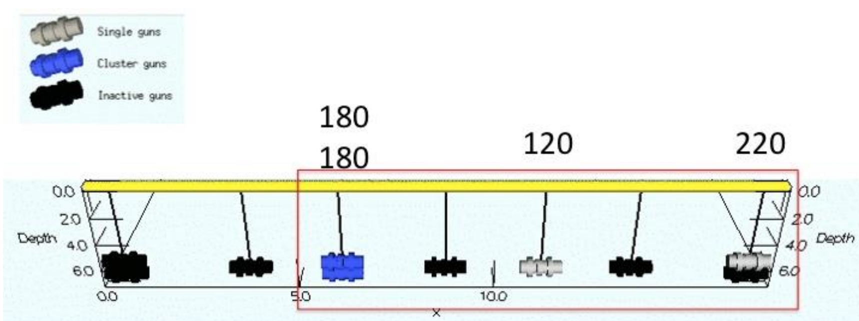

FIGURE A1. Four-airgun subset of one string that would be used as a 700-in^3 subarray for the proposed survey (individual volumes are indicated). For the 1400-in^3 array, another identical four-airgun subset of one string would be used.

Four-Airgun Subarray Specifications

Energy Source	1950-psi Bolt airguns with volumes 120–220 in^3, arranged in one string of four operating airguns
Towing depth of energy source	4.5 m or 6 m
Source output (downward), 4.5 m	0-pk is 240.4 dB re 1 μPa · m; pk-pk is 246.3 dB re 1 μPa · m
Source output (downward), 6 m	0-pk is 240.4 dB re 1 μPa · m; pk-pk is 246.7 dB re 1 μPa · m
Air discharge volume	~700 in^3
Dominant frequency components	0–188 Hz

[4] Helene Carton, Ph.D., L-DEO.

Eight-Airgun Subarray Specifications

Energy Source	1950-psi Bolt airguns with volumes 120–220 in^3, arranged in two strings of four operating airguns each
Towing depth of energy source	4.5 m or 6 m
Source output (downward), 4.5 m	0-pk is 246.5 dB re 1 μPa · m; pk-pk is 252.5 dB re 1 μPa · m
Source output (downward), 6 m	0-pk is 246.4 dB re 1 μPa · m; pk-pk is 252.8 dB re 1 μPa · m
Air discharge volume	~1400 in^3
Dominant frequency components	0–188 Hz

Because the actual source originates from either 4 or 8 airguns rather than a single point source, the highest sound levels measurable at any location in the water is less than the nominal source level. In addition, the effective source level for sound propagating in near-horizontal directions would be substantially lower than the nominal source level applicable to downward propagation because of the directional nature of the sound from the airgun array.

Modeling and Scaling Factors

Propagation measurements were obtained in shallow water for the *Langseth*'s 18-gun, 3300-in^3 (2-string) array towed at 6 m depth, in both crossline (athwartship) and inline (fore and aft) directions. Results were presented in Diebold et al. (2010), and part of their Figures 5 and 8 are reproduced here (Figure A2). The crossline measurements, which were obtained at ranges ~2 km to ~14.5 km, are shown along with the 95th percentile fit (Figure A1, top panel). This allows extrapolation for ranges <2 km and >14.5 km, providing 150 dB SEL, 170 dB SEL and 180 dB SEL distances of 15.28 km, 1097 m, and 294 m, respectively. Note that the short ranges were better sampled in inline direction including by the 6-km long MCS streamer (Figure A2, bottom panel). The measured 170 dB SEL level is at 370-m distance in inline direction, well under the extrapolated value of 1097 m in crossline direction, and the measured 180-dB SEL level is at 140-m distance in inline direction, also less than the extrapolated value of 294 m in crossline direction. Overall, received levels are ~5 dB lower inline than they are crossline, which results from the directivity of the array (the 2-string array being spatially more extended in fore and aft than athwartship directions). Mitigation radii based on the crossline measurements are thus the more conservative ones and are therefore proposed to be used as the basis for the mitigation zone for the proposed activity.

The empirically derived crossline measurements obtained for the 18-gun, 3300-in^3 array in shallow water in the Gulf of Mexico, described above, are used to derive the mitigation radii for the proposed New Jersey margin 3-D survey that would take place in June–July 2014 (Figure A3). The entire survey area would be located in shallow water (<100 m). The source for this survey would be either a 4-gun, 700-in^3 subset of 1 string (at 4.5- or 6-m tow depth), or an 8-gun, 1400 in^3 subset of two strings (at 4.5- or 6-m tow depth). The differences in array volumes, airgun configuration and tow depth are accounted for by scaling factors calculated based on the deep-water L-DEO model results (shown in Figures A4 to A8).

The scaling procedure uses radii obtained from L-DEO models. Specifically, from L-DEO modeling, 150-, 170-, and 180-dB SEL isopleths for the 18-gun, 3300-in^3 array towed at 6-m depth have radii of 4500, 450, and 142 m, respectively, in deep water (Figure A3). Similarly, the 150-, 170-, and 180-dB SEL isopleths for the 8-gun, 1400-in^3 subset of 2 strings array towed at 4.5 m depth have radii of 1964, 196, and 62 m, respectively, in deep water (Figure A6). Taking the ratios between both sets of deep-water radii yields scaling factors of 0.4356–0.4366. These scaling factors are then applied to the empirically derived shallow water radii for the 3300-in^3 array at 6-m tow depth, to derive radii for the suite of proposed airgun subsets. For example, when applying the scaling ratios for the 8-gun, 1400-in^3

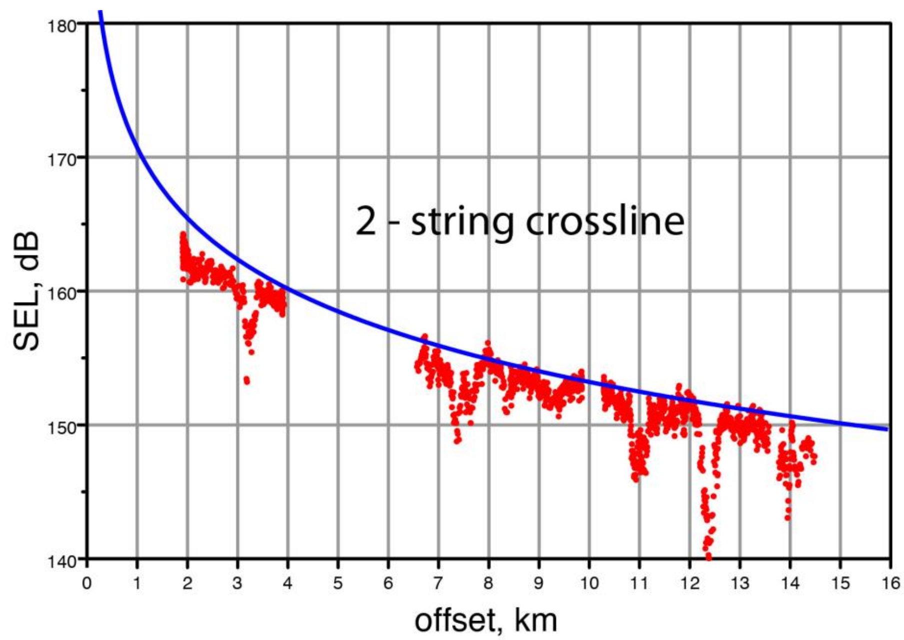

Figure 5a. Sound Exposure Levels for the crossline (side aspect) arrivals recorded along the spiral track at the shallow water calibration site, with a 95th percentile fit (using the methods described by Tolstoy et al., 2009).

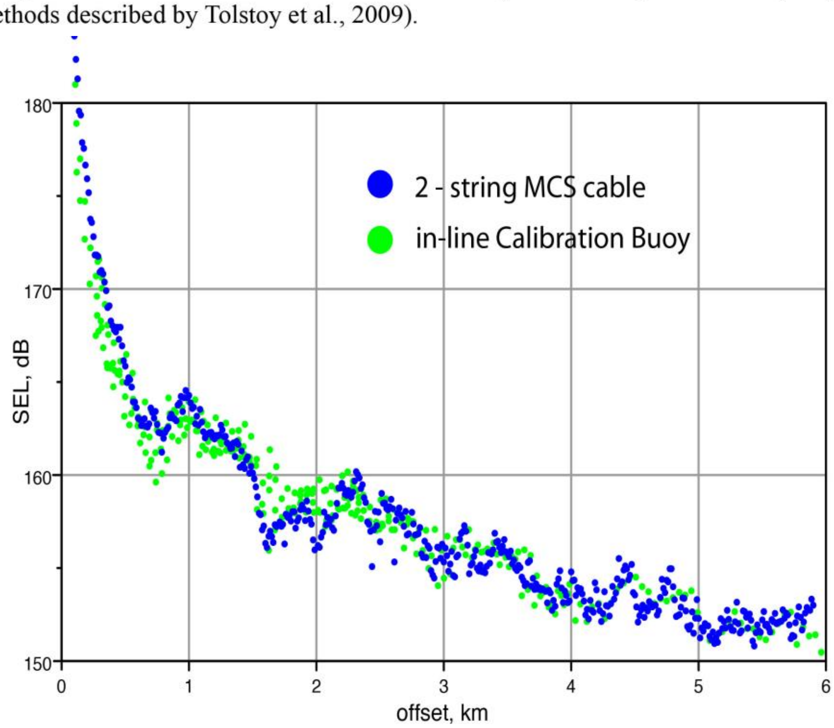

FIGURE A2. R/V *Langseth* Gulf of Mexico calibration results for the 18-gun, 3300-in^3, 2-string array at 6-m depth obtained at the shallow site (Diebold et al. 2010).

array at 4.5-m tow depth, the distances obtained are 6.67 km for 150 dB SEL (proxy for SPL 160 dB rms), 478 m for 170 dB SEL (SPL 180 dB rms), and 128 m for 180 dB SEL (SPL 190 dB rms).

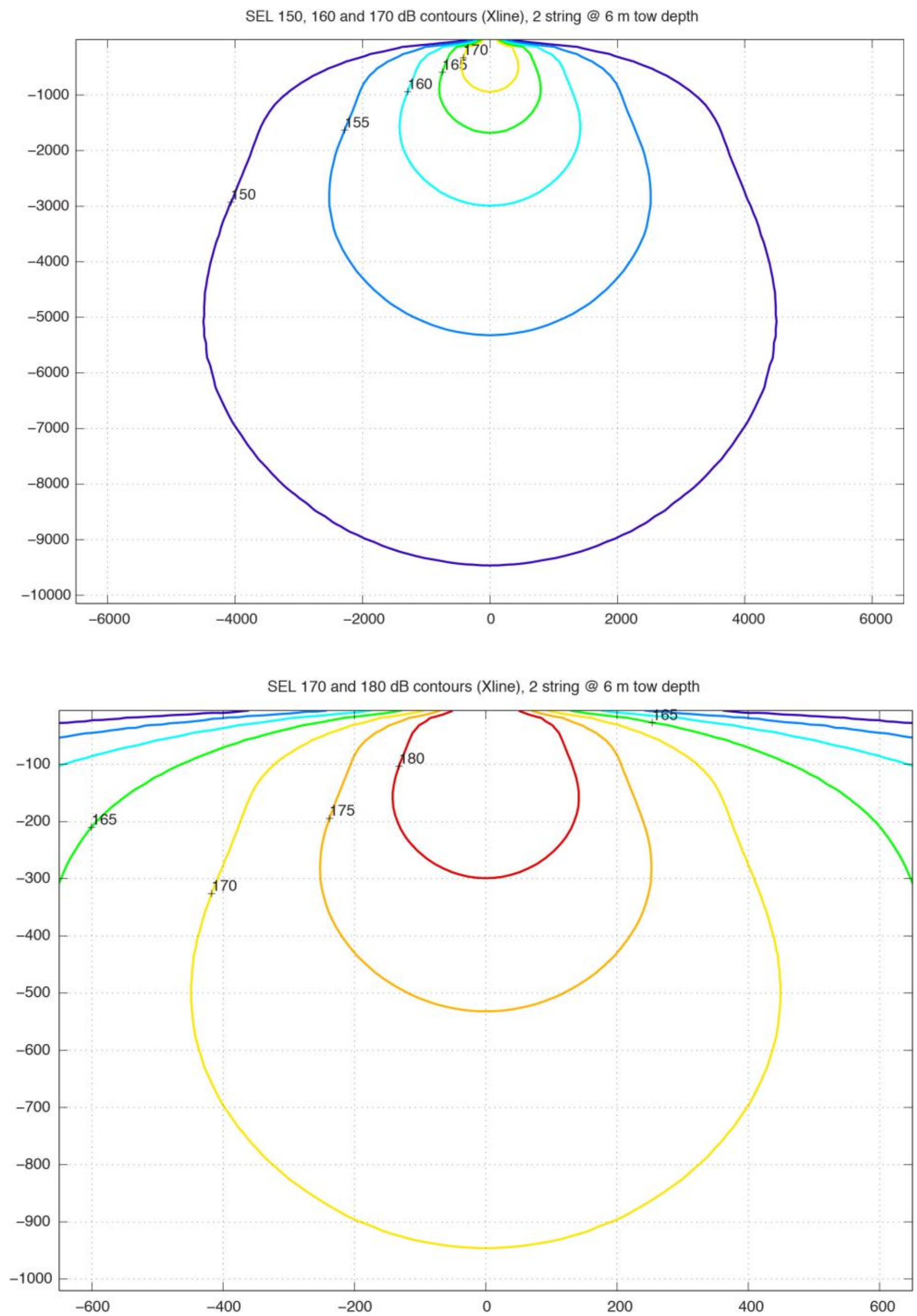

FIGURE A3. Deep-water model results for the 18-gun, 3300-in^3, 2-string array at 6-m tow depth, the configuration that was used to collect calibration measurements presented in Figure 2. The 150-dB SEL, 170-dB SEL, and 180-dB SEL (proxies for SPLs of 160, 180, and 190 dB rms[5]) distances can be read at 4500 m, 450 m, and 142 m.

---

[5] Sound sources are primarily described in sound pressure level (SPL) units. SPL is often referred to as rms or "root mean square" pressure, averaged over the pulse duration. Sound exposure level (SEL) is a measure of the received energy in a pulse and represents the SPL that would be measured if the pulse energy were spread evenly across a 1-s period.

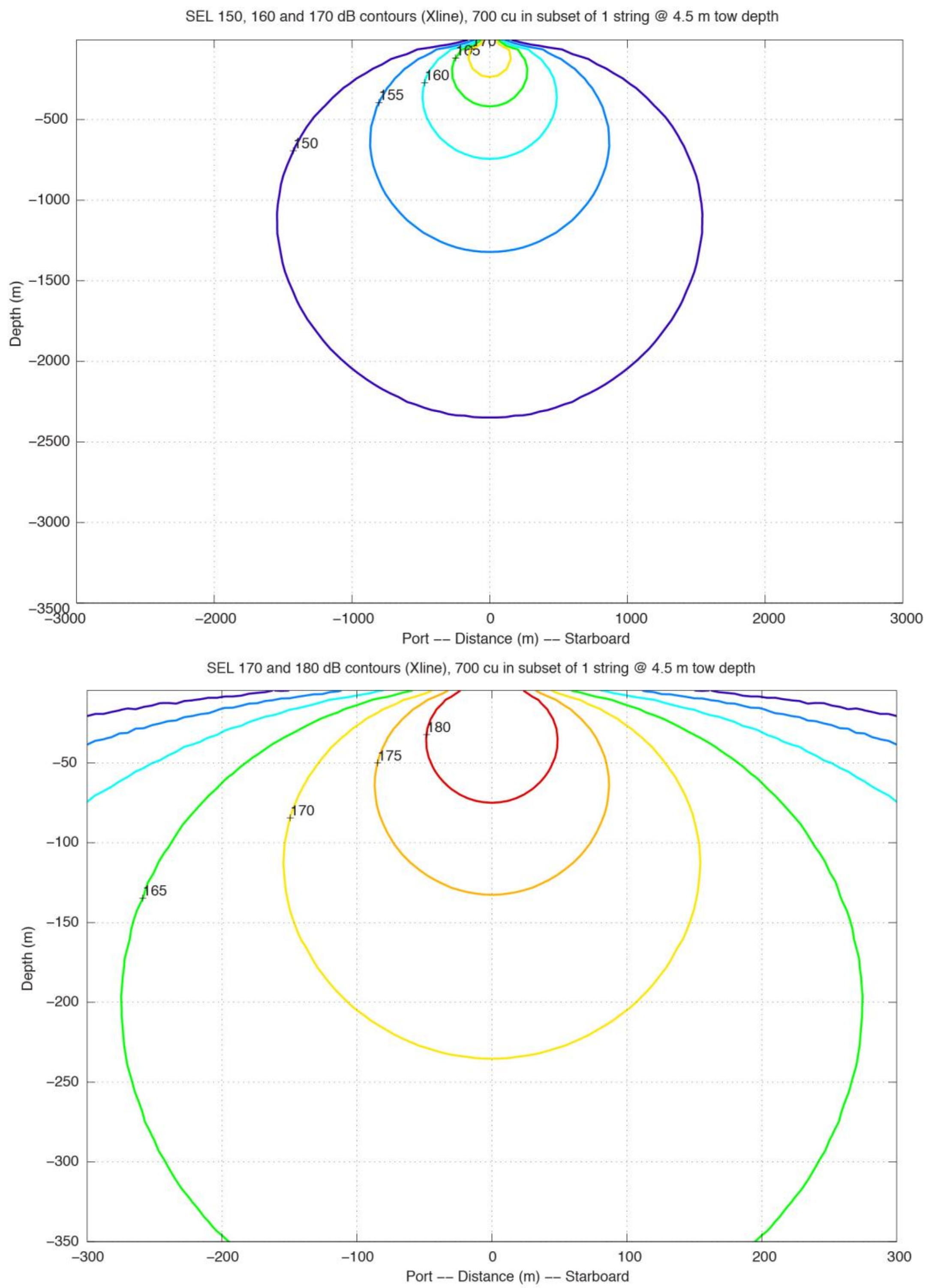

FIGURE A4. Deep-water model results for the 4-gun, 700-in^3 subset of 1-string array at 4.5-m tow depth that could be used for the NJ margin 3D survey. The 150-dB SEL, 170-dB SEL, and 180-dB SEL distances can be read at 1544 m, 155 m, and 49 m, respectively.

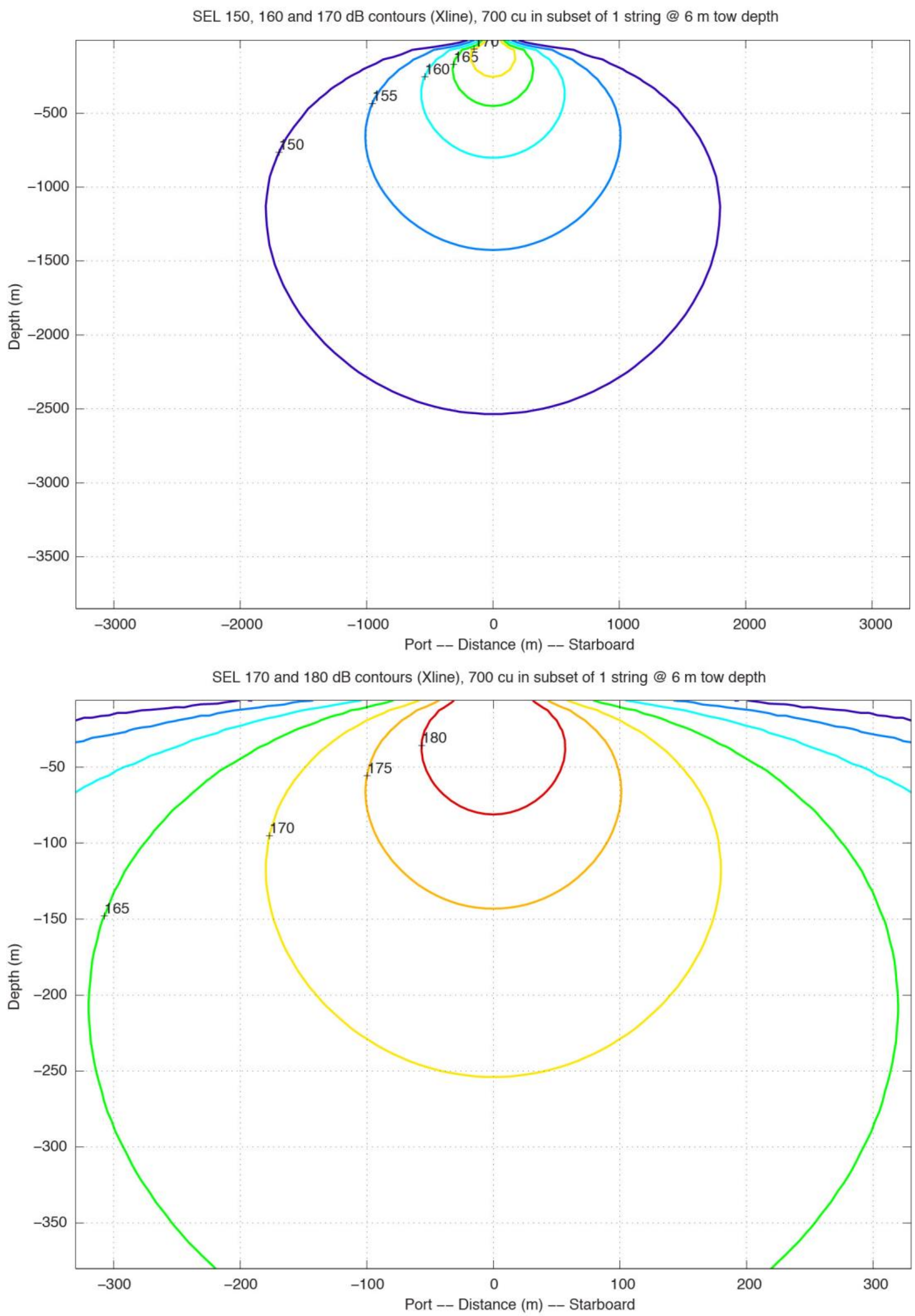

FIGURE A5. Deep-water model results for the 4-gun, 700-in^3 subset of 1-string array at 6mm tow depth that could be used for the NJ margin 3-D survey. The 150-dB SEL, 170-dB SEL, and 180-dB SEL distances can be read at 1797 m, 180 m, and 57 m, respectively.

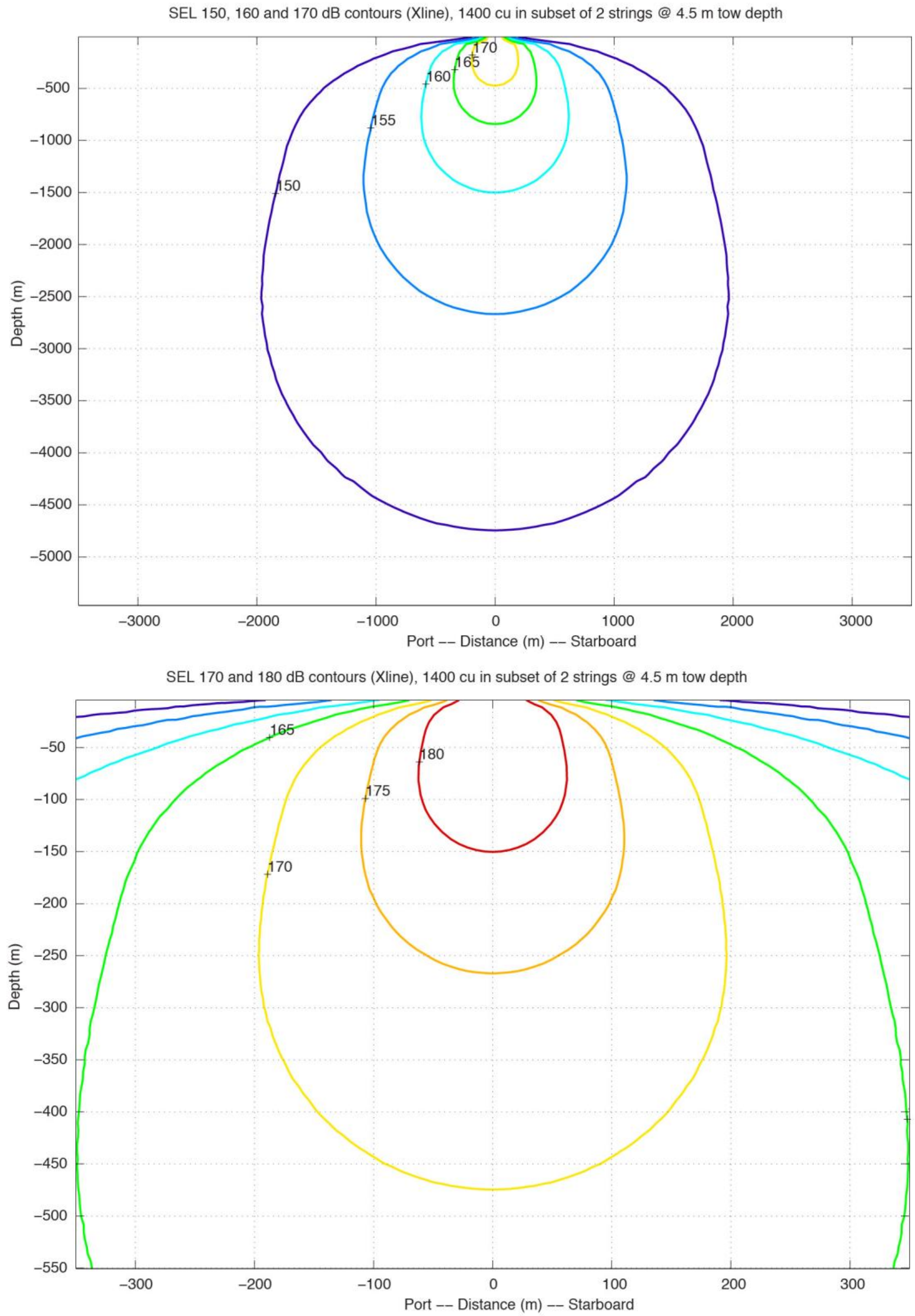

FIGURE A6. Deep-water model results for the 8-gun, 1400-in^3 subset of 2-string array at 4.5-m tow depth that could be used for the NJ margin 3-D survey. The 150-dB SEL, 170-dB SEL, and 180-dB SEL distances can be read at 1964 m, 196 m, and 62 m, respectively.

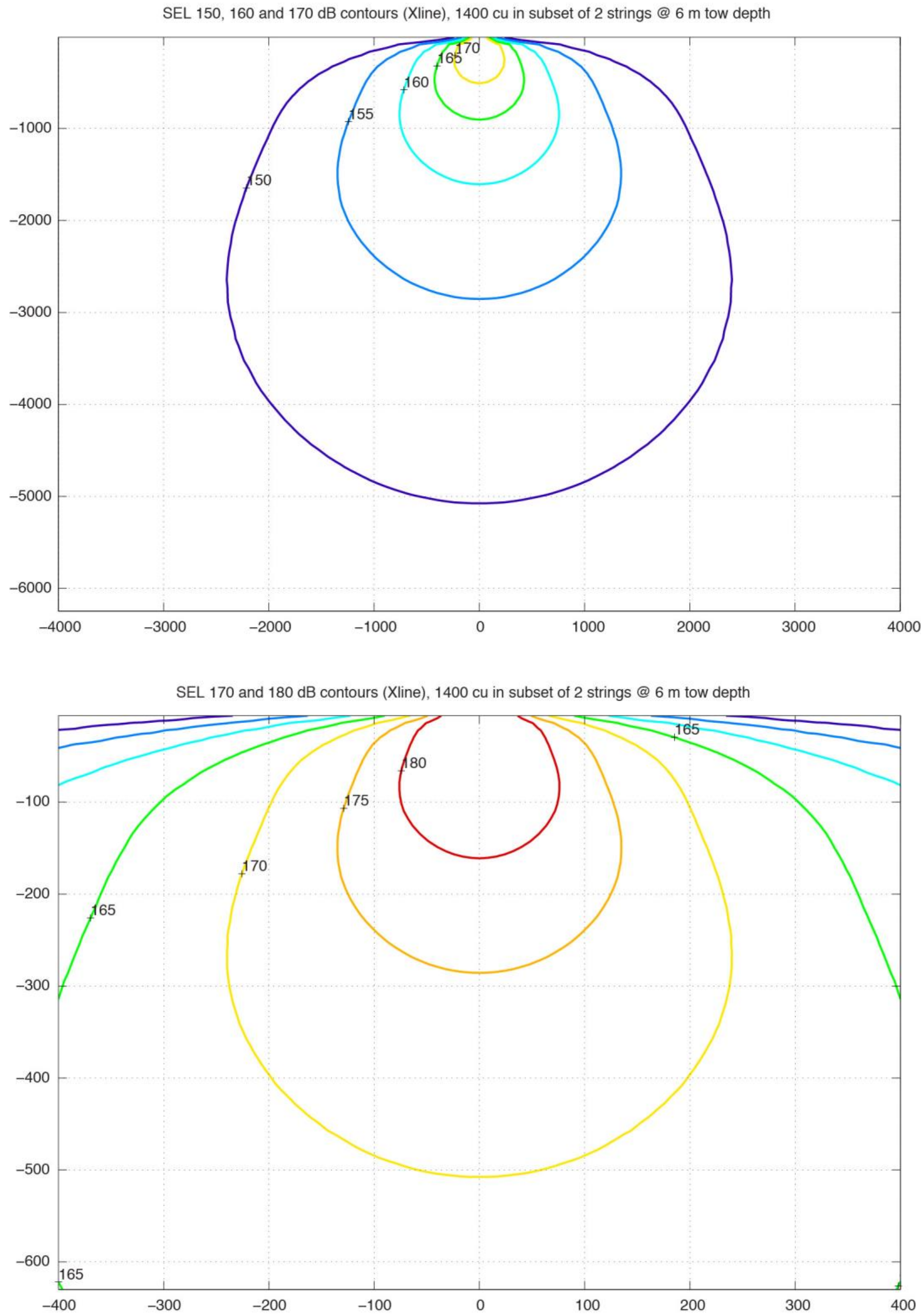

FIGURE A7. Deep-water model results for the 8-gun, 1400-in^3 subset of 1-string array at 6-m tow depth that could be used for the NJ margin 3-D survey. The 150 dB-SEL, 170-dB SEL, and 180-dB SEL distances can be read at 2401 m, 240 m, and 76 m, respectively.

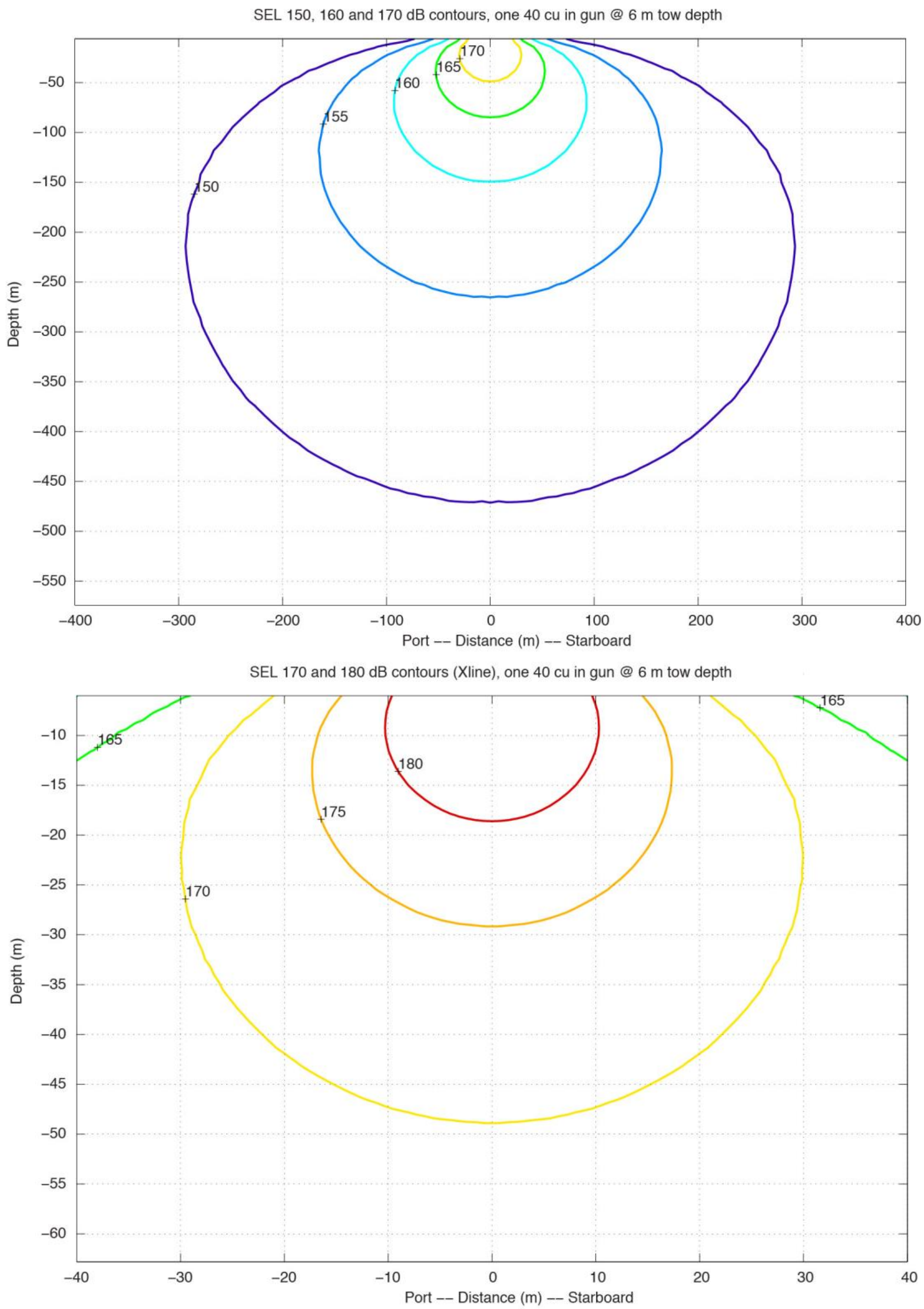

FIGURE A8. Deep-water model results for the single 40-in^3 Bolt airgun at 6-m tow depth. The 150-dB SEL, 170-dB SEL, and 180-dB SEL distances can be read at 293 m, 30 m, and 10 m, respectively.

The same procedure is applied for the suite of arrays:

(1) 4-gun 700 in^3 array, subset of 1 string at 4.5 m tow depth (Figure A4)

(2) 4-gun 700 in^3 array, subset of 1 string at 6 m tow depth (Figure A5)

(3) 8-gun 1400 in^3 array, subset of 2 strings at 4.5 m tow depth (Figure A6)

(4) 8-gun 1400 in^3 array, subset of 2 strings at 6 m tow depth (Figure A7)

(5) Single 40 in^3 mitigation gun at 6 m tow depth (Figure A8)

The derived shallow water radii are presented in Table A1. The final values are reported in Table A2.

TABLE A1. Table summarizing scaling procedure applied to empirically derived shallow-water radii to derive shallow-water radii for various array subsets that could be used during the New Jersey margin 3D survey.

Calibration Study: 18-gun, 3300-in^3 @ 6-m depth	**Deep water radii (m)** (from L-DEO model results)			**Shallow Water Radii (m)** (Based on empirically-derived crossline Measurements)
	150 dB SEL:	4500		15280
	170 dB SEL:	450		1097
	180 dB SEL:	142		294
Proposed Airgun sources	**Deep water radii** (from L-DEO model results)		**Scaling factor** *[Deep-water radii for 18-gun 3300-in^3 array @ 6 m depth]*	**Shallow water radii (m)** *[Scaling factor **x** shallow water radii for 18-gun 3300 in^3 array @ 6 m depth]*
Source #1: 4-gun, 700-in^3 @ 4.5-m depth	150 dB SEL:	1544 m	0.3431	5240
	170 dB SEL:	155 m	0.3444	378
	180 dB SEL:	49 m	0.3451	101
Source #2: 4-gun, 700-in^3 @ 6-m depth	150 dB SEL:	1797 m	0.3993	6100
	170 dB SEL:	180 m	0.4000	439
	180 dB SEL:	57 m	0.4014	118
Source #3: 8-gun, 1400-in^3 @ 4.5-m depth	150 dB SEL:	1964 m	0.4364	6670
	170 dB SEL:	196 m	0.4356	478
	180 dB SEL:	62 m	0.4366	128
Source #4: 8-gun, 1400-in^3 @ 6-m depth	150 dB SEL:	2401 m	0.5336	8150
	170 dB SEL:	240 m	0.5333	585
	180 dB SEL:	76 m	0.5352	157
Source #5: Single 40-in^3 @ 6-m depth	150 dB SEL:	293 m	0.0651	995
	170 dB SEL:	30 m	0.0667	73
	180 dB SEL:	10 m	0.0704	21

TABLE A2. Predicted distances in meters to which sound levels ≥ 180 and 160 dB re 1 μPa_{rms} would be received during the proposed 3-D survey off New Jersey, using either a 4-gun, 700-in^3 subset of 1 string (at 4.5- or 6-m tow depth), or an 8-gun, 1400-in^3 subset of two strings (at 4.5- or 6-m tow depth), and the 40-in^3 airgun during power-downs. Radii are based on Figures A1 to A6 and scaling described in the text and Table A1, assuming that received levels on an rms basis are, numerically, 10 dB higher than the SEL values.

Source and Volume	Water Depth	Predicted RMS Radii (m)	
		180 dB	160 dB
4-airgun subarray (700 in^3) @ 4.5 m	<100 m	378	5240
4-airgun subarray (700 in^3) @ 6 m	<100 m	439	6100
8-airgun subarray (1400 in^3) @ 4.5 m	<100 m	478	6670
8-airgun subarray (1400 in^3) @ 6 m	<100 m	585	8150
Single Bolt airgun (40 in^3) @ 6 m	<100 m	73	995