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

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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

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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.

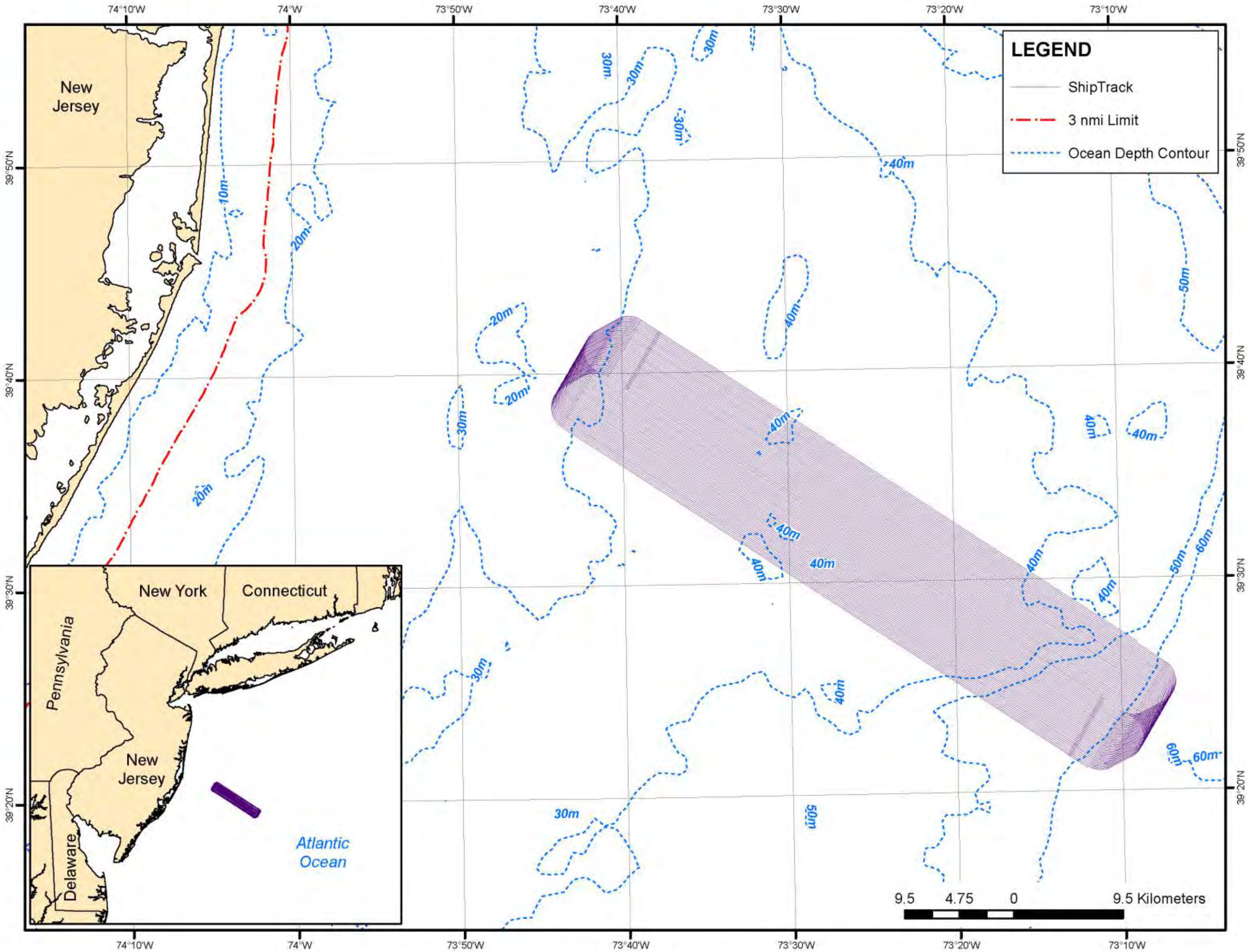

Figure 1. Location of the proposed seismic survey in the Atlantic Ocean off the coast of New Jersey.

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

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]

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

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 paleobathymetry. 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.

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[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).

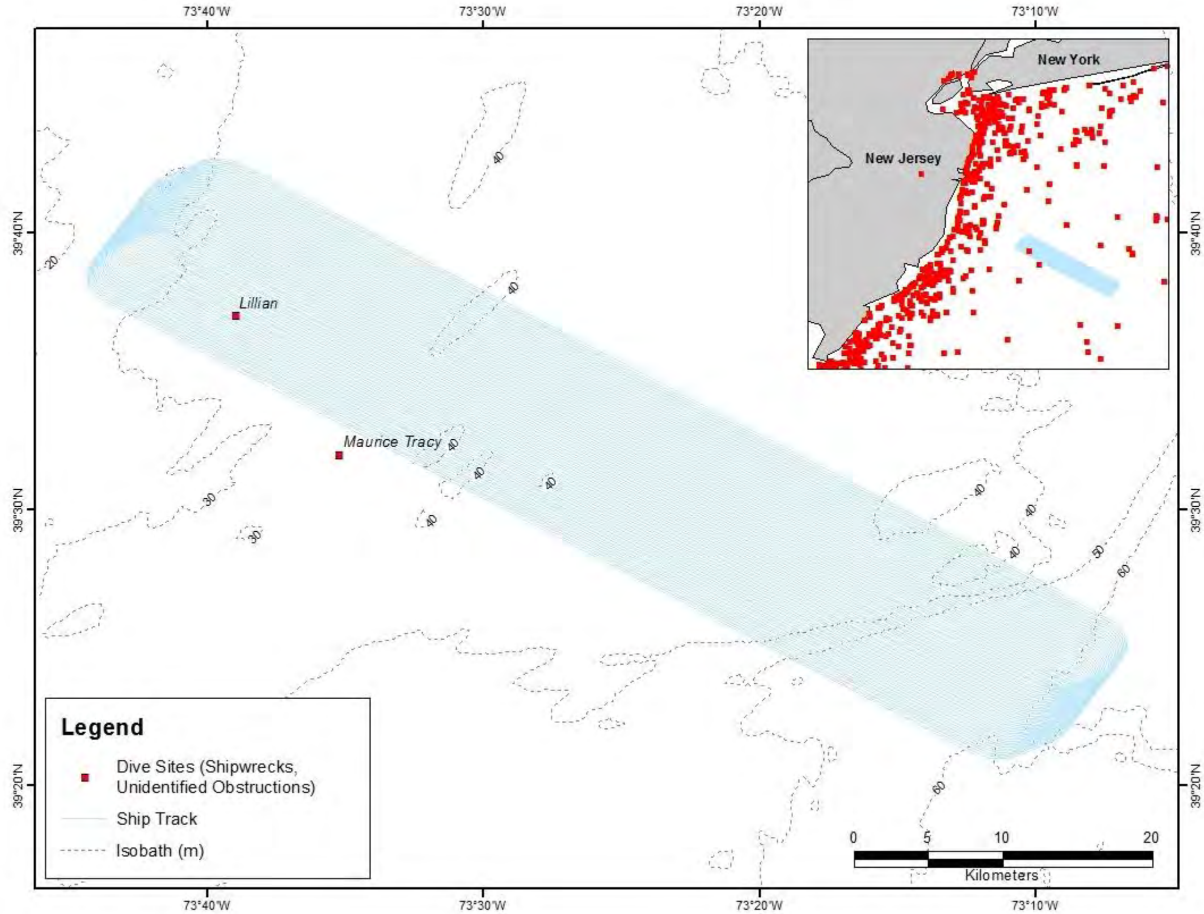

Figure 2. Potential dive sites (shipwrecks or unidentified obstructions) in New Jersey waters. Source: NOAA (2014).

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.

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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.

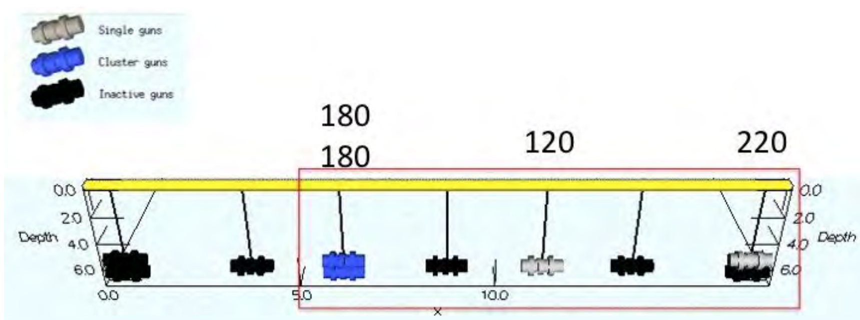

FIGURE A1. Four-airgun subset of one string that would be used as a 700-in^3 subarray for the proposed survey (individual volumes are indicated). For the 1400-in^3 array, another identical four-airgun subset of one string would be used.

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

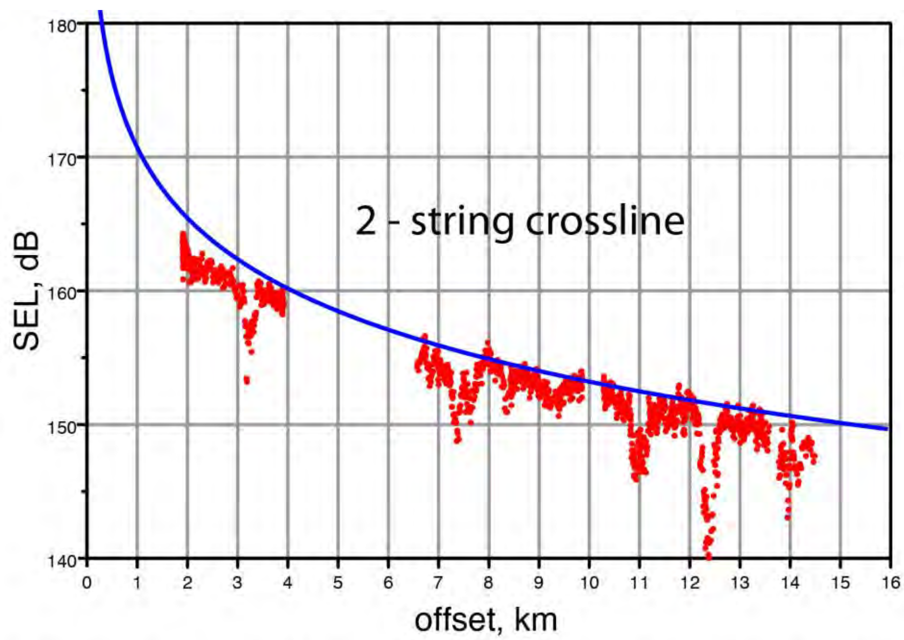

Figure 5a. Sound Exposure Levels for the crossline (side aspect) arrivals recorded along the spiral track at the shallow water calibration site, with a 95th percentile fit (using the methods described by Tolstoy et al., 2009).

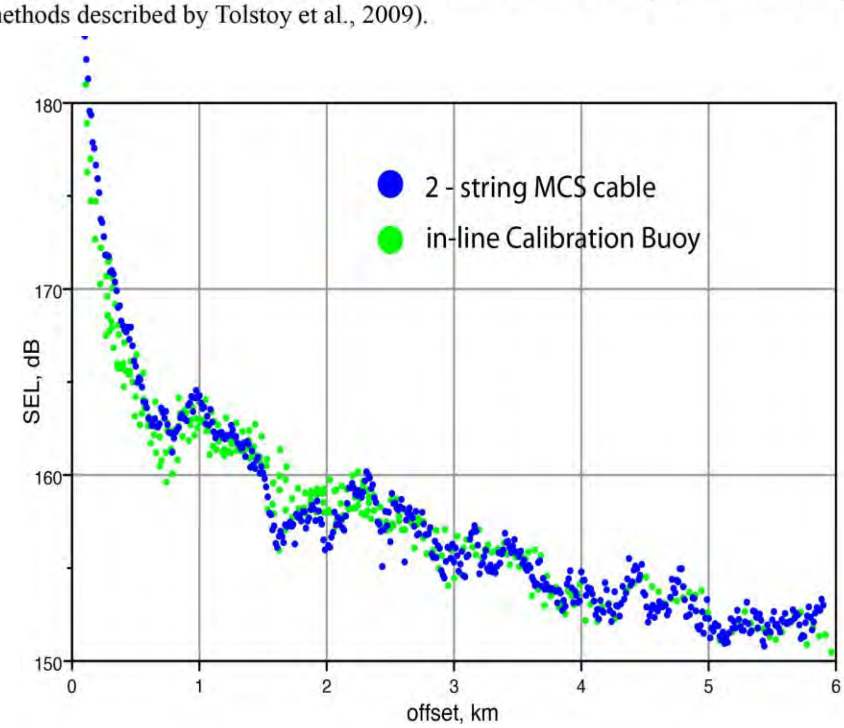

FIGURE A2. R/V *Langseth* Gulf of Mexico calibration results for the 18-gun, 3300-in^3, 2-string array at 6-m depth obtained at the shallow site (Diebold et al. 2010).

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).

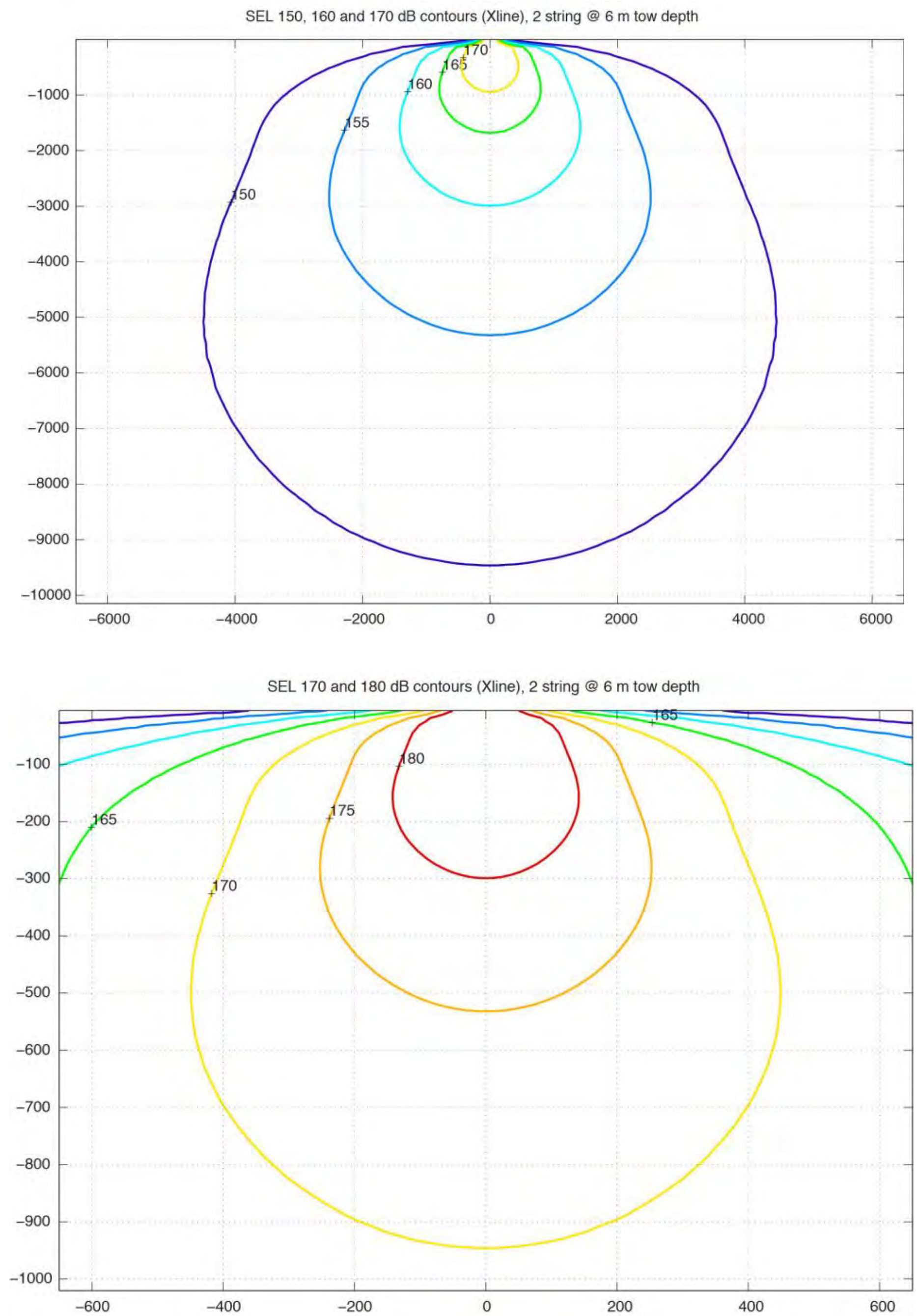

FIGURE A3. Deep-water model results for the 18-gun, 3300-in^3, 2-string array at 6-m tow depth, the configuration that was used to collect calibration measurements presented in Figure 2. The 150-dB SEL, 170-dB SEL, and 180-dB SEL (proxies for SPLs of 160, 180, and 190 dB rms[5]) distances can be read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

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[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.

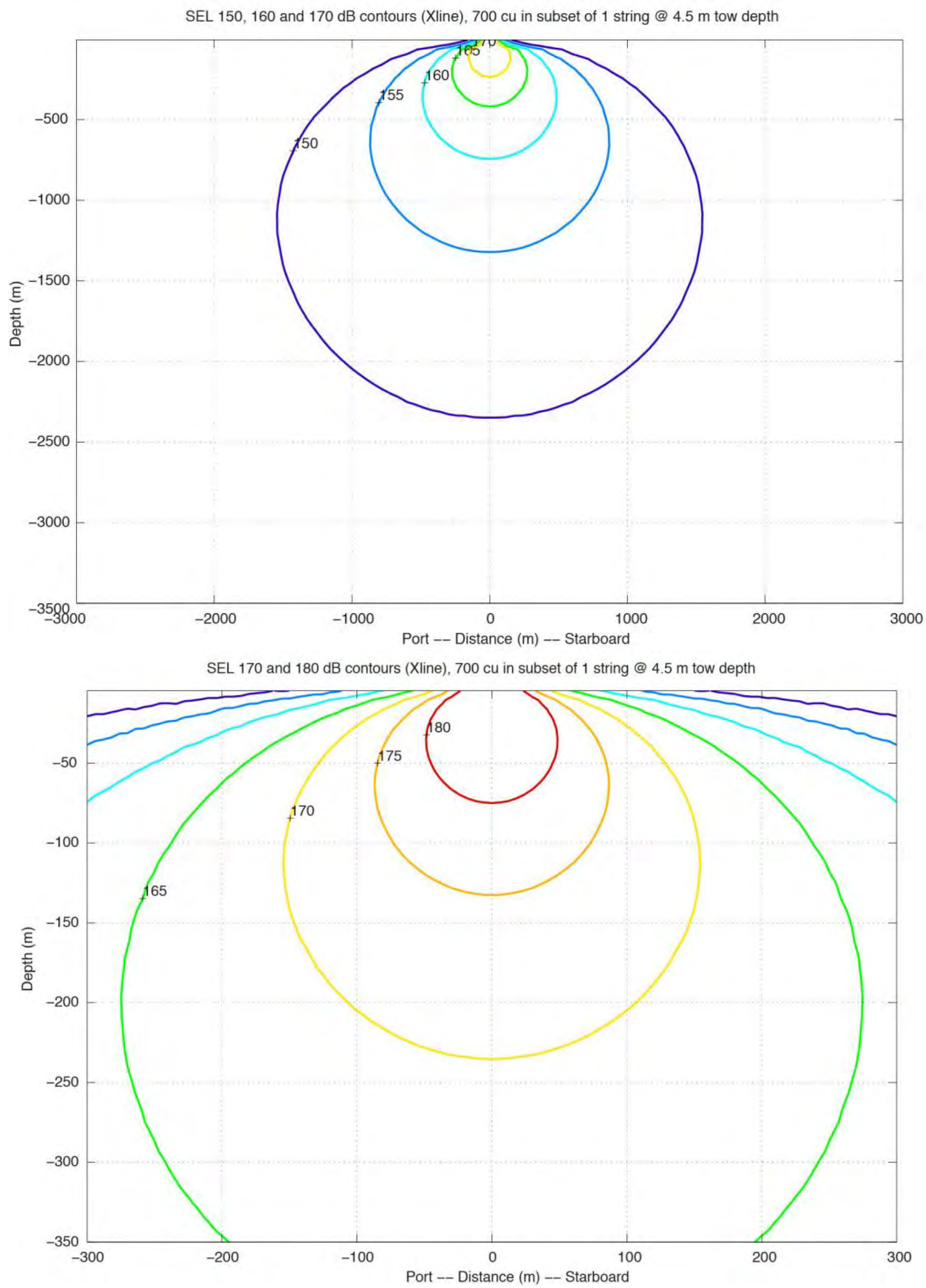


FIGURE A4. Deep-water model results for the 4-gun, 700-in^3 subset of 1-string array at 4.5-m tow depth that could be used for the NJ margin 3D survey. The 150-dB SEL, 170-dB SEL, and 180-dB SEL distances can be read at 1544 m, 155 m, and 49 m, respectively.

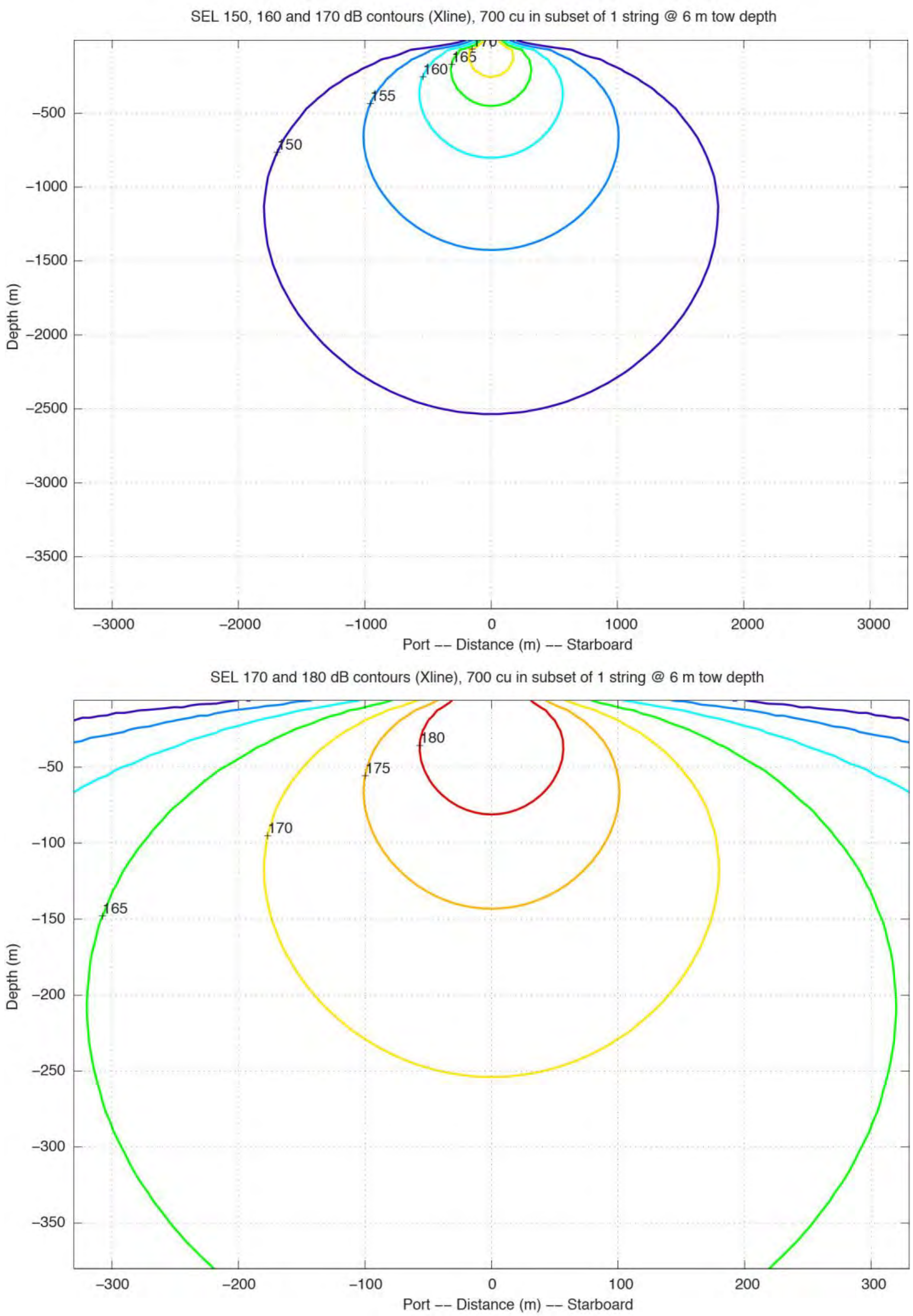


FIGURE A5. Deep-water model results for the 4-gun, 700-in^3 subset of 1-string array at 6mm tow depth that could be used for the NJ margin 3-D survey. The 150-dB SEL, 170-dB SEL, and 180-dB SEL distances can be read at 1797 m, 180 m, and 57 m, respectively.

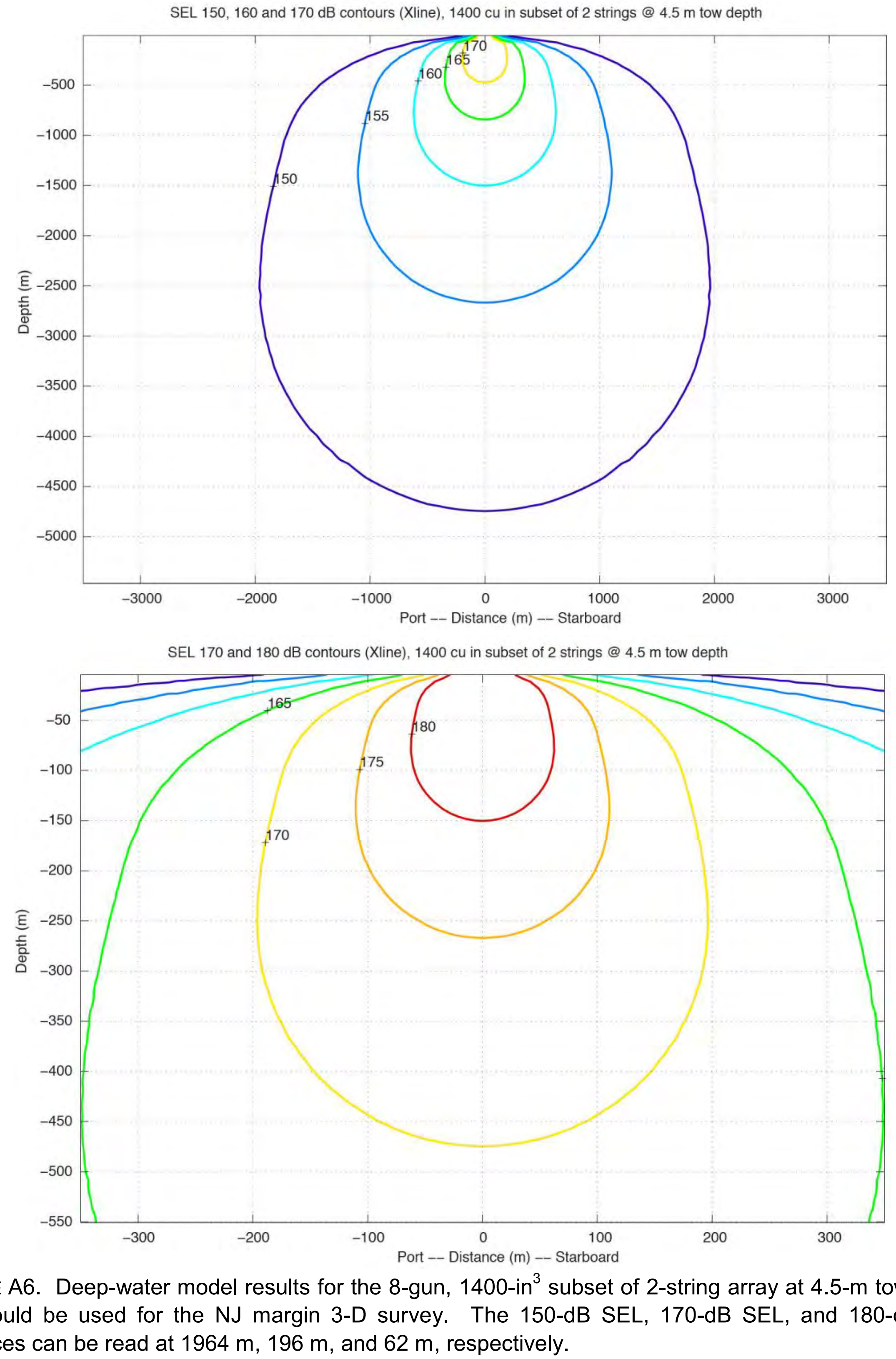
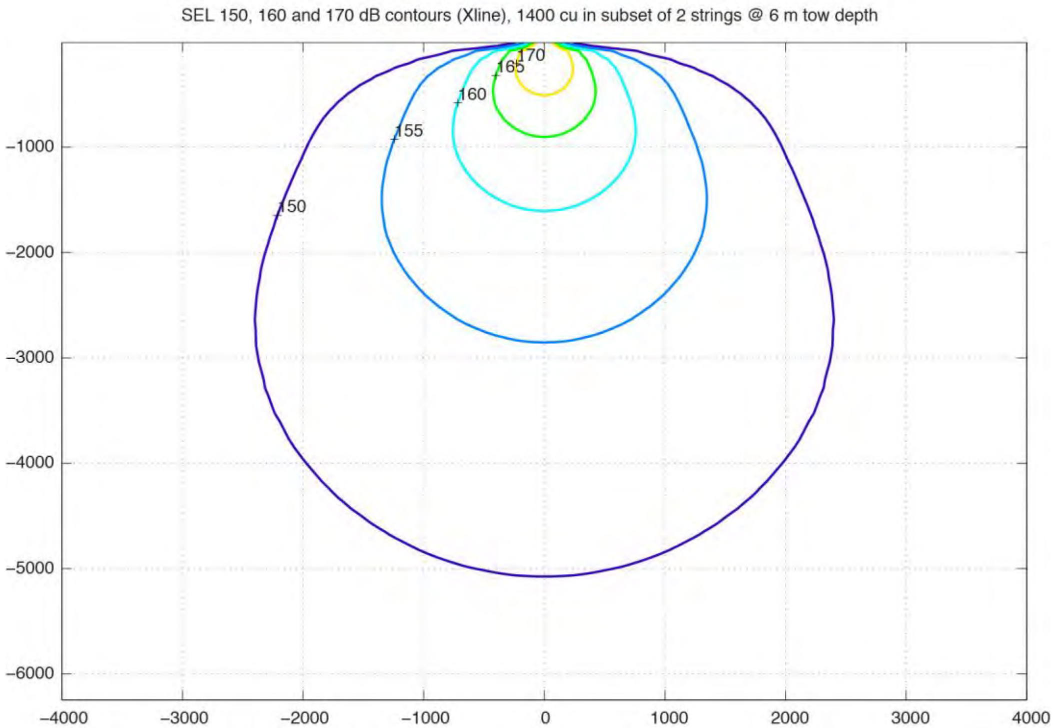


FIGURE A6. Deep-water model results for the 8-gun, 1400-in^3 subset of 2-string array at 4.5-m tow depth that could be used for the NJ margin 3-D survey. The 150-dB SEL, 170-dB SEL, and 180-dB SEL distances can be read at 1964 m, 196 m, and 62 m, respectively.



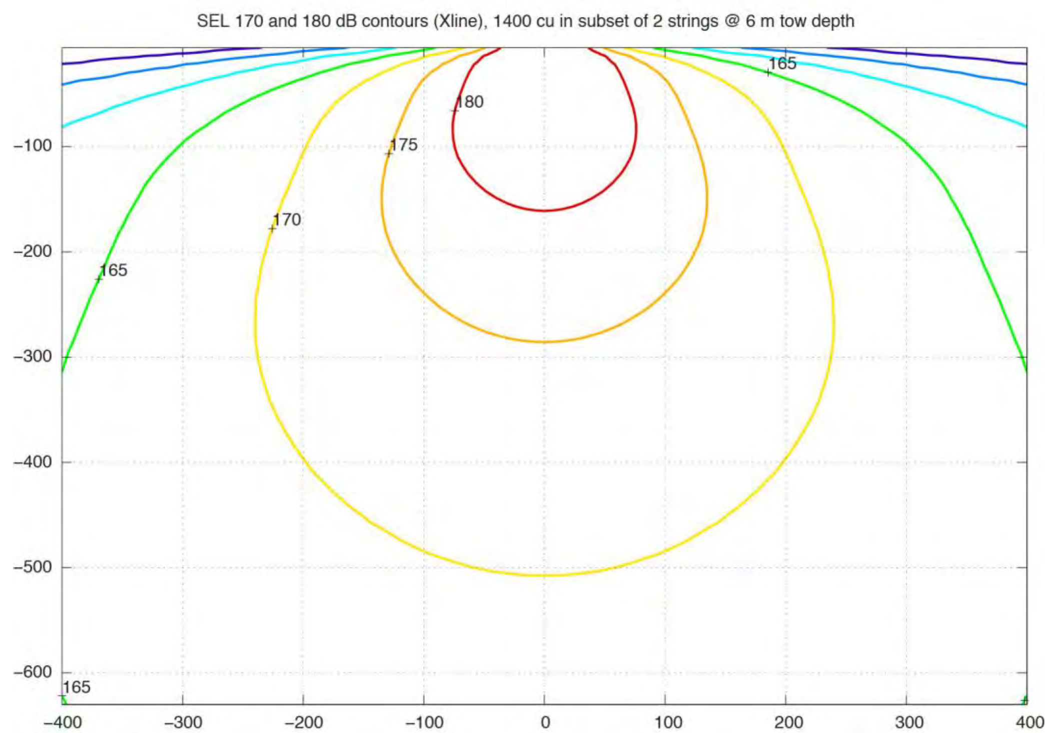


FIGURE A7. Deep-water model results for the 8-gun, 1400-in^3 subset of 1-string array at 6-m tow depth that could be used for the NJ margin 3-D survey. The 150 dB-SEL, 170-dB SEL, and 180-dB SEL distances can be read at 2401 m, 240 m, and 76 m, respectively.

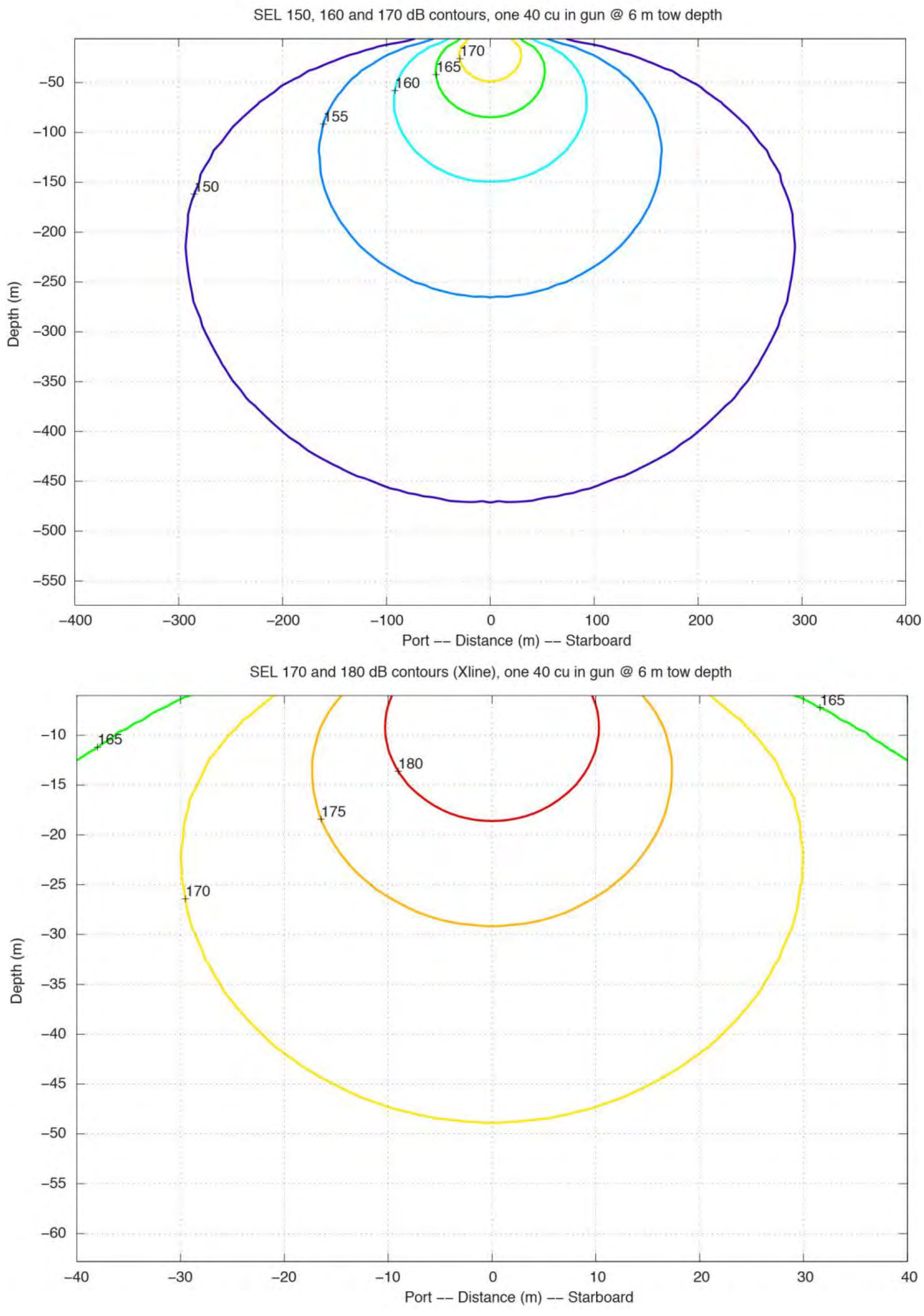


FIGURE A8. Deep-water model results for the single 40-in^3 Bolt airgun at 6-m tow depth. The 150-dB SEL, 170-dB SEL, and 180-dB SEL distances can be read at 293 m, 30 m, and 10 m, respectively.

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

Appendix B

Corrected : 08/22/2012

COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

PROGRAM ANNOUNCEMENT/SOLICITATION NO./CLOSING DATE/if not in response to a program announcement/solicitation enter NSF 11-1		FOR NSF USE ONLY
PD 98-1620	08/15/12	NSF PROPOSAL NUMBER
FOR CONSIDERATION BY NSF ORGANIZATION UNIT(S) (Indicate the most specific unit known, i.e. program, division, etc.)		**1260237**
OCE - MARINE GEOLOGY AND GEOPHYSICS		

DATE RECEIVED	NUMBER OF COPIES	DIVISION ASSIGNED	FUND CODE	DUNS# (Data Universal Numbering System)	FILE LOCATION
08/15/2012	2	06040000 OCE	1620	(b) (4) [redacted]	09/04/2012 4:50pm

EMPLOYER IDENTIFICATION NUMBER (EIN) OR TAXPAYER IDENTIFICATION NUMBER (TIN)	SHOW PREVIOUS AWARD NO. IF THIS IS	IS THIS PROPOSAL BEING SUBMITTED TO ANOTHER FEDERAL AGENCY?
(b) (4) [redacted]	☐ A RENEWAL ☐ AN ACCOMPLISHMENT-BASED RENEWAL	YES ☐ NO ☒ IF YES, LIST ACRONYM(S)

NAME OF ORGANIZATION TO WHICH AWARD SHOULD BE MADE	ADDRESS OF AWARDEE ORGANIZATION, INCLUDING 9 DIGIT ZIP CODE
Rutgers University New Brunswick	Rutgers University New Brunswick 3 Rutgers Plaza New Brunswick, N.J. 089018559
AWARDEE ORGANIZATION CODE (IF KNOWN) 0026294000	
NAME OF PRIMARY PLACE OF PERF	ADDRESS OF PRIMARY PLACE OF PERF, INCLUDING 9 DIGIT ZIP CODE
Department of Earth and Planetary Sciences	Department of Earth and Planetary Sciences 610 Taylor Rd. Piscataway ,NJ ,088548066 ,US.

IS AWARDEE ORGANIZATION (Check All That Apply) (See GPG II.C For Definitions) ☐ SMALL BUSINESS ☐ FOR-PROFIT ORGANIZATION ☐ MINORITY BUSINESS ☐ WOMAN-OWNED BUSINESS ☐ IF THIS IS A PRELIMINARY PROPOSAL THEN CHECK HERE

TITLE OF PROPOSED PROJECT **Collaborative Research: Community-Based 3D Imaging That Ties Clinoform Geometry to Facies Successions and Neogene Sea-Level Change**

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE
$ 789,819	24 months	05/01/13	

CHECK APPROPRIATE BOX(ES) IF THIS PROPOSAL INCLUDES ANY OF THE ITEMS LISTED BELOW

- ☐ BEGINNING INVESTIGATOR (GPG I.G.2)
- ☐ DISCLOSURE OF LOBBYING ACTIVITIES (GPG II.C.1.e)
- ☐ PROPRIETARY & PRIVILEGED INFORMATION (GPG I.D, II.C.1.d)
- ☐ HISTORIC PLACES (GPG II.C.2.j)
- ☐ EAGER* (GPG II.D.2) ☐ RAPID** (GPG II.D.1)
- ☐ VERTEBRATE ANIMALS (GPG II.D.6) IACUC App. Date ______ PHS Animal Welfare Assurance Number ______
- ☐ HUMAN SUBJECTS (GPG II.D.7) Human Subjects Assurance Number ______ Exemption Subsection ______ or IRB App. Date ______
- ☐ INTERNATIONAL COOPERATIVE ACTIVITIES: COUNTRY/COUNTRIES INVOLVED (GPG II.C.2.j) ______
- ☐ HIGH RESOLUTION GRAPHICS/OTHER GRAPHICS WHERE EXACT COLOR REPRESENTATION IS REQUIRED FOR PROPER INTERPRETATION (GPG I.G.1)

PI/PD DEPARTMENT	PI/PD POSTAL ADDRESS
Earth and Planetary Sciences	610 Taylor Rd. Wright Lab Piscataway, NJ 08854 United States
PI/PD FAX NUMBER 732-445-2044	

NAMES (TYPED)	High Degree	Yr of Degree	Telephone Number	Electronic Mail Address
PI/PD NAME Gregory S Mountain	PhD	(b) (6) [redacted]	732-445-0817	gmtn@rci.rutgers.edu
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				

Electronic Signature

CERTIFICATION PAGE

Certification for Authorized Organizational Representative or Individual Applicant:

By signing and submitting this proposal, the Authorized Organizational Representative or Individual Applicant is: (1) certifying that statements made herein are true and complete to the best of his/her knowledge; and (2) agreeing to accept the obligation to comply with NSF award terms and conditions if an award is made as a result of this application. Further, the applicant is hereby providing certifications regarding debarment and suspension, drug-free workplace, lobbying activities (see below), responsible conduct of research, nondiscrimination, and flood hazard insurance (when applicable) as set forth in the NSF Proposal & Award Policies & Procedures Guide, Part I: the Grant Proposal Guide (GPG) (NSF 11-1). Willful provision of false information in this application and its supporting documents or in reports required under an ensuing award is a criminal offense (U. S. Code, Title 18, Section 1001).

Conflict of Interest Certification

In addition, if the applicant institution employs more than fifty persons, by electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative of the applicant institution is certifying that the institution has implemented a written and enforced conflict of interest policy that is consistent with the provisions of the NSF Proposal & Award Policies & Procedures Guide, Part II, Award & Administration Guide (AAG) Chapter IV.A; that to the best of his/her knowledge, all financial disclosures required by that conflict of interest policy have been made; and that all identified conflicts of interest will have been satisfactorily managed, reduced or eliminated prior to the institution's expenditure of any funds under the award, in accordance with the institution's conflict of interest policy. Conflicts which cannot be satisfactorily managed, reduced or eliminated must be disclosed to NSF.

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Debarment and Suspension Certification

(If answer "yes", please provide explanation.)

Is the organization or its principals presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Federal department or agency? Yes ☐ No ☒

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The undersigned certifies, to the best of his or her knowledge and belief, that:

(1) No federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, "Disclosure of Lobbying Activities," in accordance with its instructions.

(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by section 1352, Title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

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The undersigned shall require that the language of this certification be included in any award documents for all subawards at all tiers.

AUTHORIZED ORGANIZATIONAL REPRESENTATIVE		SIGNATURE	DATE
NAME Emmeline Crowley		Electronic Signature	Aug 15 2012 10:43AM
TELEPHONE NUMBER 848-932-4027	ELECTRONIC MAIL ADDRESS Emily.Crowley@Rutgers.edu		FAX NUMBER 732-932-0162

* EAGER - EArly-concept Grants for Exploratory Research
** RAPID - Grants for Rapid Response Research

COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

PROGRAM ANNOUNCEMENT/SOLICITATION NO./CLOSING DATE/if not in response to a program announcement/solicitation enter NSF 11-1 PD 98-1620 08/15/12	FOR NSF USE ONLY
FOR CONSIDERATION BY NSF ORGANIZATION UNIT(S) (Indicate the most specific unit known, i.e. program, division, etc.) OCE - MARINE GEOLOGY AND GEOPHYSICS	NSF PROPOSAL NUMBER 1259135

DATE RECEIVED	NUMBER OF COPIES	DIVISION ASSIGNED	FUND CODE	DUNS# (Data Universal Numbering System)	FILE LOCATION
08/13/2012	2	06040000 OCE	1620	(b) (4) [redacted]	09/04/2012 4:50pm S

EMPLOYER IDENTIFICATION NUMBER (EIN) OR TAXPAYER IDENTIFICATION NUMBER (TIN)	SHOW PREVIOUS AWARD NO. IF THIS IS	IS THIS PROPOSAL BEING SUBMITTED TO ANOTHER FEDERAL AGENCY?
(b) (4) [redacted]	☐ A RENEWAL ☐ AN ACCOMPLISHMENT-BASED RENEWAL	YES ☐ NO ☒ IF YES, LIST ACRONYM(S)

NAME OF ORGANIZATION TO WHICH AWARD SHOULD BE MADE University of Texas at Austin	ADDRESS OF AWARDEE ORGANIZATION, INCLUDING 9 DIGIT ZIP CODE Austin, TX 787121532 US
AWARDEE ORGANIZATION CODE (IF KNOWN) 0036582000	
NAME OF PRIMARY PLACE OF PERF University of Texas at Austin Institute for Geophysics	ADDRESS OF PRIMARY PLACE OF PERF, INCLUDING 9 DIGIT ZIP CODE University of Texas at Austin Institute for Geophysics 10100 Burnet Road, ROC/Bldg. 196 Austin ,TX ,787584445 ,US.

IS AWARDEE ORGANIZATION (Check All That Apply) (See GPG II.C For Definitions) ☐ SMALL BUSINESS ☐ FOR-PROFIT ORGANIZATION ☐ MINORITY BUSINESS ☐ WOMAN-OWNED BUSINESS ☐ IF THIS IS A PRELIMINARY PROPOSAL THEN CHECK HERE

TITLE OF PROPOSED PROJECT **Collaborative Research: Community-Based 3D Imaging that Ties Clinoform Geometry to Facies Successions and Neogene Sea-Level Change**

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE
$ 194,431	24 months	05/01/13	

CHECK APPROPRIATE BOX(ES) IF THIS PROPOSAL INCLUDES ANY OF THE ITEMS LISTED BELOW
- ☐ BEGINNING INVESTIGATOR (GPG I.G.2)
- ☐ DISCLOSURE OF LOBBYING ACTIVITIES (GPG II.C.1.e)
- ☐ PROPRIETARY & PRIVILEGED INFORMATION (GPG I.D, II.C.1.d)
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- ☐ HIGH RESOLUTION GRAPHICS/OTHER GRAPHICS WHERE EXACT COLOR REPRESENTATION IS REQUIRED FOR PROPER INTERPRETATION (GPG I.G.1)

PI/PD DEPARTMENT Institute for Geophysics	PI/PD POSTAL ADDRESS 10100 Burnet Rd., ROC/Bldg. 196 J.J. Pickle Research Campus (R2200) Austin, TX 787584445 United States
PI/PD FAX NUMBER 512-471-0999	

NAMES (TYPED)	High Degree	Yr of Degree	Telephone Number	Electronic Mail Address
PI/PD NAME Craig S Fulthorpe	PhD	(b) (6) [redacted]	512-471-0459	craig@ig.utexas.edu
CO-PI/PD James A Austin, Jr.	PhD		512-471-0450	jamie@ig.utexas.edu
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				

Electronic Signature

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AUTHORIZED ORGANIZATIONAL REPRESENTATIVE	SIGNATURE	DATE
NAME Barbara D Reyes	Electronic Signature	Aug 13 2012 11:15AM

TELEPHONE NUMBER	ELECTRONIC MAIL ADDRESS	FAX NUMBER
512-471-6289	barbarareyes@austin.utexas.edu	512-471-6564

* EAGER - EArly-concept Grants for Exploratory Research
** RAPID - Grants for Rapid Response Research

Corrected : 08/22/2012

COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

PROGRAM ANNOUNCEMENT/SOLICITATION NO./CLOSING DATE/if not in response to a program announcement/solicitation enter NSF 11-1

PD 98-1620 08/15/12

FOR CONSIDERATION BY NSF ORGANIZATION UNIT(S) (Indicate the most specific unit known, i.e. program, division, etc.)

OCE - MARINE GEOLOGY AND GEOPHYSICS

FOR NSF USE ONLY

NSF PROPOSAL NUMBER

1259487

DATE RECEIVED	NUMBER OF COPIES	DIVISION ASSIGNED	FUND CODE	DUNS# (Data Universal Numbering System)	FILE LOCATION
08/14/2012	2	06040000 OCE	1620	(b) (4) [redacted]	09/04/2012 4:50pm

EMPLOYER IDENTIFICATION NUMBER (EIN) OR TAXPAYER IDENTIFICATION NUMBER (TIN)

(b) (4) [redacted]

SHOW PREVIOUS AWARD NO. IF THIS IS
☐ A RENEWAL
☐ AN ACCOMPLISHMENT-BASED RENEWAL

IS THIS PROPOSAL BEING SUBMITTED TO ANOTHER FEDERAL AGENCY? YES ☐ NO ☒ IF YES, LIST ACRONYM(S)

NAME OF ORGANIZATION TO WHICH AWARD SHOULD BE MADE

Columbia University

AWARDEE ORGANIZATION CODE (IF KNOWN)

0027078000

ADDRESS OF AWARDEE ORGANIZATION, INCLUDING 9 DIGIT ZIP CODE

Columbia University
2960 Broadway
New York, NY. 100276902

NAME OF PRIMARY PLACE OF PERF

Columbia University Lamont-Doherty Earth Observatory

ADDRESS OF PRIMARY PLACE OF PERF, INCLUDING 9 DIGIT ZIP CODE

Columbia University Lamont-Doherty Earth Observatory
61 Route 9W
Palisades ,NY ,109641707 ,US.

IS AWARDEE ORGANIZATION (Check All That Apply) (See GPG II.C For Definitions)
☐ SMALL BUSINESS ☐ MINORITY BUSINESS
☐ FOR-PROFIT ORGANIZATION ☐ WOMAN-OWNED BUSINESS

☐ IF THIS IS A PRELIMINARY PROPOSAL THEN CHECK HERE

TITLE OF PROPOSED PROJECT **Collaborative Research: Community-Based 3D Imaging That Ties Clinoform Geometry to Facies Successions and Neogene Sea-Level Change**

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE
$ 99,419	24 months	05/01/13	

CHECK APPROPRIATE BOX(ES) IF THIS PROPOSAL INCLUDES ANY OF THE ITEMS LISTED BELOW

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______
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PI/PD DEPARTMENT

Seismology, Geology & Tectonophysics

PI/PD FAX NUMBER

845-365-8150

PI/PD POSTAL ADDRESS

Lamont-Doherty Earth Observatory
P.O. Box 1000
Palisades, NY 109648000
United States

NAMES (TYPED)	High Degree	Yr of Degree	Telephone Number	Electronic Mail Address
PI/PD NAME Nicholas Christie-Blick	PhD	(b) (6) [redacted]	845-709-2320	ncb@ldeo.columbia.edu
CO-PI/PD Mladen Nedimovic	PhD		845-365-8561	mladen@ldeo.columbia.edu
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				

Electronic Signature

1259487

CERTIFICATION PAGE

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The undersigned certifies, to the best of his or her knowledge and belief, that:
(1) No federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.
(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, "Disclosure of Lobbying Activities," in accordance with its instructions.
(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by section 1352, Title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

Certification Regarding Nondiscrimination

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative is providing the Certification Regarding Nondiscrimination contained in Exhibit II-6 of the Grant Proposal Guide.

Certification Regarding Flood Hazard Insurance

Two sections of the National Flood Insurance Act of 1968 (42 USC §4012a and §4106) bar Federal agencies from giving financial assistance for acquisition or construction purposes in any area identified by the Federal Emergency Management Agency (FEMA) as having special flood hazards unless the:
(1) community in which that area is located participates in the national flood insurance program; and
(2) building (and any related equipment) is covered by adequate flood insurance.

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant located in FEMA-designated special flood hazard areas is certifying that adequate flood insurance has been or will be obtained in the following situations:
(1) for NSF grants for the construction of a building or facility, regardless of the dollar amount of the grant; and
(2) for other NSF Grants when more than $25,000 has been budgeted in the proposal for repair, alteration or improvement (construction) of a building or facility.

Certification Regarding Responsible Conduct of Research (RCR)
(This certification is not applicable to proposals for conferences, symposia, and workshops.)

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative of the applicant institution is certifying that, in accordance with the NSF Proposal & Award Policies & Procedures Guide, Part II, Award & Administration Guide (AAG) Chapter IV.B., the institution has a plan in place to provide appropriate training and oversight in the responsible and ethical conduct of research to undergraduates, graduate students and postdoctoral researchers who will be supported by NSF to conduct research.
The undersigned shall require that the language of this certification be included in any award documents for all subawards at all tiers.

AUTHORIZED ORGANIZATIONAL REPRESENTATIVE	SIGNATURE	DATE
NAME Maribel Respo	Electronic Signature	Aug 14 2012 11:46AM

TELEPHONE NUMBER	ELECTRONIC MAIL ADDRESS	FAX NUMBER
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* EAGER - EArly-concept Grants for Exploratory Research
** RAPID - Grants for Rapid Response Research

PROJECT SUMMARY

For the general benefit of a broad user community of scientists, educators and students, the Co-Principal Investigators propose to coordinate the use of R/V *Marcus Langseth* to acquire a 3D seismic volume encompassing the three IODP Expedition 313 drillsites on the inner-middle shelf of the New Jersey (NJ) continental margin. Exp313, the latest chapter in the multi-decade Mid-Atlantic Transect, represents the community's best opportunity to link excellently sampled/logged late Paleogene-Neogene prograding clinoforms to state-of- the-art 3D images. The primary goal of this proposal is to constrain the complex forcing functions tying evolution and preservation of the margin stratigraphic record to base-level changes. These processes include eustasy, climatic and paleooceanographic variations, tectonism, compaction and rates of sediment supply. Exp313 borehole data will provide lithostratigraphy, geochronology and paleobathymetry. Geomorphology revealed by coherency in horizontal (travel-time) slices within the volume (among other 3D imaging tools) will identify diagnostic features such as river systems, shorelines, delta channels, sediment failure scars, etc., none of which can be resolved in existing 2D seismic data to the degree required to map shifting shallow-water depositional settings in the vicinity of clinoform rollovers. Embracing a community-based strategy, the co-PIs will manage planning, acquisition and data processing up to the point of an interpretable 3D volume. This will entail a pre-cruise planning workshop, hands-on training for young scientists at sea, and rapid turn-around of the data by a commercial processor. Data will be made available to the engaged scientific community to use as the foundation of follow-on, PI- driven proposals that improve understanding of factors shaping the NJ margin in particular, and that imprint the sedimentary record at continental margins in general. The scientific parties of several ocean drilling expeditions and outcrop specialists of shallow-water systems are two groups certain to want to compare their research experience with the ground-truth these data will provide.

Intellectual Merit

The NJ margin has for decades been recognized as among the best siliciclastic passive margins for elucidating the timing/amplitude of eustatic change during the "Ice House" period of Earth history, when glacioeustatic changes shaped continental margin sediment sections around the world. A transect strategy adopted by the international scientific ocean drilling community has been used to study this interval at shallow-water settings offshore NJ, New Zealand and the Bahamas that were dominated by prograding clinoforms. 3D seismic imaging is now a viable tool for the research community, ready to be applied to the NJ margin to put these sampled records in a spatially accurate, stratigraphically meaningful context. Such imagery will allow researchers to map sequences around Exp313 sites with a resolution and confidence previously unattainable, and to analyze their spatial/temporal evolution. Long-awaited objectives include: 1) establishing the impact of known Ice House base-level changes on the stratigraphic record; 2) providing greater understanding of the response of nearshore environments to changes in elevation of global sea level (with special relevance to the current relentless rise), and 3) determining the amplitudes/timing of global sea-level changes during the mid-Cenozoic, which should help humanity put anthropogenic base-level change in a proper long-term context.

Broader Impacts

The community will be engaged in 3 ways. 1) A pre-cruise workshop will review the scientific payoff that 3D seismic-core-log integration can provide, and enable attendees to help shape acquisition and data processing details that optimize this goal; 2) 12 bunks aboard *Langseth* will be reserved for student/post-doc/young scientist volunteers to acquaint each with 3D acquisition and the myriad activities that comprise a research cruise; and 3) a post-cruise workshop will identify community-based avenues for analysis/interpretation of the processed 3D volume and integration with Exp313 results. The 3D images will very likely become an integral part of IODP outreach. Lamont-Doherty Earth Observatory and the University of Texas Institute for Geophysics have collaborative NSF grants to archive marine seismic data collected with NSF support. The raw field data will be delivered to the LDEO facility immediately after acquisition, and a fully processed 3D data 'volume' will be sent to the UTIG facility ~5 months after that, with the expectation that these data will become a showcase for how such sub-seafloor imaging can inform the understanding of stratigraphic evolution at continental margins.

TABLE OF CONTENTS

For font size and page formatting specifications, see GPG section II.B.2.

*Proposers may select any numbering mechanism for the proposal. The entire proposal however, must be paginated. Complete both columns only if the proposal is numbered consecutively.

TABLE OF CONTENTS

For font size and page formatting specifications, see GPG section II.B.2.

Appendix Items:

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TABLE OF CONTENTS

For font size and page formatting specifications, see GPG section II.B.2.

Appendix Items:

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PROJECT DESCRIPTION

Collaborative Research: Community-Based 3D Imaging that Ties Clinoform Geometry to Facies Successions and Neogene Sea-Level Change

PROLOGUE

This resubmission has benefited from constructive input by 8 mail reviewers, a panel summary, and NSF feedback (fall 2011). In response, we amplify three issues: 1) 3D imaging will detect nearshore features (e.g., meandering rivers, estuary complexes, lagoons/barrier islands, incised shelf valleys, etc.) that can be tied to IODP Exp313 sites M27-M29; mapping these features and associated facies, which developed during a time of known glacioeustatic variation, is a key both to understanding the evolution of siliciclastic systems and quantifying eustatic changes preserved in clinoformal architecture; 2) the proposed 3D survey area is 50% larger than in our initial submission, with no increase in survey time (34 days), as a result of revised estimates of in-fill shooting and downtime based on well-known histories of weather, currents, ship traffic and marine mammal activity in the proposed study region offshore New Jersey (NJ); and 3) a robust collaboration with the aligned GeoPRISMS community, including at-sea participation and pre- and post-data acquisition workshops; all activities are designed to help educators, young investigators and students understand the value of calibrating models of stratigraphic facies successions, as well as to engage them in theoretical and hands-on learning experiences with 3D seismic acquisition/processing. The goal throughout this project will be to optimize community use of the proposed product - a 3D data volume tied to continuously cored/logged/dated siliciclastic clinoforms that evolved at a stable passive margin during a time of independently measured glacioeustatic change.

INTRODUCTION

Shoreline movements and linked shifts in nearshore processes have important societal consequences. As discussion of global warming grows from speculation to more widespread acceptance (Intergovernmental Panel on Climate Change, 1995; 2001; 2007), impacts at the land-sea divide are gaining media attention. Nonetheless, journalists, policy makers, and even earth scientists often fail to grasp that while links exist among warming, melting ice and rising sea levels, actual effects on shoreline position locally vary widely. Shoreline positions are controlled by many factors, only one of which is global sea level. For example, in Scandinavia (rising due to glacial rebound) and Venice, Italy (subsiding due to sediment compaction), shorelines are moving in opposite directions despite the current rise in global sea-level of ~3mm/yr (projections point to an increase of ≥8 mm/yr by 2100; Rahmstorf et al., 2007). Other drivers include sediment supply and wave/storm-influenced sediment dispersal/compaction, plus regional influences: lithospheric cooling, isostatic/flexural loading, and dynamic topography within the asthenosphere. On old passive margins (e.g., NJ), regional effects are small and perhaps impossible to measure, but all contribute to the complexity of assessing eustatic change through geologic time.

Preserved shallow-water sediments are divided into facies successions bounded by regional unconformities (e.g., Sloss, 1963). The difficulty of mapping these "sequences" (Vail et al., 1977) in true 3D, and deconvolving factors that generate them, have long hindered all but broad interpretations regarding their relationships to eustatic change (e.g., Haq et al., 1987). Because of the importance of coarse-grained sand bodies as reservoirs, oil companies have sought ways to anticipate distributions of sequences based on seismic data alone, often without investing in costly geologic sampling. They focus on intervals/settings that offer the highest economic returns, most recently in structurally complex deep-water settings, leaving behind less productive, Neogene shelf clinoform settings. They also generally withhold their high-quality seismic data and predictive techniques from public disclosure. The international research community shares many of the same scientific interests, but relies less on high-quality seismic data and more on samples from scientific ocean drilling to link the preserved stratigraphic record with eustasy (COSOD II, 1987; Watkins and Mountain, 1990; JOIDES, 1992; Fulthorpe et al., 2008). Such efforts have focused on assembling a global compilation of co-registered analyses of paleo-water depths, sediment compaction/age, and thermal/isostatic/flexural subsidence in shallow-water basins along continental edges. Gathering these drilling-based data has been challenging, and accompanying industry-grade seismic data remain generally unavailable. Our goal here is to augment recently drilled and logged NJ shelf successions with superb 3D seismic images to provide the interested academic community an improved understanding of the factors shaping the global sedimentary record at passive margins, including the long-term history of eustatic change. Because continental margins contain the archive from which much of the world's oil and gas is extracted, and along which ~10% of humanity lives, knowledge of the interaction of this sediment record with ongoing base-level changes serves highly relevant societal interests.

BACKGROUND

The Transect Drilling Strategy

ODP/IODP-related workshops (refs. above) and more than two decades of community-based discussions have concluded that a global set of borehole transects across multiple passive margins is required to deconvolve eustatic signals from those of local processes (Christie-Blick et al., 1990; Kominz and Pekar, 2001). Only this strategy can confirm global synchroneity of sequence boundaries and document stratigraphic responses in diverse tectonic/depositional settings. To yield a reliable measure of eustatic change between two sequences, drilling must sample an intervening sequence boundary in at least three locations: 1) the youngest topset sediments of the older sequence, close to the seaward increase in gradient (the clinoform "rollover"/paleo-shelf edge); 2) the oldest bottomset sediments of the younger sequence at the seaward toe of that same clinoform; and 3) farther seaward along the same surface, where complications of reworking are diminished and age control optimal (Fulthorpe et al., 2008). Using this approach, lateral variations in facies, paleo-water depth and age can be traced along key surfaces. With proper accounting for total subsidence, reliable elevations/dimensions of sequences at their time of deposition can be estimated to distinguish local transgressive/regressive cycles (e.g., Scandinavia vs. Venice) from eustatic changes (e.g., Steckler et al, 1999).

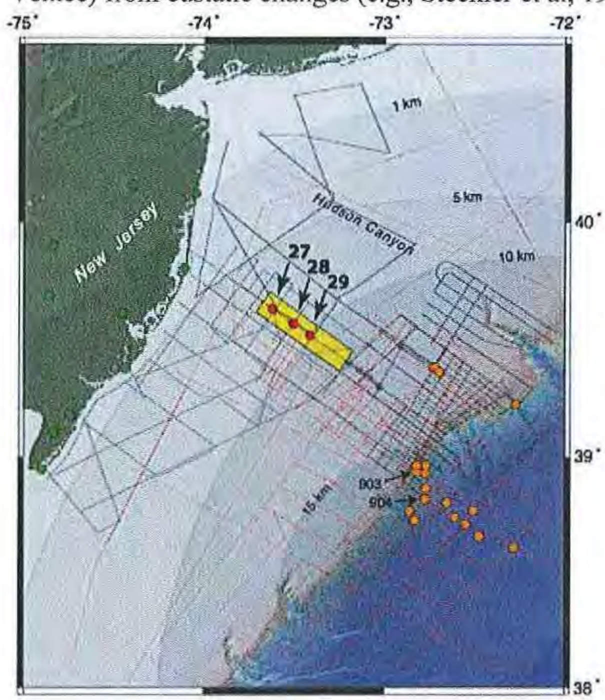

Figure 1. Proposed 12 x 50 km 3D seismic volume (yellow rectangle) encompassing Exp313 Sites 27-29 (red circles) embedded within grids of deep-penetration, reconnaissance (dashed red lines) and higher-resolution (solid gray lines) 2D MCS profiles. Previous studies have tied these grids to scientific ocean drilling wells on the outer shelf, slope and rise (orange circles). Onshore wells (green circles) provide updip equivalents to offshore stratigraphic units (see details in the text). Depths to basement are indicated (muted gray colors/contours).

IODP Expeditions 313 and 317 (NJ and offshore New Zealand, respectively) have followed this strategy, drilling dip-oriented transects imaged by grids of 2D MCS profiles (Mountain, Proust, McInroy et al., 2010; Fulthorpe, Hoyanagi, Blum et al., 2011). This proposal builds on the successful drilling of the first of these, termed the "Mid-Atlantic Transect" (MAT), by seeking to fill a critical gap in seismic correlation. Exp313 samples provide age/paleo-water depth/facies variations within and between sequences imaged by existing grids of 2D MCS data (Fig. 1). The 3D volume we propose to collect will provide accurately rendered, high-resolution "seismic geomorphology" linking depositional/erosional processes driving shoreline movements to known mid-Neogene base-level changes.

Evolution of the "Mid-Atlantic Transect" (MAT)

The NJ margin has long been recognized as a leading candidate for the study of eustatic change and its impact on the sediment record because of: 1) smooth thermal subsidence since Triassic-Early Jurassic rifting (Watts and Steckler, 1979); 2) substantial sediment supply since the mid-Oligocene (Poag, 1985), when high-latitude glaciations provide an independent measure of eustatic forcing (Miller et al., 1998;

Zachos et al., 2001; Pekar et al., 2002; Pekar and Christie-Blick, 2008); 3) optimal geochronologic control as a result of a mid-latitude setting; and 4) accessibility/wealth of supporting information (Fig. 1).

In support of the transect drilling approach, multiple 2D MCS grids have been collected since 1990 to locate potential drill sites (Fig. 1). The first was a reconnaissance grid of 120-channel, 1350 in.^{3} air-gun array profiles across shelf wells spot-cored by the U.S. Geological Survey and industry (Hathaway et al., 1976; Scholle, 1977; Libby-French, 1984). Roughly two dozen unconformity bounded, post-Eocene sequences across the shelf/upper slope were traced areally using these data. ODP Leg 150, restricted to the slope/rise, recovered sediments documenting 22 early Eocene-middle Pleistocene ("Ice House") seismic surfaces (Mountain, Miller, Blum, et al., 1994; Miller et al., 1996). In most cases, seismic sequence boundaries matched to Leg 150 boreholes showed little/no time missing across them. Coarse-grained deposits that fined upwards from the bases of many sequences were interpreted as sediments transported basinward during sea-level lowstands. The scientific community understood that Leg 150 samples were from paleo-water depths too deep to yield insight into eustatic amplitudes and their role in shaping facies successions, but shelf drilling required was not at that time deemed safe.

To attempt to remedy the need for shallow-water control, Coastal Plain drilling was begun to complement the deep-water data (Miller et al., 1994). Oligocene – mid-Miocene sequence boundaries onshore (Fig. 1) were found to correlate well with δ^{18}O increases derived from deep-ocean sampling, confirming that they formed during times of most rapid global sea-level falls (Fig. 2). Furthermore, sequence ages compared well with the Haq et al. (1987) eustatic chart (see also Miller et al., 1996, 1998).

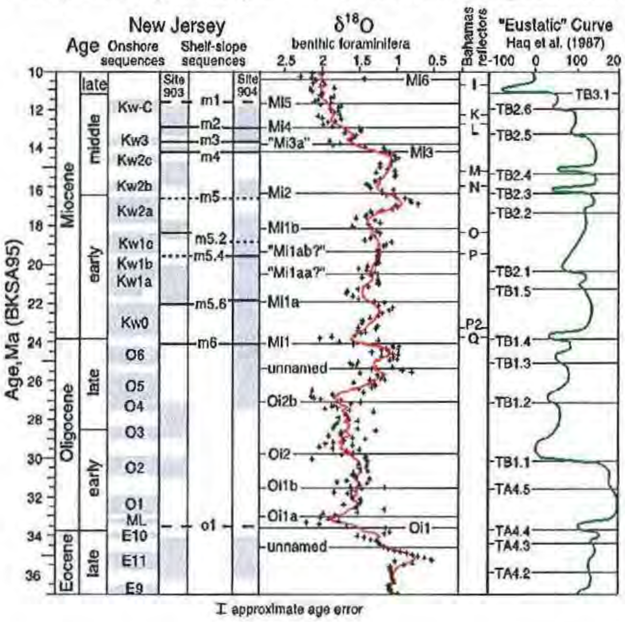

Figure 2. Correlation chart of the NJ margin, late Eocene-late middle Miocene. Onshore sequences (19 total, gray=recovered, white=hiatus) were sampled at 6 sites. Shelf sequence boundaries (10 total, o1-m1) were defined in MCS profiles (see Fig. 1) and traced to the slope. Depositional sequences at ODP slope sites 903/904 (gray=recovered, white=hiatus; Fig 1) are tied to the magnetic reversal time scale (Berggren et al, 1995) and the global δ^{18}O curve. Ice volume increases are inferred from δ^{18}O-matched hiatuses in the updip/onshore record and slope sequence boundaries. A global sea level curve inferred from coastal onlap and other means (Haq et al., 1987) is at far right. While these correlations appear robust, the critical missing piece for understanding the evolution of the siliciclastic sedimentary record during a time of known eustatic change is spatial correlation of 3D seismic images (crucial for identifying/tracking shorelines and related shallow-water features) with well-sampled drillsites, such as Sites 27-29 (Fig. 1).

The Coastal Plain effort showed that: 1) sequence boundary ages could be determined to better than ±0.5 myr, thereby providing the chronologic control needed to track eustasy for the past 42 myr (Miller et al., 1996, 1998); 2) stratal surfaces are the primary cause of margin seismic reflections (Mountain, Miller, Blum, et al., 1994); 3) middle Eocene-Miocene sequence boundaries correlate with globally recognized δ^{18}O increases, linking their formation to glacioeustatic falls (Miller et al., 1996, 1998); 4) through correlation with Leg 166 (Bahamas) drilling, siliciclastic and carbonate margins yield correlatable and in some cases comparable records of inferred sea-level change (Miller et al., 1998; Eberli, Swart, and Malone, et al., 1997); and 5) several amplitude estimates of ~20-85 m for my-duration sea-level variations exist that agree with estimates based on δ^{18}O changes (Kominz et al., 1998, 2003).

Nonetheless, onshore/slope drilling on the NJ margin cannot alone constrain late Paleogene-Neogene eustasy. Onshore wells are too far updip to recover lowstand sediments and, without seismic profiles, they lack the complementary sequence architecture needed to understand facies distributions within clinoform packages. Furthermore, neither onshore nor deep-water drilling can sample paleo-shelves/clinoform rollovers that are among the most sensitive features to post-Oligocene sea-level change. The full range of known/expected "Ice House" sea-level variations cannot be addressed without drilling on the shelf.

To prepare for shelf drilling, 2D MCS profiles across the shelf/uppermost slope were collected (Fig. 1; Austin et al., 1996). These featured two aspects required for safety: high-resolution (shallowly-towed, short-offset GI gun/streamer geometry, 12.5 m shot spacing, 1 ms sampling, ~5 m vertical resolution) and dense spacing (150 m) around locations of proposed drill sites. Such data quality and density were deemed necessary to avoid drilling into pockets of shallow, pressurized gas. These data increased the resolution and number of mappable sequences (Fulthorpe et al., 1999, 2000; Fulthorpe and Austin, 2008). Unfortunately, because the *JOIDES Resolution* generally employs open-hole drilling, ODP denied all proposed sites except two that "twinned" the COST B-2 stratigraphic test well, to ensure the absence of gas (Scholle, 1977). Consequently, ODP Leg 174A drilled Sites 1071 and 1072 on the outer shelf ~.75 and 3.5 km from B-2 (Fig. 1; Austin, Christie-Blick, Malone, et al., 1998). Loose sands and drill-ship heave resulted in limited recovery to the extent that bounding surfaces could not be sampled/dated with the desired precision. Nonetheless, observed prograding clinoformal seismic sequences were confirmed as being bracketed by unconformities that formed during sea-level falls. Other contributions included: 1) water depths during late-middle Miocene-Pleistocene lowstands were close to zero ~100 km seaward of the modern shoreline; 2) inferred fluvial incisions (restricted to topsets) suggest that ambient sea-level never fell below rollovers; and 3) benthic forams indicate that maximum highstand water depths were ~50-100 m, constraining sea-level amplitudes once the effects of accumulation, compaction and loading are taken into account.

Leg 174A results also showed that a drilling platform immune to heave and a drill rig with closed-circulation were needed to provide both the flexibility in site selection and high core recovery required to meet long-standing MAT objectives. This suggested that drilling beneath the inner shelf, where ~30 m water depths permitted use of a self-propelled jack-up rig ("mission-specific platform") planted on the seafloor, was essential. To serve safety constraints, a second 2D MCS grid was completed landward of previous surveys, again with ~5 m vertical resolution and narrow line spacing (Fig. 1; Monteverde et al, 2008). Sites were selected following the transect strategy; imaging focused on early Neogene clinoforms on the inner-middle shelf.

IODP Expedition 313 – Neogene Clinoforms Continuously Cored and Logged

Exp313 drilled/logged 3 sites, (M)27-29, in 35 of water 45-65 km offshore NJ in 2009 (Figs. 1 and 3; Mountain, Proust, McInroy et al., 2010). Goals were to: 1) identify surfaces representing late Paleogene-Neogene base-level changes and compare their ages with sea-level variations implied by the $\delta^{18}O$ glacioeustatic global proxy (Fig. 2); 2) estimate corresponding amplitudes/rates/mechanisms of sea-level change during this "Icehouse" time; and 3) evaluate/improve models predicting lithofacies successions, depositional environments and seismic architecture in response to such sea-level changes and other processes that imprint the shallow-water record. Exp313 collected 1311 m of very good-excellent quality cores with 80% recovery. The deepest hole penetrated 757 mbsf to upper Eocene sediments. Slim-line logs included spectral gamma ray, resistivity, magnetic susceptibility, sonic and acoustic televiewer. Porewater chemistry profiles were generated; uncontaminated sediments were also frozen for microbiologic studies.

Downhole logs, multi-sensor track measurements of unsplit cores, and physical properties of discrete samples, aided by vertical seismic profile measurements at each site, provided core-log-seismic ties with preliminary depth uncertainties of ±5 m or less (Mountain, Proust, McInroy et al., 2010). Excellent synthetic seismograms provide support for core-log-seismic correlation within specific intervals (Mountain and Monteverde., in review). Studies by the Exp313 Scientific Party (over 2 dozen papers representing scientific results are due for submission to *Geosphere* by Aug 4, 2012) link strata to 16 seismically mapped (Figs. 1, 4) regional surfaces/unconformities. The three sites sampled topsets, foresets and toesets of multiple stacked clinoforms. Litho- and biofacies have been correlated along key seismic surfaces to yield mutually consistent depositional histories, although, as will be described, nagging

PROJECT DESCRIPTION

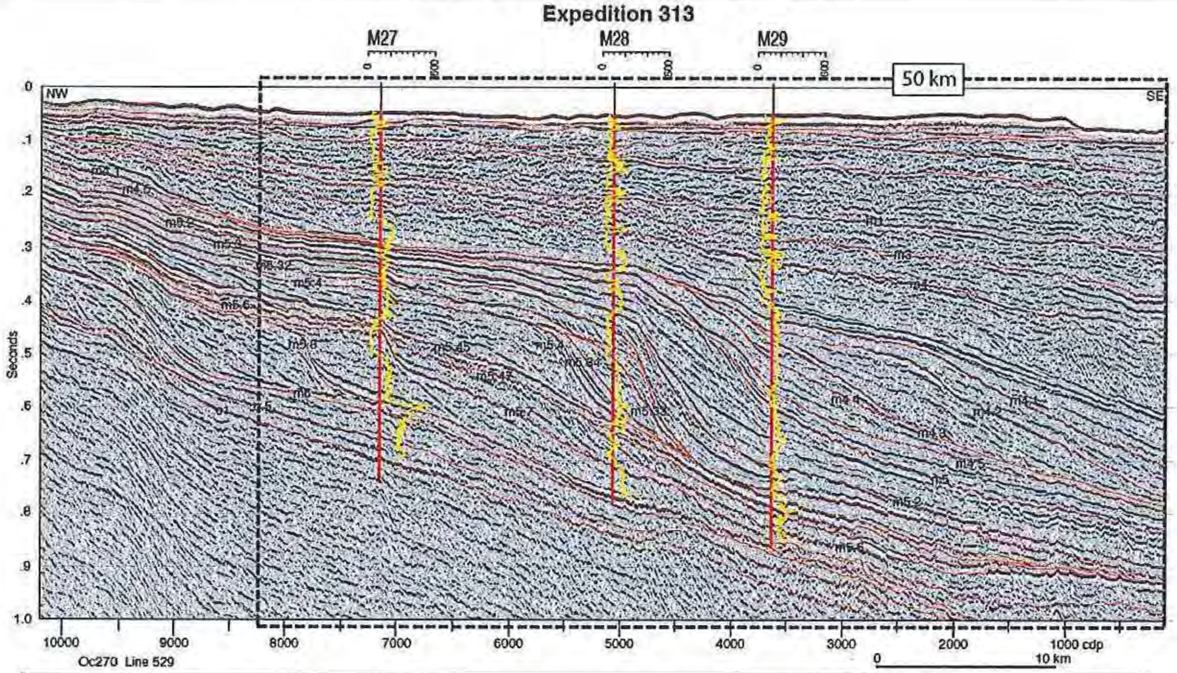

Figure 3. Oc270 line 529 through Exp313 sites M27-29 and the area we propose for a 12x50 km 3D seismic volume (dotted rectangle is the long dimension of that survey; Fig. 1). Gamma ray logs, converted to travel-time with velocities developed for Exp313, are shown in yellow. Early Oligocene - mid-Miocene sequences o1 to m4.1 have been continuously cored/logged and correlated across an existing 2D grid of seismic data on the inner shelf (Monteverde et al., 2008; Figs. 1, 4). As good as the resulting correlations appear to be, ambiguities fundamental to understanding the link between sea-level change and sequence evolution, notably the recognition of diagnostic shorelines and related shallow-water features (fluvial incisions, point bars, estuary complexes, etc.), remain and will not be fully resolved without 3D imaging encompassing these drill sites.

uncertainties remain that cannot be resolved with existing seismic coverage. Excellent paleontologic zonations (based on coccolithophores, dinocysts, diatoms and limited planktonic foraminifera), plus Sr-isotopic ages, are revealing a nearly continuous record of 0.5-2 myr sea-level cycles in the 22-12 Ma interval. Older and younger strata outside this age range have also been sampled, but were not present at all sites. Facies and benthic foram assemblages implying paleo-water depth changes of 60-80 m have been found in topset beds within transgressive-regressive cycles. Initial 2-D backstripping suggests that these paleobathymetric changes are the result of eustatic variations of ~1/2 this magnitude (Mountain and Steckler, 2011; Steckler et al, in review). Ongoing shorebased studies, involving correlation/backstripping of additional surfaces to recover original geometries, should improve eustatic amplitude estimates within the targeted time interval.

However, despite Exp313 successes, made possible by excellent core recovery with ties to logs and mapped sequences (Mountain, Proust, McInroy et al., 2010), uncertainties regarding sequence evolution and relationships with eustatic change remain: 1) If topset strata become subaerially exposed during lowstands, why are no shoreline features, and so few incised valleys, recognized on existing 2D seismic data in the Exp313 region (Fig. 4)? 2) What is the source of debris flow deposits found in Exp313 cores seaward of clinoform rollovers, during what stage(s) of the sea-level cycle are they likely to have formed, and why is there no seismic geomorphologic evidence of sediment transport from either up-dip or along-strike sources on the 2D data? 3) How are prograding Oligocene - mid-Miocene clinoforms influenced by initiation of the globally important mid-Miocene climate transition? Despite progress in sampling these clinoforms, one key element, encompassing spatial imaging, is missing. The clinoform rollover (i.e., paleo-shelf edge) is the key imaging location, because landward shoreline trajectories shift, and the growth and development of incisions in response to sea-level change can be observed seismically. Drilling calibrates those trajectories, but only spatial imaging can both recognize and document them through time.

PROJECT DESCRIPTION

We must know more about detailed processes and depositional environments at/near rollovers, especially volumes/timing of sediment bypass to clinoform slopes. Lateral variability along shorelines is also crucially important, so we must document changes in processes/depositional environments in both dip and strike directions, to the extent that resources allow.

In summary, the "MAT" has been a long-term effort, culminating in Exp313, involving repeated 2D seismics at a range of frequencies to carry out iterative drillsite targeting (using successive sampling technologies) to address the Neogene geologic history at an old passive margin. One crucial piece remains – to integrate calibrated shallow-water facies with 3D images of architecture/geomorphology.

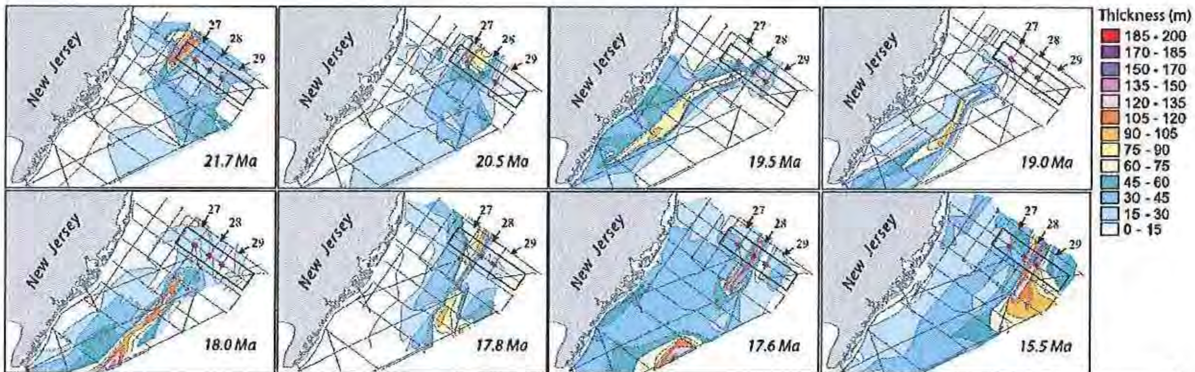

Figure 4. *Isopachs of 8 early to middle Miocene sequences offshore NJ (legend at right; after Monteverde et al., 2008; basal age of sequences from Browning et al., in review). The proposed 12 x 50 km 3D MCS volume encompassing Exp313 Sites M27-M29 (red circles) is outlined in black. Seismic sequences have been identified using 2D MCS profiles (Figs. 1, 3), tied to ODP drill sites on the outer shelf and slope (see Fig. 1), and correlated to hiatuses in ODP onshore wells (Figs. 1, 2). Note seaward progradation of Miocene sediments through time, plus progression from a northern sediment buildup (21.7 Ma), followed by a southern buildup (18.0 Ma), then returning to a northern buildup (15.5 Ma) suggesting both time-varying sources of sediment and margin-parallel redistribution. This complex evolution challenges the reliability of understanding sequence development using only sparse, primarily dip-oriented 2D profiles. The proposed 3D volume will image stratal features within both the thickest parts of some sequences and along the thinner perimeters of others.*

RESEARCH GOALS of the PROPOSED WORK

Provide Community Access to a Calibrated (by Exp 313 Drilling) 3D Seismic Volume

Integration of 3D images with Exp313 drilling results will couple the highest quality cores from this passive margin with unparalleled definition of seismic facies character and spatial geometry where they are needed, near rollovers/paleo-shelf edges most sensitive to changes in base-level during the Ice House. Such an integration will advance sea-level science, while providing unprecedented insights into impacts of migrating shorelines during rising sea level, such as we are experiencing today (see Broader Impacts). Future breakthroughs in the marine geosciences will rely on spatial imaging of the subsurface that can only be achieved with 3D technology. Since its appearance in the early 1970's (Walton, 1972), commercial 3D surveying has grown at such a rate that by 1999 it had eclipsed 2D profiling in terms of worldwide dollar value of acquisition (Liner, 1999). However, despite clear science advantages, its use by academia has followed slowly due to high costs of acquisition and processing.

NSF addressed this issue by convening the 2010 workshop *Challenges and Opportunities in Academic Marine Seismology* (http://www.steveholbrook.com/mlsoc/workshop_report.pdf) to encourage the academic research community to explore ways of increasing access to 3D data. A major recommendation comprised three parts: 1) generate "community" 3D surveys using the *Langseth*, the first academic 3D seismic vessel, 2) hire private companies to process 3D data to an initial interpretable volume within 6 months post-cruise, and 3) release 3D volumes for general use in follow-on, PI-driven interpretation projects. Our proposal follows this model, while being driven by MAT's enduring scientific goals.

Capitalize on the Fundamental Advantages of 3D Seismic Data

The power of 3D seismic volumes is their ability to elucidate both sedimentary processes and paleoenvironments, through assessments of "seismic geomorphology". Sedimentary basin fill is inherently 3D at all spatial scales. Traditional 2D surveys can document basin-scale (tens of km) three-dimensionality, but cannot differentiate km-scale (and less) morphologies, e.g., estuary complexes, shelf channels, upper slope canyons, etc., that are keys to defining shallow-water processes and paleoenvironments, which in turn can be used to determine shifting shoreline positions through time and hence constrain paleo-sea level changes. Individual profiles may image such features, but mapping them between profiles kilometers apart is possible only in a generalized fashion (see Fig. 4). Whereas commercial 3D data can meet academic research needs on some margins, such data are lacking off NJ.

A common misconception exists that 2D and 3D reflection data differ only in image presentation, i.e., that 2D surveying produces a cross section, while 3D surveying produces a volume. In truth, what can be extracted from 3D data far exceeds this conspicuous dimensional component. 2D images are also fundamentally hampered by "cylindrical ambiguity" and "viewpoint limitation". Cylindrical ambiguity means that 2D data lack information necessary to establish cross-profile positioning; there is no way to know true locations of reflections that "appear" to lie beneath the survey track, but which originate from somewhere to one (either) side of the profile plane. Viewpoint limitation means that only reflecting surfaces facing the profile plane can be imaged; all others, including those directly below with even modest cross-profile dips, remain invisible. Maximum reflector dips beneath the inner NJ shelf are small (<8°; Figs. 3, 4), so cross-profile mis-positioning of reflections is not as large as in geologic areas with more steeply dipping features. However, for the two-way travel time range of highest interest (0-0.8 s; Fig. 3), and the corresponding average velocity range (1.6-1.8 km/s), the expected maximum cross-profile mis-positioning of events on existing profiles is 35-100 m, which is as large or larger than incised valleys and related shoreline-related features we hope to observe. 3D acquisition and processing will virtually eliminate these problems.

Another challenge using 2D data for stratigraphic interpretations is caused by streamer cable side-drift/feathering (Renick, 1974; Levin, 1983). During 2D acquisition, cross-currents cause average feathering of ~10° (Yilmaz, 2001). As a result, 2D profiling becomes a limited-swath 3D survey to one side of profile track. Processing such marine survey data using standard 2D imaging procedures (as has been done to the present) creates spurious discontinuities/wipeouts in reflection events (Nedimovic et al., 2003). Currents offshore NJ vary in both strength and direction (Butman et al., 2003), so they must have caused 5-10° streamer feathering when existing 2D data were collected (Fig. 3); this is confirmed by records of visual sightings of tail buoys. Such feathering has detracted from reflection event continuity in all 2D profiles offshore NJ. Unfortunately, past feathering effects cannot be corrected because streamer navigation was not utilized during all of those 2D surveys.

Exploit the Unique Tools Associated with 3D Imaging

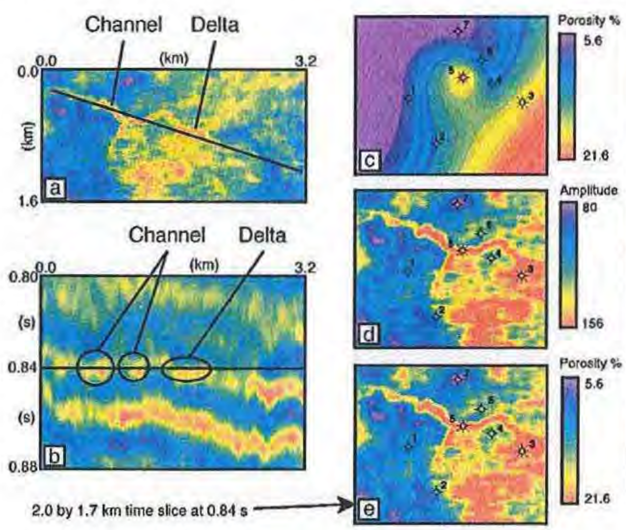

Figure 5. (a, b) Channel systems (from the Gulf of Mexico) in 2D and 3D and (c, d, e) integrating seismic and well data to extract porosity. a-b: While a map view (a) of an amplitude slice at 840 ms two-way travel-time provides a clear image of a channel and (associated) delta, little can be inferred about this system from a cross-sectional image (b) carefully chosen to cross the channel twice and the delta once. (c): Gridded porosity map at the reservoir level (840 ms, see a), based upon samples from 7 drilled holes. (d): Time slice at the same level as in (c). Note the level of detail of sratigraphic features. (e): Seismic-guided porosity map formed by integrating seismic and well data. If 3D seismic data had been collected before drilling, 5 dry holes (1, 2, 4, 6, 7) would not have been drilled. Figure adapted from Liner (1999).

PROJECT DESCRIPTION

The growing use of 3D seismic techniques has led to significant advances in stratigraphic studies. Small but important "process" features like incised channels, difficult to document using 2D data, stand out in maps derived using 3D data (Figs. 5, 6). However, stratigraphic interpretation benefits not only from a 3D view of the subsurface, but also from the ability to extract quantities called "seismic attributes" from 3D volumes. Both pre-stack and post-stack attributes will be needed from the proposed 3D volume to extract the maximum information for ongoing stratigraphic interpretations of the NJ margin.

Post-stack seismic attributes result from image manipulation (Liner, 1999; Fig. 5). For NJ, the most useful post-stack attributes are instantaneous amplitude, phase, frequency and Q (1/attenuation). When applied to 3D volumes, these attributes can be powerful indicators of lithologic variations, event continuity, fracturing and absorption. The most useful 2D attributes for delineating channels are coherency, edge detection, directional gradient (e.g., "curvature", Fig. 6) and shaded relief.

While 3D surveys provide more accurate and useful information than 2D seismic imaging (Fig. 5c-e), the most complete geologic information is extracted by combining 3D images with drilling/logging. Such a combined approach allows for detailed analysis of geometry, lithology, porosity, fluid saturation and anisotropy of buried sediments and associated depositional/erosional systems (e.g., complex fluvial channel systems; Fig. 6) and their geometric relationships with Neogene rollovers sampled by Exp313.

An excellent example of the value of 3D data is provided by ongoing research into the upper Oligocene-Recent clinoformal stratigraphy of the Northern Carnarvon Basin (NCB), Australian Northwest Shelf (NWS) (Liu et al., 2011; Sanchez et al., 2012a, b). Middle Miocene-Pliocene siliciclastic sediments represent a long-lived (~8 my) break in otherwise carbonate-dominated shelf sedimentation. Available commercial 3D volumes have enabled a profound new interpretation of these prograding siliciclastics as 27 shelf-/shelf-edge delta lobes (Fig. 7). Only through true 3D mapping has it been possible to correlate individual clinoform sets with these lobate, complex deltaic morphologies. Long-term (cumulative) progradation of this delta system and subsequent backstepping correlate with long-term sea-level fall and rise during the late middle-late Miocene. This observed siliciclastic influx correlates with other coeval increases in siliciclastic sediment supply worldwide, including offshore NJ and a prospective depocenter in the Gulf of Mexico (see text below).

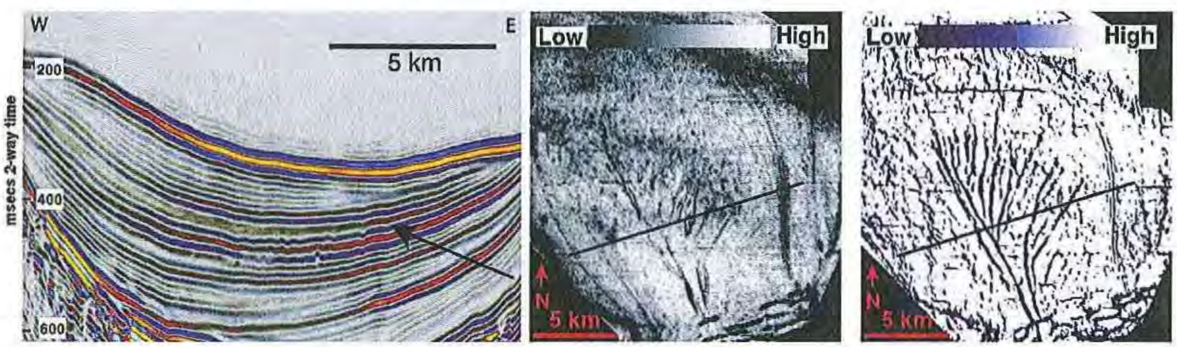

Figure 6. Visualization and interpretation of paleo-channels in 2D (left) and 3D (center, right) seismic data. Left: Strike-oriented 2D seismic reflection profile from the Gulf of Mexico showing subtle undulations in one imaged stratal horizon (indicated by the black arrow) which are produced by slope channels. However, this could not be confirmed using the 2D representation by itself. Center/right: Seismic attribute (travel-time) slices produced along the same horizon extracted from a conventional 3D volume, the center view showing "coherence" and the right view highlighting "most-negative curvature". Identifying complex channel features and tracking them spatially is straightforward using the 3D volume, but challenging if not impossible to achieve using 2D control alone, even if the 2D grid is dense, as is true for some of the grids on the NJ margin (Figs. 1, 4). From Lozano and Marfurt, 2008.

In addition, 3D mapping in the NCB has yielded important insights into the relationships between clinoformal sequence boundaries and sea-level change, particularly: 1) complex spatial acoustic evidence of karst topography (indicative of shelf exposure) along some horizons, and 2) step-like, vertical offsets up to 65 m high, downward toward the basin on the outer paleo-shelves (near rollovers) of two early-middle Miocene sequence boundaries. These have been interpreted as rarely preserved examples of wave-cut terraces or sea cliffs (Liu et al., 2011). All of these features represent direct evidence of paleo-sea level and shoreline location, which can only be interpreted with 3D data.

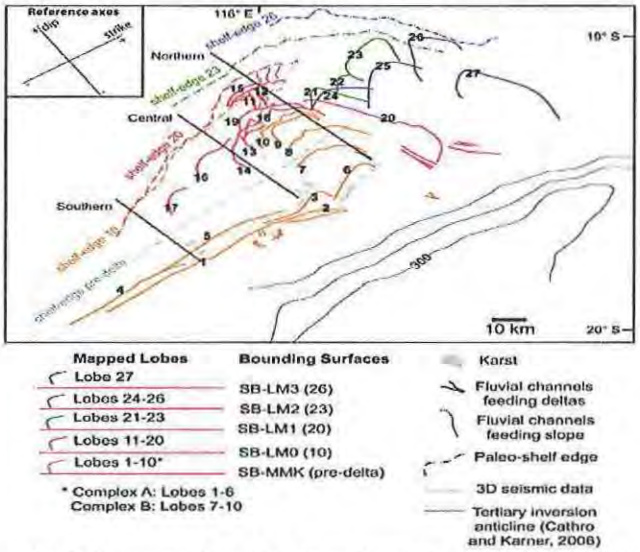

Figure 7. Delta lobes and positions of paleo-shelf edges at the ends of deltaic progradation pulses in the Northern Carnarvon Basin (NCB), Australian Northwest Shelf (NWS; Sanchez et al., 2012 a, b). The outline of each lobe corresponds to the rollover of the upper bounding unconformity of the mapped clino-form set representing that lobe. Interpreted fluvial channels within the siliciclastic interval are shown in colors correlative with their pre-sumed associated delta lobe. Interpreted karst features, indicative of paleo-shelf exposure (i.e., sea-level low stand), also underlie lobes 1-6. This interpretation of clinoform sets as a spatially complex set of prograding delta lobes was only possible through mapping within a 3D seismic volume (outline of the volume shown in the figure, thin grey line).

Tie 3D Volume to Exp 313 Results to Resolve Ambiguities of Neogene Stratigraphic Evolution

Seismic morphologies similar to those of the NWS, containing imprints of changing sea level and other factors that control shallow-water sedimentary processes, are present on the NJ margin (Fulthorpe and Austin, 1998; Nordfjord et al., 2005). The 3D MCS volume we propose to collect will focus on resolving the origin of such features critical to understanding the relationships between sea-level change and sequence development. In particular, we will focus on shallow-water features near and at paleo-shorelines: fluvial channels, point bars and estuary complexes (Nordfjord et al., 2005). MCS line 529 (Fig. 3) runs through the center of our proposed survey area and ties the three Exp313 sites. Below, we use that image to frame three working hypotheses that can be tested by combining a 3D volume with Exp313 results. These hypotheses/related goals agree with components of the Eastern North American Margin (ENAM) component of the GeoPRISMS Draft Implementation Plan (http://www.geoprisms.org/enam.html).

1) What are the spatial/temporal relationships between sea-level low stands and areas of paleo-shelf exposure adjacent to/landward of clinoform rollovers? Linked hypothesis: low stand paleo-shelf exposure has increased since the Oligocene, probably in response to increasing eustatic amplitudes (Fig. 2), resulting in an increasing number of fluvial incisions both up-section and seaward across the NJ margin.

Seismic sequences, when first defined, were classified according to the nature of their basal boundaries (Mitchum et al., 1977). While terminology has since been refined, a fundamental observation remains valid: some sequences begin with valleys cut into the top of the underlying sequence, while others have no such incisions, and begin instead with apparently conformable deposition onto beds of the preexisting shelf/uppermost slope. The former incised, "Type 1", sequence boundaries have been inferred to indicate a larger and/or more rapid fall in base-level than the latter, "Type 2", boundaries. Judging from existing 2D MCS data off NJ (Fig. 1), incised valleys appear to be scarce in paleo-shelf strata landward of rollovers, suggesting that Type 2 boundaries dominate the early Miocene within the proposed survey area (Fig. 3). Similarly, a lack of lobate low stand fans seaward of clinoform toes (Figs. 3, 4; see below) supports the hypothesis that Type 1 systems are minor to nonexistent in this lower Miocene section. Nonetheless, there is seismic evidence (at ~cdp 4000, between m5 and m4.5, Fig. 3) of a shelf-edge delta and erosional truncation of foresets, suggesting base level at m5 time was very close to, if not below, the elevation of adjacent topsets. In addition, landward of all Exp313 sites (Fig. 1), isolated incisions ~100 m wide and 5-10 m deep are observed seismically, but none can be connected with existing data coverage (Fig. 4;

Monteverde et al., 2008). Possible explanations include: 1) incised valleys are well-preserved/present, but existing 2D profiles do not cross them (unlikely); 2) such valleys were removed by ravinement during transgressions (possible, but unlikely due to the lack of core-based evidence for accompanying hiatuses between sequences in Exp313 samples); or 3) such valleys are present, but too small/widely spaced to be resolved by existing 2D coverage (very likely). This third possibility is supported by interpretations of dense, ultra-high resolution single-channel (2D/3D CHIRP geophysical profiles) of the NJ shelf 60 km to the southeast, which confirm that complex dendritic, incised fluvial systems formed during the latest Pleistocene (Davies et al., 1992; Duncan et al., 2001; Nordfjord et al., 2005). Incised valleys are crucial paleo-water depth indicators at sequence boundaries, independent of benthic foraminiferal successions. We are confident that if incised valleys exist within lower Miocene sediments around Exp313 sites, and seaward toward correlative rollovers, they will be detected using 3D images along with related morphologic enhancement techniques (Figs. 5, 6). Mapping these incisions will constrain shoreline positions through time, improve estimates of eustatic amplitudes, and enable sequence architecture/seismic geomorphologic techniques to predict facies distributions calibrated by Exp313.

While pre-middle Miocene shelf exposure near Exp313 sites is difficult to detect with existing 2D data, this is not true of younger intervals sampled by Exp313 above reflector m4.1 (Fig. 3). Spot coring at irregular surfaces corresponding to sequence boundaries m1, m3 and m4 at sites M27 and M29 recovered shallow water sands, and in several cases ~1 m of paleosol (Mountain, Proust, McInroy, et al., 2010). These surfaces can be traced seismically to clinoforms on the mid-shelf 25 km seaward of M29, but the proposed 3D imaging will not extend seaward to those younger clinoforms. Nonetheless, several hundred meters of largely discontinuous reflectors above m4.1 (Fig. 3) are virtually certain to be resolved with 3D techniques to a degree rarely seen, providing seismic expression of nearshore and coastal plain facies tied to Exp313 cores and logs.

Using the proposed 3D volume, seismic evidence for paleo-shelf exposures and proximity of fluvial sources to paleo-shelf edges/rollovers can be mapped, along with shelf/uppermost slope delta architecture (if it exists; Fig. 7), within any of the eight sequences constrained by Exp 313 results (Fig. 3). Community-based efforts can then document any enhanced fluvial contributions to observed clinoform progradation during a known time interval of long-term eustatic fall and increasing glacioeustatic amplitudes. Seismic attribute analyses, e.g., coherence displays (Fig. 6, center), offer exciting opportunities to locate/map incised valleys/canyons at sequence boundaries, to calibrate sand distribution in shallow shelf intervals/topsets, clinoform front/toe and basinal settings, and to investigate facies-dependent bedding characteristics calibrated by Exp 313. The higher fold and improved source to be used for the proposed 3D survey (see below) will also provide enhanced multiple suppression and thereby produce sharper definition of sequence boundaries (e.g., Fig. 4), a task that is especially challenging along the mid-Atlantic shelf because of highly reflective and parallel layering of interbedded muds and sands in the Neogene section (e.g., Austin, Christie-Blick et al., 1998)

2) What are the mechanisms of sediment transport seaward of clinoform rollovers, and how do they fit into the sequence stratigraphic model? Linked hypothesis: During shelf progradation, the evolution of clinoform front morphology is a complex response to changes in gradient, sediment source geometry (point- vs. line-source), and basinward redeposition by sediment gravity flows/turbidity currents.

Despite the lack of seismic evidence for inner-shelf incisions along the tops of Oligocene-middle Miocene sequences (Fig. 4), mass-transport deposits on slopes were encountered by Exp313 (Fig. 8). The classic model of siliciclastic sequence development includes submarine fans seaward of clinoform toes (Van Wagoner et al., 1988; Posamentier and Vail, 1988), presumed to represent sediment by-pass/basinward transport of mostly coarse-grained material during times of rapid sea-level fall. However, there is little evidence of such lobate depocenters in Oligocene-Miocene sections beneath the NJ shelf (Figs. 3, 4; Greenlee et al., 1992; Poulsen et al., 1998). In their place beneath the inner shelf there are well-defined deposits less than a few km seaward of rollovers that accumulated as units 10's-100's of m thick on ~2° clinoform slope gradients (Fig. 3). All pinch out landward and thin seaward, where most become seismically indistinguishable from underlying strong reflectors at slope toes. Each extends for 10's of km along-strike. These sediments have been termed "slope apron deposits"; Exp313 results have shown that they comprise glauconitic sands and mature quartz grains up to gravel size, all presumably shed from edges of adjacent clinoform tops (Fig. 8). The Exp313 team is using both litho- and seismic stratigraphic features of several of these deposits where they occur within a single sequence. The goal is to identify criteria that divide them into separate depositional units, but because they represent rapidly deposited, reworked material, such subdivisions will be difficult or impossible to establish with the existing 2D data. We will also be able to determine how slope apron deposition relates to timing of eustatic change(s), a goal at the heart of understanding clinoform evolution. A 3D volume is required to do this work.

In addition to resolving internal structures of slope aprons, the 3D volume will also detect failure scars/transport lanes that directed mass flows basinward (Fig. 8). The volume will also document spatial/temporal connections to shelf-crossing incised valleys immediately landward of rollovers. One important objective is to determine the degree to which observed incised features served as conduits for sediment originating landward of the rollover, as opposed to more local slope redistributions, such as headward erosion, gravitational creep, slumping and/or debris flow mechanisms, all of which originated seaward of rollovers. Ties between continuously sampled cores and 3D images make this possible.

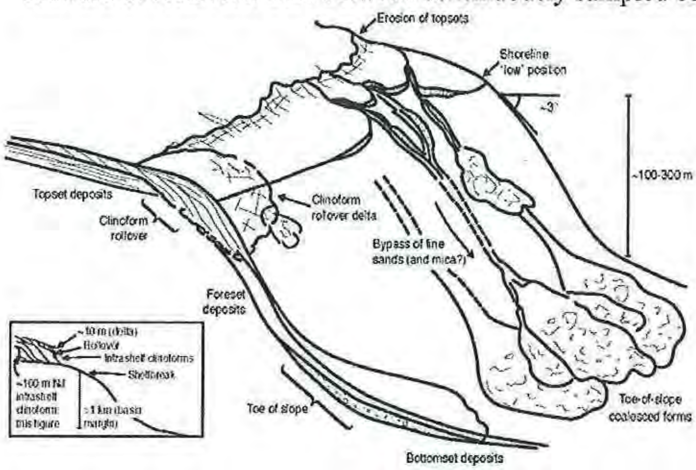

Figure 8. Conceptual model developed during Exp313 to explain regular occurrences of poorly sorted, stratified, glauconite-rich coarse sand/gravels in cores taken near the tops of clinoform slopes. Multiple channels and/or regressive shorefaces at clinoform rollovers are presumed to erode into/entrain older topset deposits. These sediments are remobilized and transported down the clinoform slope as debris flows and turbidity currents to form aprons close to the toe of slope (Mountain, Proust, McInroy et al., 2010). The 3D volume will vastly improve images of clinoform rollovers, where these sediment movements take place in response to base-level changes.

Research on sediment transport pathways using 2D data has been unable to provide definitive models of shelf/slope/basin connectivity on this or any continental margin. In the sequence stratigraphic model, fans and laterally extensive onlap depend on stable point sources of sediment (e.g., Karner and Driscoll, 1997). But even middle-late Miocene sequence boundaries that display evidence of paleo-shelf exposure are not associated with lobate lowstand accumulations basinward of clinoform toes, based on available 2D profiles (e.g., Fulthorpe et al., 2000). Perhaps such deposits were instead transported farther basinward to the continental rise and/or laterally along the margin, as probably occurred in the Miocene on Australia's NWS (Cathro et al., 2003). Lowstand fans are also absent in paleo-shelf settings of the Canterbury Basin, New Zealand, where influences of along-strike currents are unequivocal (Lu et al., 2003; Lu and Fulthorpe, 2004). Morphologic elements of paleo-slope incisions, i.e., canyons and rills, on the mid-Atlantic and other margins remain unclear with available (2D) seismic control. Pleistocene and modern canyons are large (up to 300 m deep and 2-5 km wide), closely spaced (2-10 km), and the Hudson and Delaware canyons off the east coast of the U.S. are clearly linked to river systems that have retreated westward during the Holocene sea-level rise. In contrast, middle-late Miocene canyons are both less deeply incised and less common and do not appear to be directly linked to paleo-shelf incisions, suggesting that they are not directly related to fluvial sources (Fulthorpe et al., 1999; Fulthorpe et al., 2000). Fulthorpe et al. (1999) have advanced the hypothesis that observed paleo-shelf-edge linearity results from along-strike sediment transport by waves and currents, which mutes the influence of individual fluvial point sources to form a line-source of sediment delivery to clinoform fronts (see also Fulthorpe and Austin, 2008). Individual fluvial sources apparently did not deliver sufficient sediment to overcome along-strike forcing to produce lobate depocenters (see Fig. 7), even though some fluvial incisions appear similar in width and depth to the Pleistocene Hudson and Delaware shelf channels (Fulthorpe et al., 1999). Shelf and slope incisions cannot be observed on the NCB/NWS, despite 3D imaging (Fig. 7). A lack of prominent point sources on the Miocene NJ margin (Fulthorpe et al., 1999; Pekar et al., 2003) may account for differences between NJ sequences and the standard sequence model (e.g., presence of slope aprons and absence of lobate fans). However, none of these inferences can be confirmed using only the available 2D seismic control. The only way that process-based links between sediment sources and observed/sampled NJ Oligocene-Miocene clinoforms can be established, and their relationship to sea-level cycles defined, is by 3D imaging encompassing Exp313 sites (Figs. 3-4).

Similarly, canyons cut into clinoform slopes do not appear to be linked to those incising more gently dipping surfaces basinward of clinoform toes, suggesting that different submarine erosional processes may be associated with observed changes in gradient. This may result from different "regime variables" controlling sedimentation patterns (Swift and Thorne, 1991; Fulthorpe et al., 2000). Along the modern shelf edge offshore NJ, incisions up to 140 m deep can occur even on low gradients basinward of clinoform toes, most likely due to fluid escape processes (Dugan and Flemings, 2000). 3D imaging along clinoform slopes in this project can test for this process of slope failure in the early - mid-Miocene.

3) What was the sedimentary process response to the global mid-Miocene climatic (and tectonic) transition? Linked hypothesis: Changes in the rate of sediment input to the NJ margin during the mid-Miocene, as evidenced by mapping clinoforms bracketed by sequence boundaries, are linked to globally significant changes in the relative intensity of margin erosion.

Many continental margins reveal mid-Miocene influxes of siliciclastic sediments (Molnar, 2004). In addition to NJ (Poag and Sevon, 1989; Pazzaglia and Brandon, 1996; Steckler et al., 1999), other well-constrained examples of this pattern include the Gulf of Mexico (Galloway et al., 2000; Galloway, 2008), Canterbury Basin (Lu et al., 2005), NCB (Cathro et al., 2003; Sanchez et al., 2012a, b), the Angola margin (Lavier et al., 2001), and the Maltese Islands margin (John et al., 2003). Age estimates for this influx range from 15-12 Ma. The NCB case (Fig. 7) is striking, because the observed siliciclastic increase occurred at a preexisting carbonate margin. In the Canterbury Basin, the mid-Miocene sediment increase is not linked to known tectonism in the proximal Southern Alps; the only notable increase in sedimentation rate that coincides with tectonism is much later, during a well-defined period of increasing convergence rates at the Alpine Fault (Lu et al., 2005). This global pattern of mid-Miocene sediment influxes has been linked to global cooling following the mid-Miocene $\delta^{18}O$ peak. One possible mechanism is that the post - mid-Miocene global sea-level fall may have led to increased shelf erosion everywhere. However, reconstructed paleobathymetric profiles on the NJ margin suggest that the amount of sediment required for the observed progradation, estimated as a 20-fold increase in flux, exceeds that available from paleo-shelf erosion alone (Steckler et al., 1999). Other proposed mechanisms include changes in precipitation and in the amplitude/frequency of late Cenozoic climate change (Molnar, 2001; 2004).

However, climate may not have been the only driver of mid-Miocene sediment influx. Tectonic uplift of the hinterland may also have contributed (Poag and Sevon, 1989; Pazzaglia and Brandon, 1996). Potter and Szatmari (2009) have united climatic and tectonic mechanisms for Miocene sedimentation by hypothesizing a global increase in middle-late Miocene tectonic activity driven by accelerated upwelling at two "superplumes" below the Pacific and Africa plates, which may also have produced far-field uplift of passive margins such as NJ. In their scenario, tectonic activity drove the coeval climatic transitions, through opening/closing key gateways and changing the oceanic circulation to trigger global cooling. The same Appalachian uplift that provided sediment to NJ has also been proposed as the origin of voluminous mid-Miocene sediments in the deep Gulf of Mexico (Jackson et al, 2011). These sediments were delivered by the paleo-Tennessee River, which discharged into the northeastern Gulf prior to its capture by the Mississippi (Galloway et al., 2000; Galloway, 2008). In spite of the large volumes of sandy sediment delivered to the Gulf basin, coeval updip slope canyons have not been identified, in marked contrast to the Pleistocene depositional episode (Galloway et al., 2000; Galloway, 2008). These Gulf of Mexico Miocene sediments are now targets of intensive hydrocarbon exploration, so understanding processes of middle Miocene sediment delivery from shelf to basin is economically as well as academically important.

The middle-late Miocene was a critical period in which climatic/tectonic processes combined to influence sedimentation globally. One of the long-term goals off NJ is to evaluate sedimentary response to these Miocene changes that influenced hinterland capability to provide sediment to the margin. Our proposed 3D survey will target initiation of the mid-Miocene sediment influx by imaging the transition between steep, slowly prograding Oligocene to mid-Miocene clinoforms drilled during Exp313 (Fig. 3), to more gently dipping, but more rapidly progradating features deposited later in the Miocene. Seismic geomorphology derived using the 3D volume will allow us to map temporal changes in shelf channel geometrical parameters (e.g., width, depth, sinuosity, gradient) to deduce changing sediment transport capacities from the hinterland through time, while slope morphologies, including the presence/absence of incised valley/canyons, will provide insights into processes involved in sediment bypassing to deep water (Fig. 8). In addition, correlation with the well-dated mid-Miocene sequences in the Gulf of Mexico, sourced from the same hinterland, will enable the timing of the influx in each basin to be compared.

WORK PLAN

Early-middle Miocene sequences clearly vary along-strike (Fig. 4), but a 3D volume long enough (perhaps ~100 km) to image all mapped variability is cost prohibitive. Instead, we propose to collect a 50 (dip) x 12 (strike) km volume encompassing all Exp 313 sites (Fig. 1), which has sampled ~12 sequences (Fig. 3). Some will be imaged along depocenter axes, others along peripheries, so we should image the full suite of potential shelf/slope, process-related seismic geomorphologies. Only one boundary (m5.6) will be missed. Fig. 3 shows that the volume proposed will image at least eight Miocene clinoform rollovers; these paleo-shelf edges record primary depositional processes associated with base-level change.

We have prepared a 2-year budget for acquisition/initial commercial processing of the volume (Fig.1). The data will be acquired on *Langseth*; processing will be done by a commercial company to pre-stack time-migrated (PSTM) shot gathers and 3D image volume (see quote in "Other Supplementary Documents"). The 12 km survey width optimizes turn efficiency and allows full data acquisition to be completed in two 6-km wide 'racetracks'. The 50 km dip-length enables imaging of early Miocene topsets landward of Site M27 to middle Miocene toe-of-clinoform morphologies basinward of Site M29 (Fig. 3).

We will focus on imaging the upper 1 s two-way travel time; we expect to achieve vertical resolution of 5 m or better and horizontal resolution of 15 m or better. We will record with 1 ms sampling to a travel-time depth of 4 s to image diffractions necessary for proper migration. These constraints dictate a shallow, high frequency source array and a recording design that minimizes spatial aliasing. We expect in-line dips to be <4°, and cross-line dips to be <8°, the latter along inward-facing walls of incised valleys. To reduce aliasing of diffractions that will arise from lateral discontinuities and pinchouts, we plan to collect data with a nominal bin size of 6.25 m in-line and 18.75 m cross-line. *Langseth* will tow four 3-km streamers spaced 75 m apart to provide the necessary range of source-receiver offsets required for complete imaging to a maximum estimated target depth of 5-6 km.

We estimate cruise duration based on industry acquisition standards (e.g., 30% downtime and infill) prior *Langseth* 3D projects, consultations with R. Steinhaus, Chief Sci. Officer on *Langseth*, and use of industry acquisition planning software. We anticipate leaving from/returning to Newark, NJ, a ~80 nmi transit to/from the survey area (Fig. 1). Setup/deployment/streamer ballasting should take 3 days; gear retrieval and transit at the end will be 1 day. *Langseth* will use two flip-flopping gun arrays designed for high-resolution surveying, resulting in eight CMP lines spaced at 18.75 m for each sail line. The 12 km-wide area will be covered with 80 sail lines. Total shiptime dock-to-dock is 34 days.

Data acquisition will result in 5 terabytes of field data. PGS (see quote in "Other Supplementary Documents") has responded with a detailed work plan at a competitive cost. Their approach comprises 27 processing steps leading to various 3D PSTM shot gathers and data volumes; these will provide the community with interpretable reflection results and material for follow-on data analysis proposals. The data will be processed at 2 ms sampling rate unless the records show signal above 250 Hz, in which case the processing will proceed at 1 ms. Estimated data processing time is 5 mo. Two 1-week visits to the PGS facility by two co-PIs are budgeted to participate in and oversee the data preparation. Following a post-cruise workshop for the interested community of users (see UTIG Budget and Justification), we will upload delivered results to UTIG's Academic Science Portal of the Marine Geoscience Data System, and will also upload raw data/navigation to LDEO's Seismic Reflection Data Management System.

This is a collaborative effort between PIs with decades of experience collecting, processing and analyzing marine seismic data along continental margins, and in particular NJ. M. Nedimovic (MN) has recently completed a successful 2-month cruise as a Co-PI aboard *Langseth* collecting multi-streamer 2D data. His experience planning and executing that campaign (that included 6 volunteer watch-standers onboard to gain scientific experience) is valuable for the proposed project. Post-cruise, MN will provide primary oversight of the commercial processing; he will make two 5-day trips to the processing facility in Houston. He will be joined on both trips by a second Co-PI. G.Mountain (GM) has participated in every 2D MCS acquisition survey comprising the MAT. In his role as Exp313 Co-Chief, GM is in touch with Expedition-based research that will both augment and benefit from results of the proposed 3D volume. GM, MN and N. Christie-Blick (NCB) are professors at their respective institutions with years of teaching experience that can be applied to educational aspects of pre- and post-cruise workshops and the at-sea experience of volunteer watch-standers. NCB brings lengthy experience in applying sequence stratigraphic principles at the outcrop scale, which tied to the Exp313 wells is what the proposed 3D imagery will closely rival. J. Austin (JA) and C. Fulthorpe (CF) bring decades of experience in using both 2D and 3D MCS and ultra high-resolution acoustic tools (CHIRP, boomer, swath bathymetry) to the study of sediment transport on passive margins. With ONR support, they have studied the latest Pleistocene-Holocene stratigraphic succession of the NJ shelf for 25 yrs. Furthermore, both have analyzed 3D data volumes on the NW Australian continental margin, and both have been ODP/IODP Co-Chiefs in continental shelf drilling efforts (JA: Leg 174A, CF: Exp317). All co-PIs will help run shorebased workshops pre- and post-data acquisition, and 4 will sail aboard *Langseth* and participate in the instruction of volunteer watch-standers in the theory and practice of seismic acquisition, processing and interpretation. In addition to their instructional duties, GM, JA and CF will stand 8-hr watches each day at sea; MN will oversee data QC and be on-call to troubleshoot acquisition-related problems.

The 3D, pre-stack time migrated data volume will be delivered from the processing company to JA and CF, to be loaded onto a 3D visualization workstation. The co-PIs will convene a data appraisal, first-look interpretation workshop at UTIG for the interested scientific community shortly thereafter. Research themes identified will initiate sub-groups to focus on developing important research goals. Workshop products are TBD, but the intent is clear: 1) to debut the 3D data to interested researchers, 2) to task those present with developing strategies for achieving realistic goals using the 3D volume, and 3) to rapidly link a wide community of potential researchers to the 3D data by making it publically available at the close of the workshop (see the "Data Management Plan").

INTELLECTUAL MERIT

The NJ margin is among the best siliciclastic passive margins for elucidating the timing/amplitude of eustatic change over millions of years, and for examining quantitatively the link between sea-level change and the stratigraphic record. Consequently, this margin has been a key location in all long-range plans of scientific ocean drilling since it was first identified by COSOD II (1987). While Exp313 continuously cored/logged boreholes within shallow-water facies, and has recovered complete stratigraphic information, 3D seismic imaging is needed to put that sampled record in a spatially accurate, stratigraphically meaningful context. The 29 researchers of the Exp313 scientific party are an especially valuable knowledge base of the mid-Cenozoic evolution of the NJ shelf; they and other scientists involved in research of the MAT represent a large body of experts for whom the proposed seismic geomorphology will be a tremendous asset. 3D imagery will allow them to map sequences around Exp313 sites, including shoreline positions and flanking diagnostic shallow-water features (e.g., fluvial incisions, estuary complexes, point bars). The long-term objectives remain to: 1) determine the amplitude and timing of global sea-level changes during the "Ice House" 2) establish the impact of base-level changes on the preserved stratigraphic record; and 3) improve understanding of the response of shorelines/nearshore environments to changes in global sea level, a societally relevant topic today.

BROADER IMPACTS

The team of co-PIs envisions 3 phases of robust interaction with the user community before, during and after 3D acquisition aboard *Langseth*: 1) A pre-acquisition workshop to acquaint interested participants with the project (an announcement of opportunity was placed [May 2012; see 'Other Suppl. Docs.'] on the GeoPRISMS and Consortium for Ocean Leadership [COL] websites; additional announcements will follow funding) will be held at Rutgers prior to data acquisition. The scientific value of 3D data will be displayed, the history of research on the NJ margin will be highlighted, and plans for data acquisition will be laid out. Discussions will aim at reaching a consensus concerning acquisition details and processing features of the community data volume by a commercial company. 2) Community interaction during acquisition will be primarily the hands-on participation of students/young scientists aboard *Langseth* (~12 bunks are available for volunteers [see 'Mentoring Plan']). The survey area is <40 nmi from Atlantic City, so rotation of more than one group is possible by at-sea transfer, enabling a variety of education/outreach activities with perhaps occasional live satellite feeds showing the deployment/recovery of seismic gear, etc. 3) A post-acquisition workshop at UTIG will focus on avenues for community analysis/interpretation of the processed 3D volume, once that volume is available ~5 mo post-acquisition.

The Rutgers Geology Museum has previously hosted exhibits of scientific drilling in the Coastal Plain, focusing on the K/Pg boundary core obtained at Bass River, NJ (ODP Leg 174AX; Olsson et al., 1997). We will prepare similar exhibits/talks to highlight the integration of 3D seismic with drilling. We expect that 3D images will become integral to IODP outreach, along with Exp313 results. We will showcase NJ margin results for the European Union (which funded Exp313 drilling/logging costs through IODP), for ICDP (which funded some drilling costs), the COL (responsible for logging/data management) and IODP-MI (which managed Exp313). We will provide the IODP Data Bank, and, if asked, the ECORD/ESO Drilling Operator, with 3D image data. LDEO/UTIG have an ongoing collaboration through NSF to archive marine seismic data. We will make the commercially processed 3D data available to this facility, with the expectation that they will become an enduring demonstration of how 3D imaging can improve understanding of passive margin stratigraphic evolution.

A final note about societal relevance. The proposed 3D volume, tied to cored and logged drillsites, will provide a valuable opportunity to understand better the causes of an increase in mid-Neogene deposition at many passive margins around the globe (e.g., Bartek et al., 1991.). The same Appalachian hinterland that was the source of the sedimentary record offshore NJ, and concentrated on by the MAT, fed a similar pulse of sediments into the Gulf of Mexico. Consequently, increasing knowledge of the evolution of the NJ shelf may help to improve exploration strategies in the Gulf, a proven hydrocarbon province.

RESULTS FROM PRIOR NSF SUPPORT

Gregory Mountain and **Nicholas Christie-Blick** have not received NSF support in the past 5 years.
Mladen Nedimović (w/ PIs from LDEO, WHOI + SIO; only LDEO support listed): OCE-0648303, *Collab. Res.: Seismic structure + evolu-tion of oceanic crust along the Juan de Fuca Ridge + its Flanks*, 04/01/07-03/31/10, $173,519. Resulted in 3 PhD chapters, 15 AGU abstracts, 11 peer-reviewed papers (4 in G^3, 2 in *Nature*, 2 in *EPSL*, 2 in *JGR*, and 1 in *Geology*).
Craig Fulthorpe and **James Austin**, OCE 0550004 (PIs Fulthorpe, Austin, Lavier [UTIG]), *The NW Shelf, Australia: the next step in a global approach to understanding the role of eustasy in the generation and preservation of stratigraphy*, $464,278; 2/1/06-1/31/09 + 2 no-cost extensions to 1/31/11. Commercially donated 3D+2D MCS, logs and well-completion reports were used to investigate stratal architecture of a siliciclastic-rich interval of the N. Carnarvon Basin, where late mid-Miocene siliciclastics prograded across a Paleogene carbonate ramp under wave-dominated conditions during a time of base-level fall. Thus far resulted in (Liu et al., 2011; Sanchez et al., 2012a, 2012b; 1 Ph.D. (Sanchez); aid for C. Liu to visit UTIG from China to collaborate, 2008-2010.

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SUMMARY PROPOSAL BUDGET

YEAR 1

ORGANIZATION **Rutgers University New Brunswick**	FOR NSF USE ONLY PROPOSAL NO.	DURATION (months) Proposed / Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR **Gregory Mountain**	AWARD NO.	

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Gregory S Mountain - Professor**	(b) (4), (b) (6) [redacted]				
2.					
3.					
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)					
7. (**1**) TOTAL SENIOR PERSONNEL (1 - 6)					
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS					
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)					
3. (**0**) GRADUATE STUDENTS					
4. (**0**) UNDERGRADUATE STUDENTS					
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)					
6. (**0**) OTHER					
TOTAL SALARIES AND WAGES (A + B)					
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)					
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)					
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				(b) (4) [redacted]	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)					
2. FOREIGN					
F. PARTICIPANT SUPPORT COSTS (b) (4) [redacted] 1. STIPENDS $ 2. TRAVEL 3. SUBSISTENCE 4. OTHER					
TOTAL NUMBER OF PARTICIPANT ... TOTAL PARTICIPANT COSTS				(b) (4) [redacted]	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES					
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					
3. CONSULTANT SERVICES					
4. COMPUTER SERVICES					
5. SUBAWARDS					
6. OTHER					
TOTAL OTHER DIRECT COSTS					
H. TOTAL DIRECT COSTS (A THROUGH G)					
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) (b) (4) [redacted]					
TOTAL INDIRECT COSTS (F&A)				(b) (4) [redacted]	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)					
K. RESIDUAL FUNDS					
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				**787,551**	
M. COST SHARING PROPOSED LEVEL $ **Not Shown**	AGREED LEVEL IF DIFFERENT $				

PI/PD NAME **Gregory Mountain**	FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME* **Emmeline Crowley**	Date Checked	Date Of Rate Sheet	Initials - ORG

1 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

SUMMARY PROPOSAL BUDGET

YEAR 2

ORGANIZATION **Rutgers University New Brunswick**	FOR NSF USE ONLY PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR **Gregory Mountain**	AWARD NO.		

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Gregory S Mountain - Professor**	0.00	0.00	0.00	0	
2.					
3.					
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (**1**) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	0	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	0	
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (**0**) GRADUATE STUDENTS				0	
4. (**0**) UNDERGRADUATE STUDENTS				0	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (**0**) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				0	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				0	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				0	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				(b) (4) [redacted]	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)					
2. FOREIGN					
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ 0					
2. TRAVEL 0					
3. SUBSISTENCE 0					
4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				(b) (4) [redacted]	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					
3. CONSULTANT SERVICES					
4. COMPUTER SERVICES					
5. SUBAWARDS					
6. OTHER					
TOTAL OTHER DIRECT COSTS					
H. TOTAL DIRECT COSTS (A THROUGH G)					
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) (b) (4) [redacted]					
TOTAL INDIRECT COSTS (F&A)				(b) (4) [redacted]	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)					
K. RESIDUAL FUNDS					
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				2,268	
M. COST SHARING PROPOSED LEVEL $ **Not Shown**	AGREED LEVEL IF DIFFERENT $				

PI/PD NAME **Gregory Mountain**	FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME* **Emmeline Crowley**	Date Checked	Date Of Rate Sheet	Initials - ORG

2 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

SUMMARY PROPOSAL BUDGET

Cumulative

ORGANIZATION **Rutgers University New Brunswick**		FOR NSF USE ONLY PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR **Gregory Mountain**		AWARD NO.		

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Gregory S Mountain - Professor**	(b) (4), (b) (6) [redacted]				
2.					
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)					
7. (**1**) TOTAL SENIOR PERSONNEL (1 - 6)					
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS					
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)					
3. (**0**) GRADUATE STUDENTS					
4. (**0**) UNDERGRADUATE STUDENTS					
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)					
6. (**0**) OTHER					
TOTAL SALARIES AND WAGES (A + B)					
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)					
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)					
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				(b) (4) [redacted]	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)					
2. FOREIGN					
F. PARTICIPANT SUPPORT COSTS (b) (4) [redacted] 1. STIPENDS $ 2. TRAVEL 3. SUBSISTENCE 4. OTHER					
TOTAL NUMBER OF PARTICIPANT TOTAL PARTICIPANT COSTS				(b) (4) [redacted]	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				(b) (4) [redacted]	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					
3. CONSULTANT SERVICES					
4. COMPUTER SERVICES					
5. SUBAWARDS					
6. OTHER					
TOTAL OTHER DIRECT COSTS					
H. TOTAL DIRECT COSTS (A THROUGH G)					
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)					
TOTAL INDIRECT COSTS (F&A)				(b) (4) [redacted]	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)					
K. RESIDUAL FUNDS					
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				**789,819**	
M. COST SHARING PROPOSED LEVEL $ **Not Shown**	AGREED LEVEL IF DIFFERENT $				

PI/PD NAME **Gregory Mountain**	FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME* **Emmeline Crowley**	Date Checked	Date Of Rate Sheet	Initials - ORG

C *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

RUTGERS BUDGET JUSTIFICATION

(b) (4), (b) (6)

[redacted]

(b) (4), (b) (6)

[redacted]

BUDGET SUMMARY

Collaborative Research: Community-Based 3D Imaging that Ties Clinoform Geometry to Facies Successions and Neogene Sea-Level Change

Rutgers University

(b) (4), (b) (6)

[redacted]

J. Total Costs	**$787,551**	**$2,268**	**$789,819**

SUMMARY PROPOSAL BUDGET

YEAR 1

		FOR NSF USE ONLY	
ORGANIZATION **University of Texas at Austin**	PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR **Craig S Fulthorpe**	AWARD NO.		

	NSF Funded Person-months	Funds Requested By proposer	Funds granted by NSF (if different)
A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	(b) (4), (b) (6) [redacted]		
1. **Craig S Fulthorpe - Sr. Research Scientist**			
2. **James A Austin, Jr. - Sr. Research Scientist**			
3.			
4.			
5.			
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)			
7. (**2**) TOTAL SENIOR PERSONNEL (1 - 6)			
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)			
1. (**0**) POST DOCTORAL SCHOLARS			
2. (**1**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)			
3. (**0**) GRADUATE STUDENTS			
4. (**0**) UNDERGRADUATE STUDENTS			
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)			
6. (**0**) OTHER			
TOTAL SALARIES AND WAGES (A + B)			
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)			
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)			
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEED			
TOTAL EQUIPMENT		(b) (4) [redacted]	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)			
2. FOREIGN			
F. PARTICIPANT SUPPORT COSTS			
1. STIPENDS $ **0**			
2. TRAVEL **0**			
3. SUBSISTENCE **0**			
4. OTHER **0**			
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS		**0**	
G. OTHER DIRECT COSTS			
1. MATERIALS AND SUPPLIES		(b) (4) [redacted]	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION			
3. CONSULTANT SERVICES			
4. COMPUTER SERVICES			
5. SUBAWARDS			
6. OTHER			
TOTAL OTHER DIRECT COSTS			
H. TOTAL DIRECT COSTS (A THROUGH G)			
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) (b) (4) [redacted]			
TOTAL INDIRECT COSTS (F&A)		(b) (4) [redacted]	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)			
K. RESIDUAL FUNDS			
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)		**79,603**	
M. COST SHARING PROPOSED LEVEL $ **Not Shown**	AGREED LEVEL IF DIFFERENT $		

	FOR NSF USE ONLY		
PI/PD NAME **Craig S Fulthorpe**	INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME* **Barbara Reyes**	Date Checked	Date Of Rate Sheet	Initials - ORG

1 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

SUMMARY PROPOSAL BUDGET

YEAR 2

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months)	
	Proposed	Granted
AWARD NO.		

ORGANIZATION
University of Texas at Austin

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Craig S Fulthorpe

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Craig S Fulthorpe - Sr. Research Scientist**	(b) (4) [redacted]				
2. **James A Austin, Jr. - Sr. Research Scientist**					
3.					
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE					
7. (**2**) TOTAL SENIOR PERSONNEL (1 - 6)					
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS					
2. (**2**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)					
3. (**0**) GRADUATE STUDENTS					
4. (**0**) UNDERGRADUATE STUDENTS					
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)					
6. (**0**) OTHER					
TOTAL SALARIES AND WAGES (A + B)					
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)					
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)					

	Funds Requested By proposer	Funds granted by NSF (if different)
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)		
TOTAL EQUIPMENT	(b) (4) [redacted]	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)		
2. FOREIGN		
F. PARTICIPANT SUPPORT COSTS (b) (4) [redacted]		
1. STIPENDS $		
2. TRAVEL		
3. SUBSISTENCE		
4. OTHER		
TOTAL NUMBER OF PARTICIPANT TOTAL PARTICIPANT COSTS	(b) (4) [redacted]	
G. OTHER DIRECT COSTS		
1. MATERIALS AND SUPPLIES	(b) (4) [redacted]	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION		
3. CONSULTANT SERVICES		
4. COMPUTER SERVICES		
5. SUBAWARDS		
6. OTHER		
TOTAL OTHER DIRECT COSTS		
H. TOTAL DIRECT COSTS (A THROUGH G)		
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) (b) (4) [redacted]		
TOTAL INDIRECT COSTS (F&A)	(b) (4) [redacted]	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)		
K. RESIDUAL FUNDS		
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)	**114,828**	

M. COST SHARING PROPOSED LEVEL $ **Not Shown** AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Craig S Fulthorpe

ORG. REP. NAME*
Barbara Reyes

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

2 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

SUMMARY PROPOSAL BUDGET

Cumulative

ORGANIZATION: University of Texas at Austin				FOR NSF USE ONLY	
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: Craig S Fulthorpe				PROPOSAL NO. / AWARD NO.	DURATION (months): Proposed / Granted
A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months: CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. Craig S Fulthorpe - Sr. Research Scientist	(b) (4), (b) (6) [redacted]				
2. James A Austin, Jr. - Sr. Research Scientist					
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)					
7. (2) TOTAL SENIOR PERSONNEL (1 - 6)					
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL SCHOLARS					
2. (3) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)					
3. (0) GRADUATE STUDENTS					
4. (0) UNDERGRADUATE STUDENTS					
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)					
6. (0) OTHER					
TOTAL SALARIES AND WAGES (A + B)					
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)					
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)					
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				(b) (4) [redacted]	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)					
2. FOREIGN					
F. PARTICIPANT SUPPORT COSTS (b) (4) [redacted]					
1. STIPENDS $					
2. TRAVEL					
3. SUBSISTENCE					
4. OTHER					
TOTAL NUMBER OF PARTICIPANT — TOTAL PARTICIPANT COSTS				(b) (4) [redacted]	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				(b) (4) [redacted]	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					
3. CONSULTANT SERVICES					
4. COMPUTER SERVICES					
5. SUBAWARDS					
6. OTHER					
TOTAL OTHER DIRECT COSTS					
H. TOTAL DIRECT COSTS (A THROUGH G)					
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)					
TOTAL INDIRECT COSTS (F&A)				(b) (4) [redacted]	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)					
K. RESIDUAL FUNDS					
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				194,431	
M. COST SHARING PROPOSED LEVEL $ Not Shown	AGREED LEVEL IF DIFFERENT $				
PI/PD NAME: Craig S Fulthorpe	FOR NSF USE ONLY — INDIRECT COST RATE VERIFICATION				
ORG. REP. NAME*: Barbara Reyes	Date Checked		Date Of Rate Sheet		Initials - ORG

C *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

BUDGET SUMMARY

Collaborative Research: Community-Based 3D Imaging that Ties Clinoform Geometry to Facies Successions and Neogene Sea-Level Change

The University of Texas at Austin

May 1, 2013 - April 30, 2015

(b) (4), (b) (6)

[redacted]

BUDGET JUSTIFICATION

Collaborative Research: Community-Based 3D Imaging that Ties Clinoform Geometry to Facies Successions and Neogene Sea-Level Change

The University of Texas at Austin Institute for Geophysics (UTIG)

May 1, 2013 - April 30, 2015

(b) (4), (b) (6)

[redacted]

(b) (4), (b) (6)

[redacted]

SUMMARY PROPOSAL BUDGET

YEAR 1

ORGANIZATION **Columbia University**				FOR NSF USE ONLY PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR **Nicholas Christie-Blick**				AWARD NO.		
A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)	
1. **Nicholas Christie-Blick - Professor**	(b) (4), (b) (6) [redacted]					
2. **Mladen Nedimovic - Adjunt Research Scientist**						
3. **Total Salaries**						
4.						
5.						
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE						
7. (**3**) TOTAL SENIOR PERSONNEL (1 - 6)						
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)						
1. (**0**) POST DOCTORAL SCHOLARS						
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)						
3. (**0**) GRADUATE STUDENTS						
4. (**0**) UNDERGRADUATE STUDENTS						
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)						
6. (**1**) OTHER						
TOTAL SALARIES AND WAGES (A + B)						
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)						
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)						
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)						
TOTAL EQUIPMENT				(b) (4), (b) (6) [redacted]		
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)						
2. FOREIGN						
F. PARTICIPANT SUPPORT COSTS						
1. STIPENDS $ **0**						
2. TRAVEL **0**						
3. SUBSISTENCE **0**						
4. OTHER **0**						
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**		
G. OTHER DIRECT COSTS						
1. MATERIALS AND SUPPLIES				(b) (4) [redacted]		
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION						
3. CONSULTANT SERVICES						
4. COMPUTER SERVICES						
5. SUBAWARDS						
6. OTHER						
TOTAL OTHER DIRECT COSTS						
H. TOTAL DIRECT COSTS (A THROUGH G)						
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) (b) (4) [redacted]						
TOTAL INDIRECT COSTS (F&A)				(b) (4) [redacted]		
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)						
K. RESIDUAL FUNDS						
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				**94,508**		
M. COST SHARING PROPOSED LEVEL $ **Not Shown**	AGREED LEVEL IF DIFFERENT $					
PI/PD NAME **Nicholas Christie-Blick**				FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME* **Maribel Respo**				Date Checked	Date Of Rate Sheet	Initials - ORG

1 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

SUMMARY PROPOSAL BUDGET

YEAR 2

ORGANIZATION Columbia University				FOR NSF USE ONLY PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR Nicholas Christie-Blick				AWARD NO.		
A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)	
1. Nicholas Christie-Blick - Professor	0.00	0.00	0.00	0		
2. Mladen Nedimovic - Adjunt Research Scientist	0.00	0.00	0.00	0		
3. Total Salaries	0.00	0.00	0.00	0		
4.						
5.						
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0		
7. (3) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	0		
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)						
1. (0) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	0		
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0		
3. (0) GRADUATE STUDENTS				0		
4. (0) UNDERGRADUATE STUDENTS				0		
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0		
6. (0) OTHER				0		
TOTAL SALARIES AND WAGES (A + B)				0		
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				0		
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				0		
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)						
TOTAL EQUIPMENT				(b) (4) [redacted]		
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)						
2. FOREIGN						
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 0 2. TRAVEL 0 3. SUBSISTENCE 0 4. OTHER 0						
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0		
G. OTHER DIRECT COSTS						
1. MATERIALS AND SUPPLIES				(b) (4) [redacted]		
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION						
3. CONSULTANT SERVICES						
4. COMPUTER SERVICES						
5. SUBAWARDS						
6. OTHER						
TOTAL OTHER DIRECT COSTS						
H. TOTAL DIRECT COSTS (A THROUGH G)						
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) (b) (4) [redacted]						
TOTAL INDIRECT COSTS (F&A)				(b) (4) [redacted]		
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)						
K. RESIDUAL FUNDS						
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				4,911		
M. COST SHARING PROPOSED LEVEL $ Not Shown	AGREED LEVEL IF DIFFERENT $					
PI/PD NAME Nicholas Christie-Blick				FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME* Maribel Respo				Date Checked	Date Of Rate Sheet	Initials - ORG

2 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

SUMMARY PROPOSAL BUDGET

Cumulative

ORGANIZATION **Columbia University**	PROPOSAL NO.	DURATION (months) Proposed / Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR **Nicholas Christie-Blick**	AWARD NO.	

FOR NSF USE ONLY

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Nicholas Christie-Blick - Professor**	(b) (4) [redacted]				
2. **Mladen Nedimovic - Adjunt Research Scientist**					
3. **Total Salaries**					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE					
7. (**3**) TOTAL SENIOR PERSONNEL (1 - 6)					
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS					
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)					
3. (**0**) GRADUATE STUDENTS					
4. (**0**) UNDERGRADUATE STUDENTS					
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)					
6. (**1**) OTHER					
TOTAL SALARIES AND WAGES (A + B)					
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)					
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)					
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				(b) (4) [redacted]	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)					
2. FOREIGN					
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				(b) (4) [redacted]	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					
3. CONSULTANT SERVICES					
4. COMPUTER SERVICES					
5. SUBAWARDS					
6. OTHER					
TOTAL OTHER DIRECT COSTS					
H. TOTAL DIRECT COSTS (A THROUGH G)					
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)					
TOTAL INDIRECT COSTS (F&A)				(b) (4) [redacted]	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)					
K. RESIDUAL FUNDS					
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				**99,419**	
M. COST SHARING PROPOSED LEVEL $ **Not Shown**	AGREED LEVEL IF DIFFERENT $				

PI/PD NAME **Nicholas Christie-Blick**	FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION
ORG. REP. NAME* **Maribel Respo**	Date Checked / Date Of Rate Sheet / Initials - ORG

C *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

BUDGET JUSTIFICATION

The following is confidential information that The Trustees of Columbia University requests not be released to persons outside the Government, except for purposes of review and evaluation

(b) (4), (b) (6)

[redacted]

TITLE: Collaborative Research: Community-Based 3D Imaging That Ties Clinoform Geometry
PRINCIPAL INVESTIGATOR(S): Nicholas Christie-Blick, PI; Mladen Nedimovic, Co-PI
PERIOD OF PERFORMANCE: May 1, 2013 - April 30, 2015

(b) (4), (b) (6)

[redacted]

CURRENT AND PENDING SUPPORT
8/7/12

Gregory Mountain

A Supporting Agency	B Project Title	C Award Amount	D Pd Covered Award	E Man-Mos. Acad. Sum. Cal.	F Location

A. Current Support

(b) (4), (b) (6)

[redacted]

Dept. of Energy / subcontract from Battelle Corp.	Midwestern Regional Carbon Sequestration Partnership (MCRSP): Rutgers	$568,800	07/01/12 - 06/30/16	1/1/1/1 (all Sum.)	Rutgers

B. Pending Support

(b) (4), (b) (6)

[redacted]

Current and Pending Support

(See GPG Section II.C.2.h for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Craig Fulthorpe

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

(b) (4), (b) (6)

[redacted]

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

(b) (4), (b) (6)

[redacted]

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

(b) (4), (b) (6)

[redacted]

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Summ:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.C.2.h for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: James Austin, Jr.	Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

(b) (4), (b) (6)

[redacted]

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

(b) (4), (b) (6)

[redacted]

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

(b) (4), (b) (6)

[redacted]

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

(b) (4), (b) (6)

[redacted]

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

(b) (4), (b) (6)

[redacted]

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

 USE ADDITIONAL SHEETS AS NECESSARY

CURRENT AND PENDING SUPPORT
8/6/2012

NICHOLAS CHRISTIE-BLICK

A Supporting Agency	B Project Title	C Award Amount	D Period Covered Award	E Man-Month Acad. Sum. Cal.	F Location

A. Current Support
NONE

(b) (4), (b) (6)
[redacted]

CURRENT AND PENDING SUPPORT
8/7/2012

MLADEN NEDIMOVIC

A Supporting Agency	B Project Title	C Award Amount	D Period Covered Award	E Man-Month Acad. Sum. Cal.	F Location
A. Current Support					
NSF OCE 10-29411	COLLABORATIVE RESEARCH: EVOLUTION AND HYDRATION OF THE JUAN DE FUCA CRUST AND UPPERMOST MANTLE: A PLATE-SCALE SEISMIC INVESTIGATION FROM RIDGE TO TRENCH (CARBOTTE, S., PI; CARTON, H., NEDIMOVIC, M., CO-PI's)	223,709	3/1/12 2/28/13	NC/YR	LDEO
NSF EAR 06-07687	COLLABORATIVE RESEARCH: UPLIFT AND FAULTING AT THE TRANSITION FROM SUBDUCTION TO COLLISION- A FIELD AND MODELING STUDY OF THE CALABRIAN ARC. (STECKLER, M., PI; SEEBER, L., CO-PI; STARK, C., CO-PI; SCHAEFER, J., CO-PI; MALINVERNO, A., CO-PI; W/ NEDIMOVIC, M.; ARMBRUSTER, J.; KIM, W.Y.)	1,764,627	8/1/06 7/31/13	2/1/.5/1/NC/ NC/NC	LDEO
NSF OCE 09-26614	MEGATHRUST SEISMIC HAZARDS BY REFLECTION MAPPING (SHILLINGTON, D., PI; WEBB, S., NEDIMOVIC, M.; CO-PI'S)	713,878	1/1/10 12/31/12	NC	LDEO

(b) (4), (b) (6)

[redacted]

MLADEN NEDIMOVIC

(b) (4), (b) (6)

[redacted]

RUTGERS FACILITIES, EQUIPMENT & OTHER RESOURCES

FACILITIES:

Laboratory: 900 sq ft computer processing, visualization laboratory for students, researchers, faculty and visitors

Clinical:
N/A

Animal:
N/A

Computer: Instruction and pre-cruise data review for the first community workshop will be held in an 1800 sq ft instructional computer lab equipped with 16 HP 6200 Small Form Factor Computers. Each is at least a first generation i5 processor with 4GB of ram, and all are running Scientific Linux 6 as the default operating system. Fundamentals of 2D multichannel seismic processing will be demonstrated and participants will be able to complete training exercises on these machines using Seismic Unix. These same machines are connected via a Cisco 2948 switch which operates at 100 mb/s (FastEthernet), and bound to our department's LDAP and served home directories from our file server. The latter is an HP 380 G6, and utilizes a raid 5 disk array with 8TB of space that is backed up 3x daily. During the workshop we will also connect each of the client machines to our Virtual Desktop Infrastructure to enable 2D and 3D seismic visualization running SMT-Kingdom 64-bit licensed software on an HP xw6600 Windows 2008 R2 server with 4GB of ram and dual quadcore Intel Xeon E5420 processors and 1 TB of storage on a RAID 5 array. All of the existing public 2D seismic data and scientific results of IODP Exp313 are stored locally and available for instruction and participant exercises that will be prepared for this workshop.

Office:

MAJOR EQUIPMENT:

OTHER RESOURCES:

The PI will prepare lectures and instructional material for the participants in the pre-cruise workshop as well as at sea during the acquisition phase.

NSF Form 1363 (10/99)

FACILITIES, EQUIPMENT & OTHER RESOURCES

FACILITIES: Identify the facilities to be used at each performance site listed and, as appropriate, indicate their capacities, pertinent capabilities, relative proximity, and extent of availability to the project. Use "Other" to describe the facilities at any other performance sites listed and at sites for field studies. Use additional pages if necessary.

Laboratory:

The University of Texas at Austin Institute for Geophysics ("UTIG") has some laboratory space at the main Institute building and a larger space in another building nearby for staging preparation for field work.

Clinical:

N/A

Animal:

N/A

Computer:

UTIG is connected to the University of Texas at Austin and the internet via a 10 gigabit Ethernet connection. Internally, a switched 10/1 gigabit LAN interconnects Solaris and Linux workstations, PCs and Macintoshes. Significant computer resources include 32 64bit Linux computers with nearly 300 cores and 1.2TB of memory. Five servers participate in a 4Gb/s fiber-channel SAN with 20TB of disk. 25TB of public fast disk with tiered demand migration to 105TB of slower disk and 220TB of tape serve Unix and Windows clients; 300TB of other network disk is online. An assortment of tape drives (3480, 4mm, 8mm, DLT, LTO3/4) allow data to be staged to disk or processed directly. Plotting devices include two 42" HP inkjet plotters, several letter-to-tabloid-size color printers and many black-and-white printers. A 42" scanner is available. Software available on all systems includes program development tools, plotting tools, and both public domain and commercial data analysis packages. All PCs and Macs have common graphics tools and office productivity applications, and share files with the Unix systems.

Office:

UTIG's main office space at the University of Texas's J.J. Pickle Research Campus, 10100 Burnet Road, Bldg. 196, Austin, Texas, is available for the proposed research.

MAJOR EQUIPMENT: List the most important items available for this project and, as appropriate, identify the location and pertinent capabilities of each.

- 2 x 32 core servers 2.7GHz/64GB/100G/4gigE
- 3 x 16 core servers 2.2+GHz/32GB/3TB/4gigE
- 7 x 12 core servers 2.9+GHz/24+GB/10TB/4gigE
- 3 x 8 core servers 2.2+GHz/16GB/1-4TB/2gigE
- 17 x 4 core servers 2.2+GHz/4-10GB/140GB/2gigE
- 1 x 4 core Sun x4200 server 2.8GHz/24G/140GB/4gigE
- 1 x 4 core Sun T2000 server 1GHz/8GB/140GB/4gigE
- 3 x 2 core Sun servers 900Mhz/4Gbyte/72G/1gigE
- 4Gb/s FC SAN; 10G network; SAM-FS data migration software
- Paradigm Focus seismic processing software
- Paradigm Geodepth pre-stack migration software
- Geoquest, Landmark interpretation software
- Arc/GIS, Caris Multi-Beam, Matlab software
- Two HP 42" color plotters; 42" scanner

OTHER RESOURCES: Provide any information describing the other resources available for the project. Identify support services such as consultant, secretarial, machine shop, and electronics shop, and the extent to which they will be available for the project. Include an explanation of any consortium/contractual/sub award arrangements with other organizations.

UTIG has administrative and computer support personnel.

LDEO FACILITIES, EQUIPMENT AND OTHER RESOURCES

FACILITIES

Laboratory:
N/A

Clinical:
N/A

Animal:
N/A

Computer:
Computing resources at LDEO include an extensive network of Sun and Linux workstations, fileservers and peripherals. Site-licensed software is available for interactive MCS data manipulation, 2D and 3D imaging, waveform analysis, and graphical visualization from both Landmark and Paradigm (e.g., Promax, SeisWorks, Focus, STRATA, etc.). The multichannel seismic reflection processing facility has five linux based 3.06 GHz Intel Xeon multithread dual CPU DELL workstations each with 3 GB of RAM and 750 GB internal raid arrays, and a unix based SUN enterprise 450 server with 296 MHz dual CPU, 2 GB of RAM and 510 GB of disk space. These are all 21-inch dual monitor stations. A 16 node 32 CPU linux-box cluster connected to a NAS raid array providing 100 TB useable disk space is available. There are also a number of other SUN Ultrasparc 10 stations. The MCS facility also has two 3490E cartridge drives with stack loaders, two DLT7000 cartridge drives, and two DLT2000 cartridge drives.

Office:
Office space, heating, air conditioning, administrative support, grants management and financial services, library and other academic services to support the effort are all provided under the negotiated ICR.

MAJOR EQUIPMENT:
N/A

OTHER RESOURCES:
N. Christie-Blick (PI) and M. Nedimovic (Co-PI) will participate in the planning of the cruise, the pre-cruise workshop, the post-processing data review, and the post-cruise workshop at which community-based opportunities for analysis/interpretation of the processed 3D volume and integration with Exp313 results will be developed. M. Nedimovic (Co-PI) will also take part in the cruise, and the data processing in Houston.

Data Management Plan

This project will create ~7.5 terabytes of 120-channel, 3D seismic reflection field data integrated with navigation in standard SEG-D and UKOOA formats, respectively. Metadata related to QA/QC monitoring of MCS operations, routine to all such activities aboard the *R/V Langseth*, will be recorded as well. Additional digital data gathered from other shipboard sensors, including multibeam sonar, gravity and meteorological data, will be transmitted to the Lamont Database group that will, in turn, ensure that these data are deposited in appropriate national archives for long-term preservation. The 'raw' MCS field data will be copied to the Academic Seismic Portal at Lamont-Doherty (http://www.marine-geo.org/portals/seismic/), where it will undergo additional QA/QC in preparation for archiving purposes and for its delivery to the processing center.

The MCS field shot data described above will be copied to a robust external hard drive and delivered to the commercial processing company of choice (e.g., PGS of Houston, TX; see accompanying quote), where a prearranged flow of processing steps, overseen by the PIs, will produce a 3D 'volume' of pre-stack, time-migrated data within ~5 mos. of the end of data acquisition. Processed data will be returned to Lamont-Doherty in standard SEG-Y format, with navigation embedded in trace headers.

A copy of the processed dataset will be sent to the Univ. of Texas, Austin/Institute for Geophysics where it will be served on a network of 3D-data MCS workstations. All public data from Exp313 will be installed on this network and integrated with these seismic data for access during a community workshop at UTIG, whose purpose is to examine data quality and develop strategies for maximizing the opportunities for the ensuing stage of scientific analysis.

The processed 3D data volume will be transferred to the Academic Seismic Portal at the Univ. of Texas, Austin/Institute for Geophysics (http://www.ig.utexas.edu/sdc/) which handles processed seismic data and where it will be instantly available for public distribution without restriction. The field shot data archived at the Lamont-Doherty Academic Seismic Portal will be made available at this time as well. Like any other data set released by this national facility, rules concerning derivative products and re-distribution will apply, but any qualified user who abides by these agreements will have complete access to both the processed data and the raw field data.

Postdoctoral Researcher Mentoring Plan

We seek no funds for Post-Doctoral Researchers to conduct scientific analysis of data acquired in the proposed project. While individuals selected by the PIs through an application process will be invited to participate on the cruise, they may or may not be Post-Docs. 4-6 months pre-cruise a public call will go out for 'young researchers' (grad students / post-docs / young scientists) who are looking towards a career that requires knowledge of 3D MCS acquisition, processing and/or interpretation. Following the advice of the MG&G program of NSF, we are providing this 'qualified' mentoring plan to define clearly the manner in which Post-Doctoral researchers may benefit from the proposed project.

We are acting on recommendations of the 2010 community workshop entitled *Challenges and Opportunities in Academic Marine Seismology* (http://www.steveholbrook.com/mlsoc/workshop_report.pdf) that encouraged (1) greater community access to 3D MCS data, and (2) providing bunk space on cruises that could yield hands-on learning experiences for the upcoming generation of marine scientists. Accordingly, we ask that up to 12 berths aboard the *R/V Langseth* be reserved for these young researchers. Funds are requested to subsidize their travel to and from the ship, but we seek no other financial support for them prior to, during, or following the cruise. (Of course, the daily operational costs of the *Langseth* will absorb their 'room and board' expenses at sea.) Their exact roles and contributions to the project will depend on the skills they bring with them. We hope to have the luxury of more applicants than berths and be able to select those best qualified to benefit from this opportunity.

The goals will be to: (1) provide a 'learning by doing' experience to a broad range of participants; (2) transfer experience from the 4 on-board PIs to these young researchers in such areas as planning and running a cruise, handling gear on deck, the theory and practice of seismic processing, applications of 2 and 3D MCS, etc.; and (3) stimulate members of the group to participate in the data showcase workshop (see the Project Description) and pursue a research project using the data they helped to collect. Each of the 4 PIs who will be on the *Langseth* have lecture experience, and 2 teach marine geology and geophysics at the college and graduate level. We are all prepared to conduct lessons at sea, tailored to the backgrounds and interests of the young researchers.

Appendix C

NOAA's National Marine Fisheries Service
Endangered Species Act Section 7 Consultation Biological Opinion

Agencies: National Science Foundation-Division of Ocean Sciences and NOAA's National Marine Fisheries Service-Office of Protected Resources-Permits and Conservation Division

Activities Considered: Seismic survey by the Lamont-Doherty Earth Observatory along New Jersey and Issuance of an Incidental Harassment Authorization pursuant to Section 101(a)(5)(D) of the Marine Mammal Protection Act (MMPA)

Consultation Conducted by: NOAA's National Marine Fisheries Service-Office of Protected Resources-ESA Interagency Cooperation Division

Approved by: PERRY GAYACDO For Donna Wieting

Date: JUL 1 2014

Section 7(a)(2) of the Endangered Species Act (ESA)(16 U.S.C. 1531 et seq.) requires that each federal agency insure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of critical habitat of such species. When the action of a federal agency "may affect" a listed species or critical habitat designated for it, that agency is required to consult with NOAA's National Marine Fisheries Service (NMFS) or the U.S. Fish and Wildlife Service, depending upon the listed resources that may be affected. For the activities described in this document, the Federal action agencies are the National Science Foundation (NSF) and NMFS' Permits and Conservation Division. The NSF proposes to allow the use of its research vessel, *Marcus G. Langseth* (*Langseth*), which is operated by the Lamont-Doherty Earth Observatory (L-DEO), to conduct a seismic survey off the coast of New Jersey from June to August of 2014, in support of an NSF-funded collaborative research project led by Rutgers University. The NMFS' Permits and Conservation Division is also a Federal action agency as it is proposing to issue an IHA authorizing non-lethal "takes" by Level B harassment (as defined by the MMPA) of marine mammals incidental to the planned seismic survey, pursuant to Section 101 (a)(5)(D) of the MMPA, 16 U.S.C. § 1371 (a)(5)(D). The consulting agency is the NMFS' Office of Protected Resources – ESA Interagency Cooperation Division.

This document represents the NMFS' ESA Interagency Cooperation Division's biological opinion (Opinion) of the effects of the proposed actions on endangered and threatened species as well as designated critical habitat and has been prepared in accordance with Section 7 of the ESA. This Opinion is based on information provided in the MMPA Incidental Harassment Authorization (IHA) application, draft notice of proposed IHA, environmental assessment, monitoring reports from similar activities, published and unpublished scientific information on endangered and threatened species and their surrogates, scientific and commercial information such as reports from government agencies and the peer-reviewed literature, Opinions on similar activities, and other sources of information.

Table of Contents

List of Acronyms

ADCP-Acoustic Doppler current profiler

BOEM-Bureau of Ocean Energy Management

CFR-Code of Federal Regulations

CI-Confidence interval

CITES-Convention on the International Trade of Endangered Species

CV-Coefficient of variation

dB-decibel

DDE-Dichlorodiphenyldichloroethylene

DDT-Dichlorodiphenyltrichloroethane

DPS-Distinct population segment

EEZ-Exclusive economic zone

ESA-Endangered Species Act

EZ-Exclusion zone

GDNR-Georgia Department of Natural Resources

HCB-Hexachlorobenzene

HCH-Hexachlorocyclohexane

HMS FMP-Highly migratory species fisheries management plan

HPA-Hypothalamic-pituitary-adrenal axis

Hz-Hertz

IHA-Incidental harassment authorization

IPCC-Intergovernmental Panel on Climate Change

IUCN-International Union on the Conservation of Nature

IWC-International Whaling Commission

kHz-kilohertz

kg-kilogram

L-DEO-Lamont Doherty Earth Observatory

MMPA-Marine Mammal Protection Act

MMS-Minerals Management Service

NAO-North Atlantic oscillation

NCWRC-North Carolina Wildlife Resources Commission

NEFSC-Northeast Fisheries Science Center

NMFS-National Marine Fisheries Service

NOAA-National Oceanic and Atmospheric Administration

NSF-National Science Foundation

PAA-Peroxyacetic acid

PAM-Passive acoustic monitoring

PBDE-Polybrominated diphenyl ethers

PCB-Polychlorinated biphenyl

PDE-Phosphodiesterase

PFC-Perflourinated chemicals

PFCA-Perfluorinated carboxylic acids

PFOA-Perfluorooctanoic acid

PFOS-Perfluorooctanesulfonic acid

PIT-Passive integrated transponder

PSI-pounds per square inch

PSVO-Protected species visual observer

PTS-Permanent threshold shift

RMS-Root mean squared

SCDNR-South Carolina Department of Natural Resources

SE-Standard error

SEFSC-Southeast Fisheries Science Center

SEL-Sound exposure level

TED-Turtle excluder device

TEWG-Turtle Expert Working Group

TTS-Temporary threshold shift

U.S.-United States

USC-United States Code

USFWS-United States Fish and Wildlife Service

1 INTRODUCTION

Section 7(a)(2) of the Endangered Species Act (ESA)(16 U.S.C. 1531 et seq.) requires that each federal agency insure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of critical habitat of such species. When the action of a federal agency "may affect" a listed species or critical habitat designated for it, that agency is required to consult with NOAA's National Marine Fisheries Service (NMFS) or the U.S. Fish and Wildlife Service, depending upon the listed resources that may be affected. For the activities described in this document, the Federal action agencies are the National Science Foundation (NSF) and NMFS' Permits and Conservation Division. The NSF proposes to allow the use of its research vessel, *Marcus G. Langseth* (*Langseth*), which is operated by the Lamont-Doherty Earth Observatory (L-DEO), to conduct a seismic survey off the coast of New Jersey from June to August of 2014, in support of an NSF-funded collaborative research project led by Rutgers University. The NMFS' Permits and Conservation Division is also a Federal action agency as it is proposing to issue an IHA authorizing non-lethal "takes" by Level B harassment (as defined by the MMPA) of marine mammals incidental to the planned seismic survey, pursuant to Section 101 (a)(5)(D) of the MMPA, 16 U.S.C. § 1371 (a)(5)(D). The consulting agency is the NMFS' Office of Protected Resources – ESA Interagency Cooperation Division.

This document represents the NMFS' ESA Interagency Cooperation Division's biological opinion (Opinion) of the effects of the proposed actions on endangered and threatened species as well as designated critical habitat and has been prepared in accordance with Section 7 of the ESA. This Opinion is based on information provided in the MMPA Incidental Harassment Authorization (IHA) application, draft notice of proposed IHA, environmental assessment, monitoring reports from similar activities, published and unpublished scientific information on endangered and threatened species and their surrogates, scientific and commercial information such as reports from government agencies and the peer-reviewed literature, Opinions on similar activities, and other sources of information.

1.1 Consultation History

On December 17, 2013, the NMFS' ESA Interagency Cooperation Division received a request for formal consultation from the NSF to incidentally harass marine mammal and sea turtle species during the seismic survey; information was sufficient to initiate consultation with the NSF on this date. On the same date, the NMFS' Permits and Conservation Division received an application from the L-DEO to incidentally harass marine mammal species during the proposed seismic survey.

On February 3, 2014, the NMFS' ESA Interagency Cooperation Division received a request for formal consultation from the NMFS' Permits and Conservation Division. Information was sufficient to initiate consultation with the Permits and Conservation Division on this date.

On February 28, 2014, the NMFS' ESA Interagency Cooperation Division provided to the NSF a list of concerns found in its Environmental Assessment and suggestions for improvement.

On March 17, 2014, the NMFS' Permits and Conservation Division sent the application for the proposed seismic survey out to reviewers and published a notice in the *Federal Register* soliciting public comment on their intent to issue an IHA.

On April 19, 2014, the NSF provided an updated Environmental Assessment that addressed many of the concerns expressed on February 28. Remaining issues pertinent to assessing the effects of the action were resolved during other dates of the consultation.

On April 28, 2014, the NSF and NMFS' ESA Interagency Cooperation Division agreed to extend the consultation period to June 17, 2014.

2 DESCRIPTION OF THE PROPOSED ACTIONS

The NSF proposes to allow the use of its research vessel, *Marcus G. Langseth* (*Langseth*), which is operated by the Lamont-Doherty Earth Observatory (L-DEO), to conduct a seismic survey off the coast of New Jersey during an approximate 30 day period in late June to mid-August, 2014 in support of an NSF-funded collaborative research project led by Rutgers University. An array of four or eight airguns will be deployed as an energy source. In addition, a multibeam echosounder, a sub-bottom profiler, and an acoustic Doppler current profiler (ADCP) will continuously operate from the *Langseth*, except during transit to the survey site. A system of three kilometer-long hydrophone streamers will also be deployed. NMFS' Permits and Conservation Division proposes to issue an IHA for Level B harassment (behavioral disturbance) of marine mammals that would occur incidental to these studies, pursuant to Section 101(a)(5)(D) of the Marine Mammal Protection Act (MMPA), 16 U.S.C. §1371 (a)(5)(D).

The purpose of the proposed activities 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 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 will be imaged using 3-D seismic data and will enable follow-on studies to identify the magnitude, time, and impact of major changes in sea level. The proposed seismic survey will collect data in support of a research proposal that was 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.

2.1 Schedule

The NSF proposes to allow the use of the Langseth by L-DEO roughly 30 days of seismic operations and an additional seven days of non-airgun operations. Some minor deviation from the proposed dates is possible, depending on logistics, weather conditions, and the need to repeat some lines if data quality is substandard. During an approximate 30-day period in late-June to mid-August 2014, corresponding to an effective IHA, the *Langseth* would survey the action area (Figure 1). The *Langseth* would depart from and return to Newark, New Jersey. Therefore, NMFS' Permits and Conservation Division proposes to issue an authorization that is effective from June 26, 2014 to August 17, 2014.

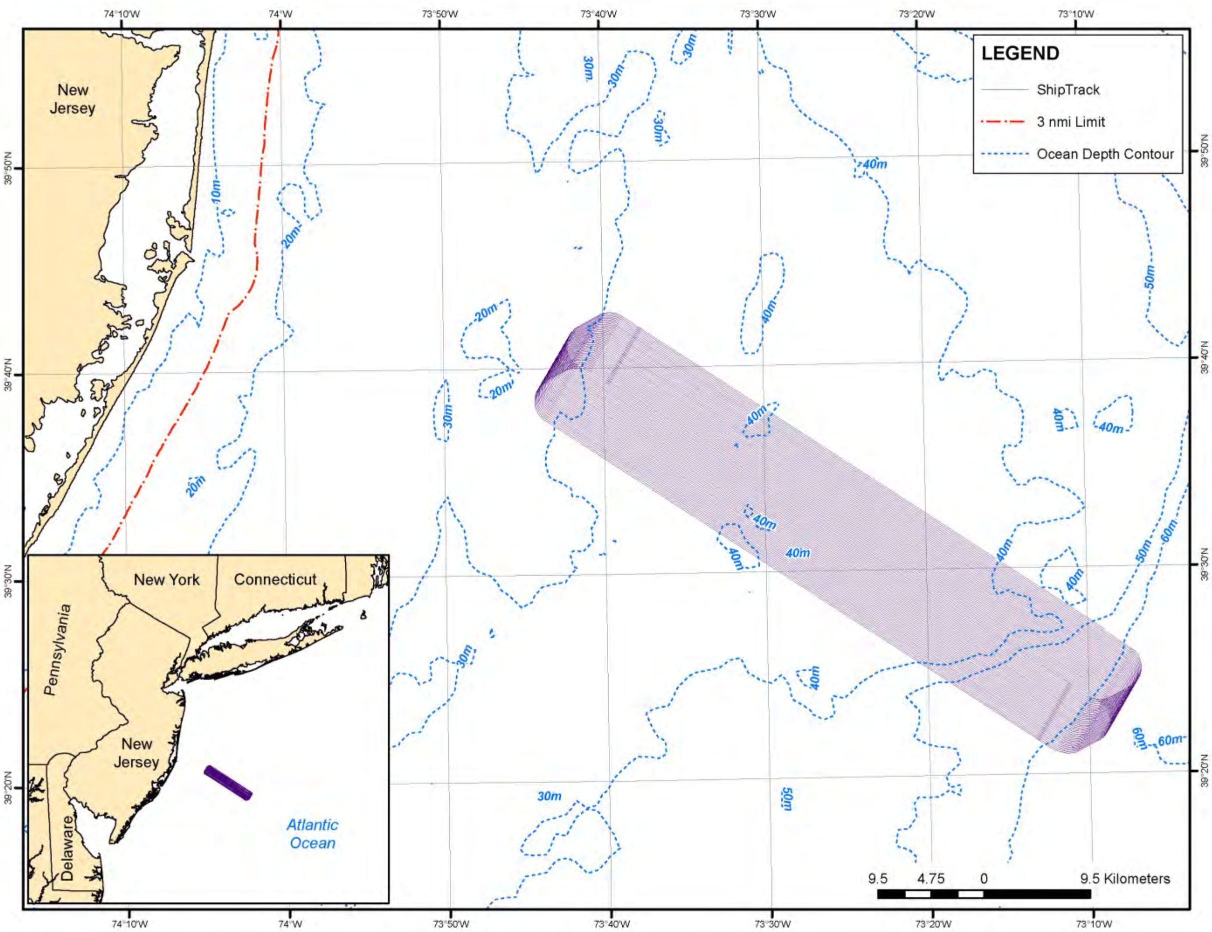

Figure 1. Proposed area for the marine seismic survey off New Jersey.

2.2 Source Vessel Specifications

The *Langseth* will tow a 40-airgun array along predetermined lines (see Figure 1). The *Langseth's* design is that of a seismic research vessel, with a particularly quiet propulsion system to avoid interference with the seismic signals. The operating speed during seismic acquisition is typically 8.3 km/h (4.4 knots). When not towing seismic survey gear, the *Langseth* typically cruises at 18.5 km/h (10 knots).

The *Langseth* will also serve as the platform from which protected species visual observers (PSVOs) would watch for animals. Although the airgun array will operate during straight-line and early turn portions of the transects, only a mitigation gun will operate during most of the turns and entries into straight-line transects.

A chase vessel will also be used in support of the project. Although the exact vessel is uncertain, it is described in the NSF's Environmental Assessment prepared under the National Environmental Policy Act, as resembling an offshore utility vessel of roughly 28 m in length, 2.6 m in draft, and twin screws of 450 horsepower each.

2.3 Airgun Description

The airgun array will consist of 40 airguns, with a total volume of approximately 6,600 in^3. However, most of these airguns will not be operational and total discharge volume will be limited to 700 or 1,400 in^3. The airgun configuration includes four identical linear arrays or “strings” (Figure 2). Each string will have ten airguns. Eight airguns in two strings (four in each string) or four airguns in one string would fire at any one time. The four airgun strings will be towed approximately 150 m behind the vessel. The tow depth of the array will be 4.5-6 m. The airgun array will fire roughly every five seconds. During firing, a brief (approximately 0.1 s) pulse of sound will be emitted, but be silent during the intervening periods. This signal attenuates as it moves away from the source, decreasing in amplitude, but also increasing in signal duration. Airguns will operate continually during the survey period except for unscheduled shutdowns.

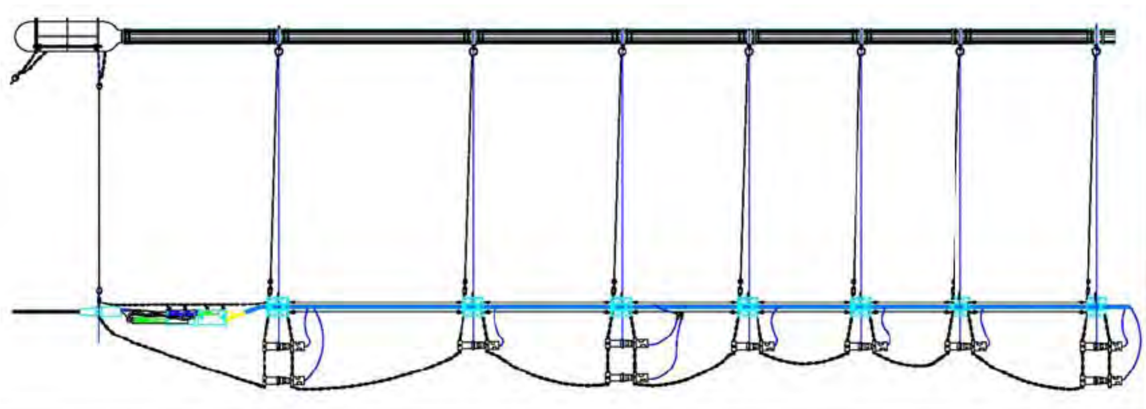

Figure 2. One linear airgun array or string with ten airguns.

Four- and eight-airgun array specifications

• Energy source	4 to 8-1,950 psi bolt airguns of 120-220 in^3 each, in four strings of nine operating airguns per string
• Source output (downward)-4 airgun array	0-pk is 240.4 dB re 1 μPa·m; pk-pk is 246.3-246.7 dB re 1 μPa·m
• Source output (downward)-8 airgun array	0-pk is 246.4-246.5 dB re 1 μPa·m; pk-pk is 252.5-252.8 dB re 1 μPa·m
• Air discharge volume	~700-1,400 in^3
• Dominant frequency components	0–188 Hz

Because the actual source originates from 4-8 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 will be substantially lower than the nominal source level applicable to downward propagation because of the directional nature of the sound from the airgun array.

2.4 Multibeam Echosounder, Sub-bottom Profiler, and Acoustic Doppler Current Profiler (ADCP)

Along with airgun operations, three additional acoustical data acquisition systems will operate during the survey from the *Langseth*. The multibeam echosounder and sub-bottom profiler systems will map the ocean floor during the survey and the ADCP will map currents. These sound sources will operate from the *Langseth* simultaneously with the airgun array.

The multibeam echosounder is a hull-mounted system operating at 10.5-13 kHz. The beamwidth is 1 or 2° fore–aft and 150° perpendicular to the ship's line of travel. The maximum source level is 242 dB re 1 μPa·m_{rms}. For deepwater operation, each "ping" consists of eight successive fan-shaped transmissions, each 2 to 15 ms in duration and each ensonifying a sector that extends 1° fore–aft. The eight successive transmissions span an overall cross-track angular extent of about 150°, with 2 ms gaps between the pulses for successive sectors (Maritime 2005).

The sub-bottom profiler provides information about the sedimentary features and the bottom topography that is being mapped simultaneously by the multibeam echosounder. The output varies with water depth from 50 watts in shallow water to 1,000 (204 dB) watts in deep water. The pulse interval is 1 s, but a common mode of operation is to broadcast five pulses at 1-s intervals followed by a 5-s pause.

Langseth sub-bottom profiler specifications

• Maximum/normal source output (downward)	204 dB re 1 μPa·m; 800 watts
• Dominant frequency component	3.5 kHz
• Bandwidth	1.0 kHz with pulse duration 4 ms 0.5 kHz with pulse duration 2 ms 0.25 kHz with pulse duration 1 ms
• Nominal beam width	30º
• Pulse duration	1, 2, or 4 ms

The ADCP is a Teledyne OS75 operating at 75 kHz with a beam width of 30° (total of four beams). The EA suggests that the maximum source level for this device is 224 dB re 1μPam.

2.5 Proposed Exclusion Zones

The L-DEO will implement exclusion zones (EZs) around the *Langseth* to minimize any potential adverse effects of airgun sound on MMPA and ESA-listed species. These zones are areas where seismic airguns would be powered down or shut down to reduce exposure of marine mammals and sea turtles to sound levels expected to produce potential fitness consequences. These EZs are based upon modeled sound levels at various distances from the *Langseth*, described below.

Predicted Sound Levels vs. Distance and Depth. The L-DEO has predicted received sound levels in deep water (free-field model), in relation to distance and direction from 4-airgun and 8-airgun arrays (Figure 3) as well as a 40-in^3 single 1900LLX airgun used during power-downs (Figure 4). In shallow water, empirical data concerning 180 and 160 dB re 1 μPa_{rms} distances were acquired during the acoustic calibration study of the *Langseth*'s 18-airgun 3,300in^3 array in the Gulf of Mexico (Diebold et al. 2010). However, the array configuration and tow depth were different in the Gulf of Mexico calibration study (3,300in^3, 6 m tow depth) than in the proposed survey (700 or 1,400in^3, 4.5 or 6 m tow depth). To adapt the shallow-water measurements obtained during the calibration survey to the proposed array configuration(s) and tow depth(s), scaling factors have been applied to the distances reported by Diebold et al. (2009) for shallow waters, and this scaling is done according to the SEL contours obtained from the free-field modeling. Figures 3-7 show predicted distances of the various configurations of the airguns.

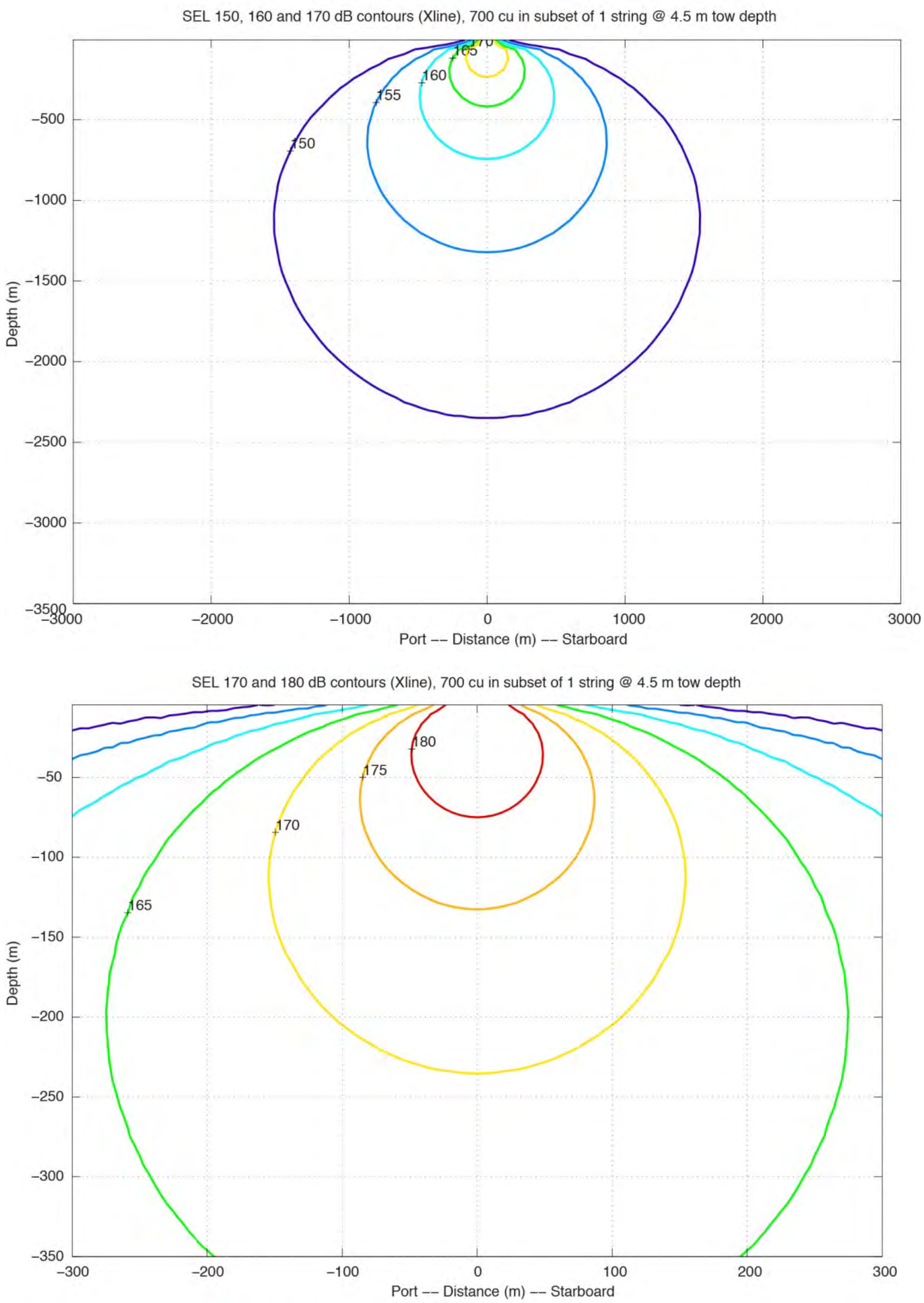

Figure 3. Modelled distances for the four-airgun array at 4.5 meter tow depth in deep water.

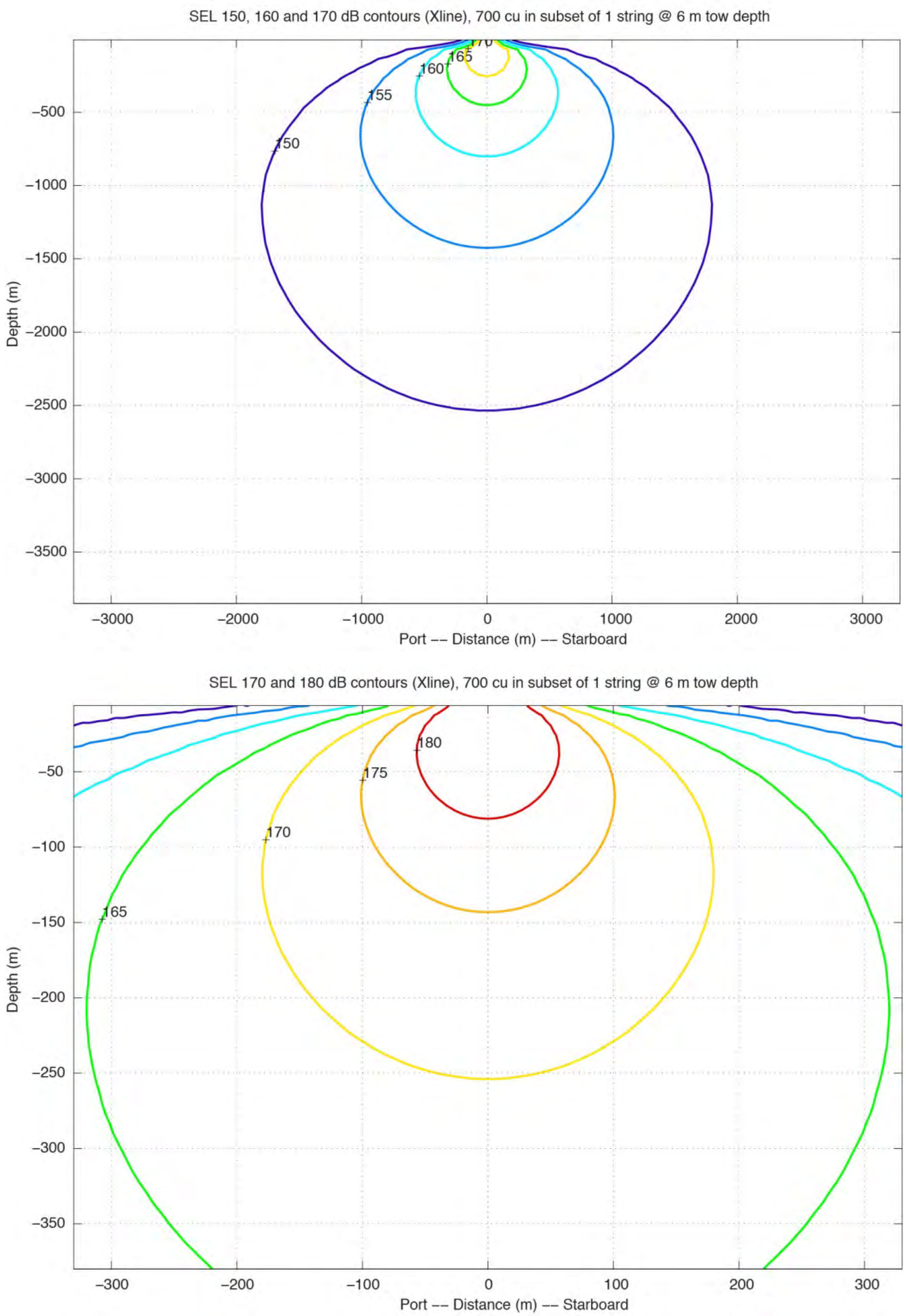

Figure 4. Modelled distances for the four-airgun array at six meter tow depth in deep water.

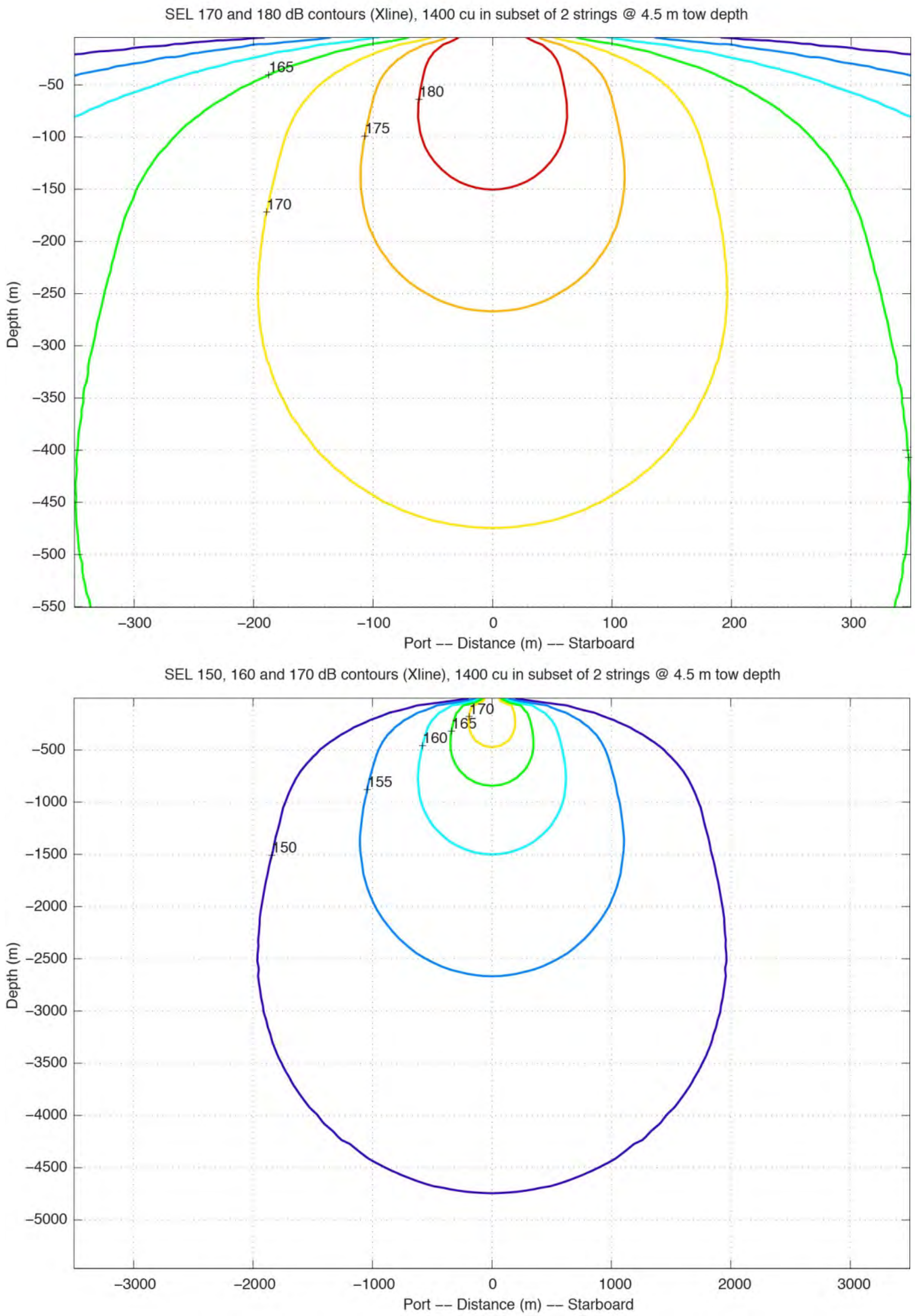

Figure 5. Modelled distances for the eight-airgun array at 4.5 meter tow depth in deep water.

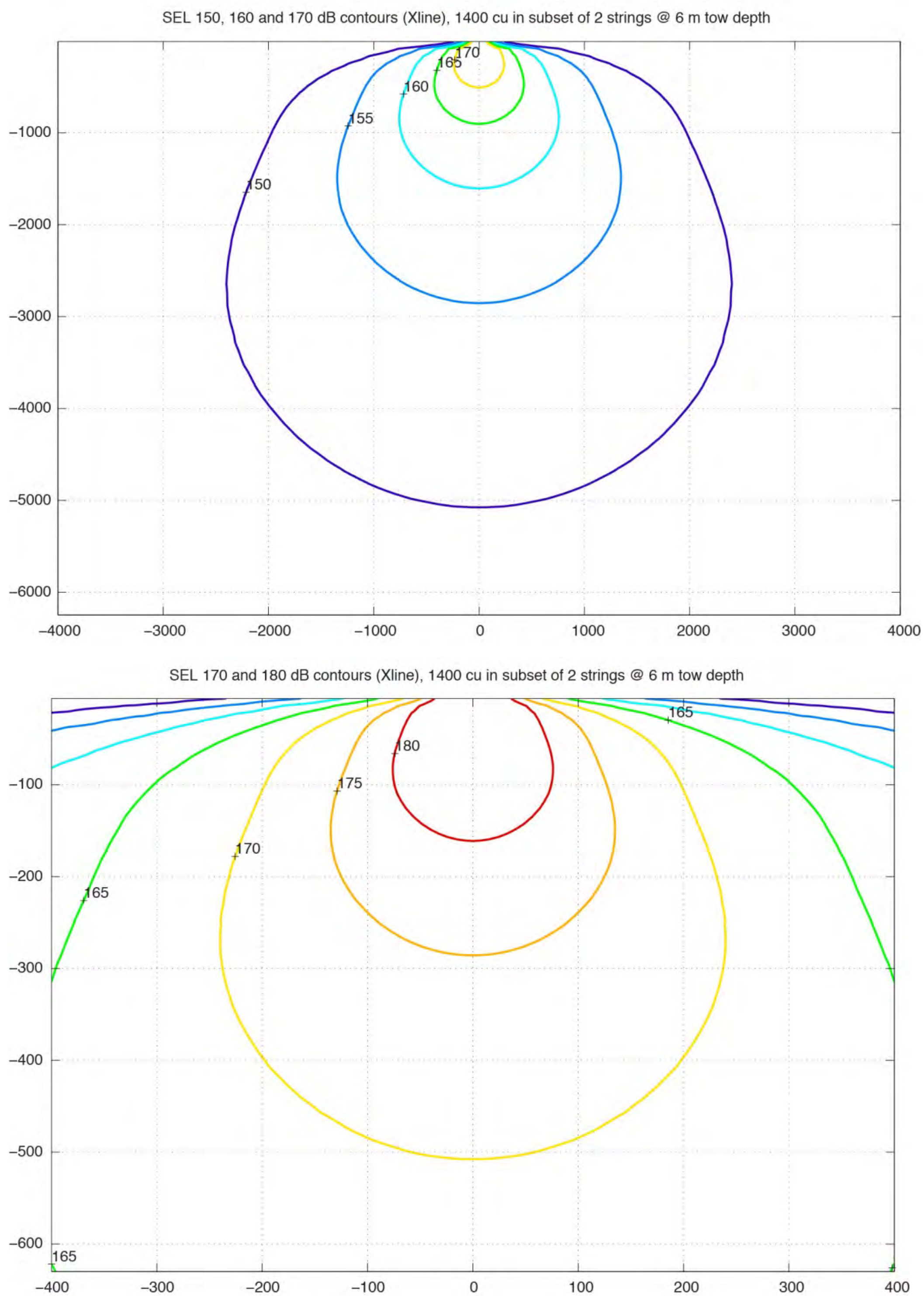

Figure 6. Modelled distances for the eight-airgun array at six meter tow depth in deep water.

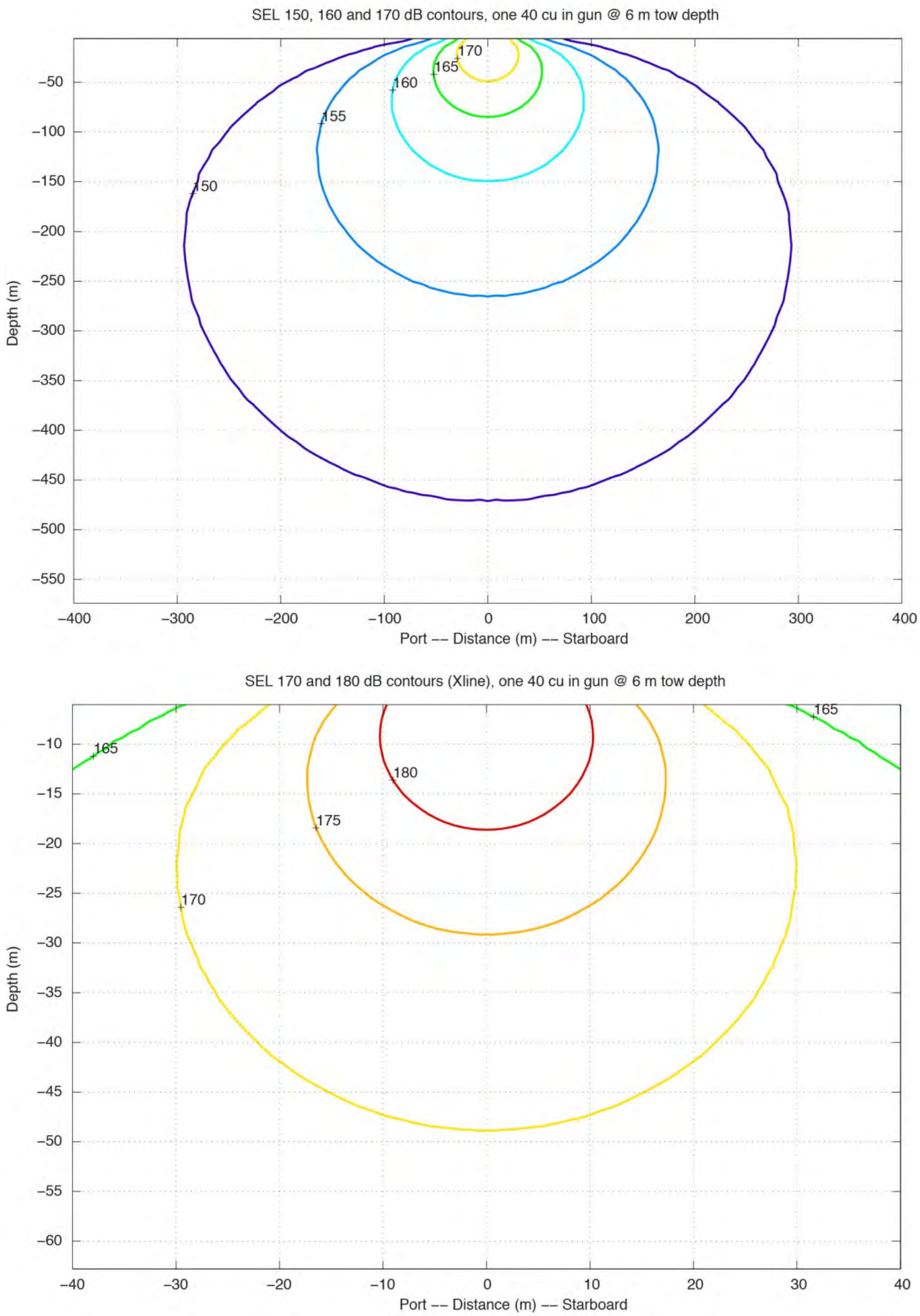

Figure 7. Modelled distances for the 40 in^3 mitigation gun at six meter tow depth in deep water.

Table 1 shows the distances at which four rms (root mean squared) sound levels are expected to be received from the 4- and 8-airgun arrays and a single airgun. The 180 dB re 1 μPa_{rms} distance is the safety criteria as specified by NMFS (1995) as applicable to cetaceans under the MMPA. The 180 dB distance will be doubled (to encompass the 177 dB isopleth) for this cruise per IHA requirements, which will then be used as the exclusion zone (EZ) for marine mammals, as required by NMFS during most other recent L-DEO seismic projects (Holst and Beland 2008; Holst and Smultea 2008b; Holst et al. 2005a; Holt 2008; Smultea et al. 2004). The 177 dB isopleth would also be the EZ boundary for sea turtles. The 166 dB isopleth represents our best understanding of the threshold at which sea turtles exhibit behavioral responses to seismic airguns. The 160 dB re 1 μPa_{rms} distance is the distance at which MMPA take, by Level B harassment, is expected to occur.

Table 1. Predicted distances to which sound levels of 180, 166, and 160 dB re 1 μPa_{rms} could be received from the 4- and 8- airgun arrays as well as the 40 in^3 airgun in water depths under 100 m.

Source, volume, and tow depth	Predicted RMS radii (m)		
	180 dB	166 dB	160 dB
4-airgun array 700 in^3 @ 4.5 m	378	2,229	5,240
4-airgun array 700 in^3 @ 6 m	439	2,599	6,100
8-airgun array 1,400 in^3 @ 4.5 m	478	2,844	6,670
8-airgun array 1,400 in^3 @ 6 m	585	3,471	8,150
Single Bolt airgun, 40 in^3 @ 6 m	100	424	995

3 INCIDENTAL HARASSMENT AUTHORIZATION

The NMFS' Permits and Conservation Division is proposing to issue an IHA authorizing non-lethal "takes" by Level B harassment of marine mammals incidental to the planned seismic survey. The IHA will be valid from June 30, 2014 through August 17, 2014, and will authorize the incidental harassment of the following endangered species (among other species): blue whales (*Balaenoptera musculus*), fin whales (*Balaenoptera physalus*), sei whales (*Balaenoptera borealis*), humpback whales (*Megaptera novaeangliae*), North Atlantic right whale (*Eubalaena glacialis*), sperm whales (*Physeter macrocephalus*), and other non-listed marine mammals. The proposed IHA identifies the following requirements that L-DEO must comply with as part of its authorization.

A. Establish a safety radius corresponding to the anticipated 177-dB isopleth for full (1,400 or 700 in^3) and single (40 in^3) airgun operations.

B. Use two, NMFS-approved, vessel-based PSVOs to watch for and monitor marine mammals near the seismic source vessel during daytime airgun operations, start-ups of airguns at night, and while the seismic array and streamers are being deployed and retrieved. Vessel crew will also assist in detecting marine mammals, when practical. Observers will have access to reticle binoculars (7 X 50 Fujinon), and big-eye binoculars (25 X 150). PSVOs shifts will last no longer than 4 hours at a time. PSVOs will also observe during daytime periods when the seismic system is not operating for comparisons of animal abundance and behavior, when feasible.

C. Record the following information when a marine mammal is sighted:

i. Species, group size, age/size/sex categories (if determinable), behavior when first sighted and after initial sighting, heading (if consistent), bearing and distance from seismic vessel, sighting cue, apparent reaction to the airguns or vessel (e.g., none, avoidance, approach, paralleling, etc., and including responses to ramp-up), and behavioral pace.

ii. Time, location, heading, speed, activity of the vessel (including number of airguns operating and whether in state of ramp-up or power-down), Beaufort sea state and wind force, visibility, cloud cover, and sun glare.

iii. The data listed under ii. would also be recorded at the start and end of each observation watch and during a watch whenever there is a change in one or more of the variables.

D. Visually observe the entire extent of the safety radius using PSVOs, for at least 30 min prior to starting the airgun (day or night). If PSVOs find a marine mammal within the safety zone, L-DEO must delay the seismic survey until the marine mammal has left the area. If the PSVO sees a marine mammal that surfaces, then dives below the surface, the observer shall wait 30 minutes. If the PSVO sees no marine mammals during that time, they should assume that the animal has moved beyond the safety zone. If for any reason the entire radius cannot be seen for the entire 30 min (e.g. rough seas, fog, darkness), or if marine mammals are near, approaching or in the safety radius, the airguns may not be started up. If one airgun is already running at a source level of at least 177 dB, L-DEO may start subsequent guns without observing the entire safety radius for 30 min prior, provided no marine mammals are known to be near the safety radius. While it is considered unlikely, in the event a North Atlantic right whale (*Eubalaena glacialis*) is visually sighted, the airgun array will be shut-down regardless of the distance of the animal(s) to the sound source. The array will not resume firing until 30 min after the last documented whale visual sighting.

E. Use the passive acoustic monitoring system (PAM) to detect marine mammals around the *Langseth* during all airgun operations and during most periods when airguns are not operating. One PSVO and/or bioacoustician will monitor the PAM at all times in shifts of 1-6 h. A bioacoustician shall design and set up the PAM system and be present to operate or oversee PAM, and available when technical issues occur during the survey.

F. Record the following when an animal is detected by the PAM:

i. Contact the PSVO immediately (and initiate power or shut-down, if required);

ii. Enter the information regarding the vocalization into a database. The data to be entered include an acoustic encounter identification number, whether it was linked with a visual sighting, date, time when first and last heard and whenever any additional information was recorded, position and water depth when first detected, bearing if determinable, species or species group, types and nature of sounds heard (e.g., clicks, continuous, sporadic, whistles, creaks, burst pulses, strength of signal, etc.), and any other notable information.

G. Apply a "ramp-up" procedure when starting up at the beginning of seismic operations or any time after the entire array has been shut down for more than 8 min, which means start the smallest gun first and add airguns in a sequence such that the source level of the array will increase in steps not exceeding approximately 6 dB per 5-min period. During ramp-up, the PSVOs will monitor the safety radius, and if marine mammals are sighted, a course/speed alteration, power-down, or shut-down will occur as though the full array were operational.

H. Alter speed or course during seismic operations if a marine mammal, based on its position and relative motion, appears likely to enter the safety zone. If speed or course alteration is not safe or practical, or if after alteration the marine mammal still appears likely to enter the safety zone, further mitigation measures, such as power-down or shut-down, will be taken.

I. Shut-down or power-down the airguns upon marine mammal detection within, approaching, or entering the safety radius. A power-down means shutting down one or more airguns and reducing the safety radius to the degree that the animal is outside of it. Following a power-down, if the marine mammal approaches the smaller designated safety radius, the airguns must completely shut down. Airgun activity will not resume until the marine mammal has cleared the safety radius, which means it was visually observed to have left the safety radius, or has not been seen within the radius for 15 min (small odontocetes) or 30 min (mysticetes and large odontocetes). The array will not resume firing until 30 min after the last documented whale visual sighting. The *Langseth* may operate a small-volume airgun (*i.e.*, mitigation airgun) during turns and maintenance at approximately one shot per minute. During turns or brief transits between seismic tracklines, one airgun would continue to operate.

J. To the maximum extent practicable, schedule seismic operations (i.e., shooting airguns) during daylight hours. Marine seismic operations may continue into night and low-light hours if such segment(s) of the survey is initiated when the entire relevant exclusion zones are visible and can be effectively monitored. No initiation of airgun array operations is permitted from a shut-down position at night or during low-light hours (such as in dense fog or heavy rain) when the entire relevant exclusion zone cannot be effectively monitored by the PSVO(s) on duty.

K. In the unanticipated event that any taking of a marine mammal in a manner prohibited by the proposed Authorization occurs, such as an injury, serious injury or mortality, and is judged to result from these activities, L-DEO will immediately cease operating all authorized sound sources and report the incident to the Chief of the Permits and Conservation Division, Office of Protected Resources, NMFS, at 301-427-8401. L-DEO will postpone the research activities until NMFS is able to review the circumstances of the take. NMFS will work with L-DEO to determine whether modifications in the activities are appropriate and necessary, and notify L-DEO that they may resume the seismic survey operations.

L. In the unanticipated event that any cases of marine mammal injury or mortality are judged to result from these activities (*e.g.*, ship-strike, gear interaction, and/or entanglement), L-DEO will cease operating seismic airguns and report the incident to NMFS' Office of Protected Resources at 301-427-8401 immediately. Airgun operation will then be postponed until NMFS is able to review the circumstances and work with L-DEO to determine whether modifications in the activities are appropriate and necessary. If the lead observer judged that the injury or mortality is not a result of the authorized activities, operations may continue.

M. L-DEO is required to comply with the Terms and Conditions of this Opinion's Incidental Take Statement issued to both the NSF and the NMFS' Office of Protected Resources.

In addition, the proposed IHA requires L-DEO to adhere to the following reporting requirements:

A. The Holder of this Authorization is required to submit a report on all activities and monitoring results to the Office of Protected Resources, NMFS, within 90 days after the expiration of the IHA. This report must contain and summarize the following information:

i. Dates, times, locations, heading, speed, weather, and associated activities during all seismic operations.

ii. Species, number, location, distance from the vessel, and behavior of any marine mammals, as well as associated seismic activity (number of power-downs and shutdowns), observed throughout all monitoring activities.

iii. An estimate of the number (by species) of marine mammals that:

a. Are known to have been exposed to the seismic activity (visual observation) at received levels greater than or equal to 160 dB re 1 microPa (rms) and/or 177 dB re 1 microPa (rms) for cetaceans with a discussion of any specific behaviors those individuals exhibited.

b. May have been exposed (modeling results) to the seismic activity at received levels greater than or equal to 160 dB re 1 microPa (rms) and/or 177 dB re 1 microPa (rms) with a discussion of the nature of the probable consequences of that exposure on the individuals that have been exposed.

iv. A description of the implementation and effectiveness of the:

a. Terms and conditions of the Opinion's Incidental Take Statement.

b. Mitigation measures of the IHA. For the Opinion, the report will confirm the implementation of each term and condition and describe the effectiveness, as well as any conservation measures, for minimizing the adverse effects of the action on listed whales.

4 APPROACH TO THE ASSESSMENT

The NMFS approaches its Section 7 analyses of agency actions through a series of steps. The first step identifies those aspects of proposed actions that are likely to have direct and indirect physical, chemical, and biotic effects on listed species or on the physical, chemical, and biotic environment of an action area. As part of this step, we identify the spatial extent of these direct and indirect effects, including changes in that spatial extent over time. The result of this step includes defining the *action area* for the consultation. The second step of our analyses identifies the listed resources that are likely to co-occur with these effects in space and time and the nature of that co-occurrence (these represent our *Exposure Analyses*). In this step of our analyses, we try to identify the number, age (or life stage), and gender of the individuals that are likely to be exposed to an action's effects and the populations or subpopulations those individuals represent. Once we identify which listed resources are likely to be exposed to an action's effects and the nature of that exposure, we examine the scientific and commercial data available to determine whether and how those listed resources are likely to respond given their exposure (these represent our *response analyses*).

The final steps of our analyses – establishing the risks those responses pose to listed resources – are different for listed species and designated critical habitat (these represent our *Risk Analyses*). Our jeopardy determinations must be based on an action's effects on the continued existence of threatened or endangered species as those "species" have been listed, which can include true biological species, subspecies, or distinct population segments of vertebrate species. The continued existence of these "species" depends on the fate of the populations that comprise them. Similarly, the continued existence of populations are determined by the fate of the individuals that comprise them – populations grow or decline as the individuals that comprise the population live, die, grow, mature, migrate, and reproduce (or fail to do so).

Our risk analyses reflect these relationships between listed species, the populations that comprise that species, and the individuals that comprise those populations. Our risk analyses begin by identifying the probable risks actions pose to listed individuals that are likely to be exposed to an action's effects. Our analyses then integrate those individual risks to identify consequences to the populations those individuals represent. Our analyses conclude by determining the consequences of those population-level risks to the species those populations comprise.

We measure risks to listed individuals using the individuals' "fitness," or the individual's growth, survival, annual reproductive success, and lifetime reproductive success. In particular, we examine the scientific and commercial data available to determine if an individual's probable lethal, sub-lethal, or behavioral responses to an action's effect on the environment (which we identify during our response analyses) are likely to have consequences for the individual's fitness.

When an individual is expected to experience reductions in fitness in response to an action's effects, those fitness reductions may reduce the abundance, reproduction, or growth rates (or increase the variance in these measures) of the populations those individuals represent (see Stearns 1992). Reductions in at least one of these variables (or one of the variables we derive from them) is a *necessary* condition for reductions in a population's viability, which is itself a *necessary* condition for reductions in a species' viability. As a result, when listed plants or animals exposed to an action's effects are *not* expected to experience reductions in fitness, we would not expect the action to have adverse consequences on the viability of the populations those individuals represent or the species those populations comprise (e.g., Anderson 2000; Brandon 1978; Mills and Beatty 1979; Stearns 1992). As a result, if we conclude that listed plants or animals are *not* likely to experience reductions in their fitness, we would conclude our assessment.

Although reductions in fitness of individuals is a *necessary* condition for reductions in a population's viability, reducing the fitness of individuals in a population is not always *sufficient* to reduce the viability of the population(s) those individuals represent. Therefore, if we conclude that listed plants or animals are likely to experience reductions in their fitness, we determine whether those fitness reductions are likely to reduce the viability of the populations the individuals represent (measured using changes in the populations' abundance, reproduction, spatial structure and connectivity, growth rates, variance in these measures, or measures of extinction risk). In this step of our analyses, we use the population's base condition (established in the *Environmental Baseline* and *Status of Listed Resources* sections of this Opinion) as our point of reference. If we conclude that reductions in individual fitness are not likely to reduce the viability of the populations those individuals represent, we would conclude our assessment.

Reducing the viability of a population is not always *sufficient* to reduce the viability of the species those populations comprise. Therefore, in the final step of our analyses, we determine if reductions in a population's viability are likely to reduce the viability of the species those populations comprise using changes in a species' reproduction, numbers, distribution, estimates of extinction risk, or probability of being conserved. In this step of our analyses, we use the species' status (established in the *Status of Listed Resources* section of this Opinion) as our point of reference. Our final determinations are based on whether threatened or endangered species are likely to experience reductions in their viability and whether such reductions are likely to be appreciable.

To conduct these analyses, we rely on all of the best scientific and commercial evidence available to us. This evidence consists of the environmental assessment submitted by the NSF, monitoring reports submitted by past and present seismic survey operators, reports from NMFS Science Centers; reports prepared by natural resource agencies in states and other countries, reports from non-governmental organizations involved in marine conservation issues, the information provided by NMFS' Permits and Conservation Division when it initiates formal consultation, the general scientific literature, and our expert opinion.

We supplement this evidence with reports and other documents – environmental assessments, environmental impact statements, and monitoring reports – prepared by other federal and state agencies like the Bureau of Ocean Energy Management, U.S. Coast Guard, and U.S. Navy whose operations extend into the marine environment.

During the consultation, we conducted electronic searches of the general scientific literature using search engines, including Agricola, Ingenta Connect, Aquatic Sciences and Fisheries Abstracts, JSTOR, Conference Papers Index, First Search (Article First, ECO, WorldCat), Web of Science, Oceanic Abstracts, Google Scholar, and Science Direct. We also referred to an internal electronic library that represents a major repository on the biology of ESA-listed species under the NMFS' jurisdiction.

We supplemented these searches with electronic searches of doctoral dissertations and master's theses. These searches specifically tried to identify data or other information that supports a particular conclusion (for example, a study that suggests whales will exhibit a particular response to acoustic exposure or close vessel approach) as well as data that do not support that conclusion. When data are equivocal or when faced with substantial uncertainty, our decisions are designed to avoid the risks of incorrectly concluding that an action would not have an adverse effect on listed species when, in fact, such adverse effects are likely (i.e., Type II error).

In this particular assessment, we identified the stressors associated with the action and determined which had a significant possibility of occurring based upon previous seismic surveys. Of the probable stressors, we identified the species that are expected to co-occur with the effects of the action, particularly the acoustic isopleths of the airgun and other sound sources. Utilizing survey data from previous years and predictive environmental factors, density estimates per unit area of listed whales were multiplied by the area to be ensonified where effects were expected.

In the process of this assessment, we were required to make several assumptions where data were insufficient to support conclusions regarding the specific species and actions at hand. These included:

- Baleen whales can generally hear low-frequency sound (Southall et al. 2007a) better than high frequencies (Southall et al. 2007a), as the former is primarily the range in which they vocalize. Humpback whales frequently vocalize with mid-frequency sound (Southall et al. 2007a) and are likely to hear at these frequencies as well. Because of this, we can partition baleen whales into two groups: those that are specialists at hearing low frequencies (e.g.: blue, fin, and sei whales) and those that hear at low- to mid-frequencies (humpback whales). Toothed whales (such as sperm whales) are better adapted to hear mid- and high-frequency sound for the same reason (although this species also responds to low-frequency sound and is considered to hear at low-, mid-, and high frequencies; i.e. vocalization, as is assumed for baleen whales). Sperm whales are also assumed to have similar hearing qualities as other, better studied, toothed whales. Hearing in sea turtles is generally similar within the taxa, with data from loggerhead and green sea turtles being representative of the taxa as a whole.

- Species for which little or no information on response to sound will respond similarly to their close taxonomic or ecological relatives (i.e., baleen whales respond similarly to each other; same for sea turtles).

5 ACTION AREA

The seismic survey is proposed to be conducted off the New Jersey coast, outside of state waters, and within the Exclusive Economic Zone of the U.S. The region in which the seismic survey will occur is between 39.3° and 39.7° N and 73.2° and 73.8° W (see Figure 1). The region encompasses water depths from 30-75 m along roughly 3,920 km of trackline, including turns and other seismic operations. In addition, the applicant estimated a 25% increase in trackline due to equipment failures, a need to reshoot some areas, and other logistical impacts, increasing the expected trackline to 4,900 km. Responses to seismic sound sources by listed marine mammals occur within the 160 dB isopleths (modeled to be up to 8.150 km from the *Langseth*), increasing the area ensonified along the trackline, excluding overlapping areas but including 25% increase due to contingencies, to 65 km^2. Responses to seismic sound sources by listed sea turtles occur within the 166 dB isopleths (modeled to be up to 3.471 km from the *Langseth*), increasing the area ensonified along the trackline, excluding overlapping areas but including 25% increase due to contingencies, to 28 km^2. The transect lines are very close to one another, meaning that many areas will be re-ensonified at high levels multiple times. This expands the action area beyond the seismic survey track lines to an ensonified region of roughly 2,502 km^2 within the 160 dB re 1 μPa_{rms} isopleth (1,066 km^2 within the 166 dB re 1 μPa_{rms}). We also assessed the transit to and from port for potential effects.

6 STATUS OF LISTED RESOURCES

The actions considered in this Opinion may affect species listed in Table 2, which are provided protection under the ESA.

Table 2. Listed species in the action area that may experience adverse effects as a result of the proposed actions.

Common Name	*Scientific Name*	*Status*
Cetaceans		
Blue whale	*Balaenoptera musculus*	Endangered
Fin whale	*Balaenoptera physalus*	Endangered
Humpback whale	*Megaptera novaeangliae*	Endangered
North Atlantic right whale	*Eubalaena glacialis*	Endangered
Sei whale	*Balaenoptera borealis*	Endangered

Sperm whale	*Physeter macrocephalus*	Endangered
Marine Turtles		
Green sea turtle	*Chelonia mydas*	Threatened
Hawksbill sea turtle	*Eretmochelys imbricata*	Endangered
Kemp's ridley sea turtle	*Lepidochelys kempii*	Endangered
Leatherback sea turtle	*Dermochelys coriacea*	Endangered
Loggerhead sea turtle – Northeast Atlantic DPS	*Caretta caretta*	Endangered

Although the area in which the seismic survey is proposed to occur is relatively close to shore, we do not believe that listed sturgeons are likely to be present in the action area. Both Atlantic and shortnose sturgeon occur in nearshore marine waters along the mid-Atlantic, but tagging studies have not found them to occur as far offshore as the proposed action area. We also do not expect Atlantic salmon to occur in the action area during the seismic survey. Thus, NMFS does not anticipate that the proposed seismic survey would incidentally take any listed sturgeons or Atlantic salmon. The biology and ecology of species with anticipated exposure below informs the effects analysis for this Opinion. Summaries of the global status and trends of each species presented provide a foundation for the analysis of species as a whole.

6.1 Blue whale

Subspecies. Several blue whale subspecies have been characterized from morphological and geographical variability, but the validity of blue whale subspecies designations remains uncertain (McDonald et al. 2006). The largest, the Antarctic or true blue whale (*Balaenoptera musculus intermedia*), occurs in the highest Southern Hemisphere latitudes (Gilpatrick and Perryman. 2009). During austral summers, "true" blue whales occur close to Antarctic ice. A slightly smaller blue whale, *B. musculus musculus*, inhabits the Northern Hemisphere (Gilpatrick and Perryman. 2009). The pygmy blue whale (*B. musculus brevicauda*), may be geographically distinct from *B. m. musculus* (Kato et al. 1995). Pygmy blue whales occur north of the Antarctic Convergence (60°-80° E and 66°-70° S), while true blue whales are found south of the Convergence (58° S) in the austral summer (Kasamatsu et al. 1996; Kato et al. 1995). A fourth subspecies, *B. musculus indica*, may exist in the northern Indian Ocean (McDonald et al. 2006), although these whales are frequently referred to as *B. m. brevicauda* (Anderson et al. 2012a). Inbreeding between *B. m. intermedia* and *B. m. brevicauda* does occur (Attard et al. 2012).

Population structure. Little is known about population and stock structure[1] of blue whales. Studies suggest a wide range of alternative population and stock scenarios based on movement, feeding, and acoustic data. Some suggest that as many as 10 global populations may exist, while other studies suggest that the species is composed of a single panmictic population (Gambell 1979; Gilpatrick and Perryman. 2009; Reeves et al. 1998). For management purposes, the International Whaling Commission (IWC) considers all Pacific blue whales to be a single stock, whereas under the MMPA, the NMFS recognizes four stocks of blue whales: western North Pacific Ocean, eastern North Pacific Ocean, Northern Indian Ocean, and Southern Hemisphere.

[1] "Populations" herein are a group of individual organisms that live in a given area and share a common genetic heritage. While genetic exchange may occur with neighboring populations, the rate of exchange is greater between individuals of the same population than among populations---a population is driven more by internal dynamics, birth and death processes, than by immigration or emigration of individuals. To differentiate populations, NMFS considers geographic distribution and spatial separation, life history, behavioral and morphological traits, as well as genetic differentiation, where it has been examined. In many cases, the behavioral and morphological differences may evolve and be detected before genetic variation occurs. In some cases, the term "stock" is synonymous with this definition of "population" while other usages of "stock" are not.

Until recently, blue whale population structure had not been tested using molecular or nuclear genetic analyses (Reeves et al. 1998). A recent study by Conway (2005) suggested that the global population could be divided into four major subdivisions, which roughly correspond to major ocean basins: eastern North and tropical Pacific Ocean, Southern Indian Ocean, Southern Ocean, and western North Atlantic Ocean. The eastern North/tropical Pacific Ocean subpopulation includes California, western Mexico, western Costa Rica, and Ecuador (Conway 2005). Genetic studies of blue whales occupying a foraging area south of Australia (most likely pygmy blue whales) have been found to belong to a single population (Attard et al. 2010). Herein, blue whales are treated as four distinct populations as outlined by Conway (2005).

North Atlantic. Blue whales are found from the Arctic to at least mid-latitude waters, and typically inhabit the open ocean with occasional occurrences in the U.S. Exclusive Economic Zone (EEZ) (Gagnon and Clark 1993; Wenzel et al. 1988; Yochem and Leatherwood 1985). Yochem and Leatherwood (1985) summarized records suggesting winter range extends south to Florida and the Gulf of Mexico. The U.S. Navy's Sound Surveillance System acoustic system has detected blue whales in much of the North Atlantic, including subtropical waters north of the West Indies and deep waters east of the U.S. Atlantic EEZ (Clark 1995). Blue whales are rare in the shelf waters of the eastern U.S. In the western North Atlantic, blue whales are most frequently sighted from the Gulf of St. Lawrence and eastern Nova Scotia and in waters off Newfoundland, during the winter (Sears et al. 1987). In the eastern North Atlantic, blue whales have been observed off the Azores, although Reiner et al. (1993) did not consider them common in that area. Observations of feeding have recently occurred over Ireland's western continental slope (Wall et al. 2009). No sightings have been made in the action area, although scattered rare sightings in the general region are documented (NSF 2014).

North Pacific. Blue whales occur widely throughout the North Pacific. Acoustic monitoring has recorded blue whales off Oahu and the Midway Islands, although sightings or strandings in Hawaiian waters have not been reported (Barlow et al. 1997a; Northrop et al. 1971; Thompson and Friedl 1982a). Nishiwaki (1966) notes blue whale occurrence among the Aleutian Islands and in the Gulf of Alaska, but until recently, no one has sighted a blue whale in Alaska, despite several surveys (Carretta et al. 2005; Forney and Brownell Jr. 1996; Leatherwood et al. 1982; Stewart et al. 1987), possibly supporting a return to historical migration patterns (Anonmyous. 2009a).

Blue whales are thought to summer in high latitudes and move into the subtropics and tropics during the winter (Yochem and Leatherwood 1985). Minimal data suggest whales in the western region of the North Pacific may summer southwest of Kamchatka, south of the Aleutians, and in the Gulf of Alaska, and winter in the lower latitudes of the western Pacific (Sea of Japan, the East China, Yellow, and Philippine Seas) and less frequently in the central Pacific, including Hawaii (Carretta et al. 2005; Stafford 2003; Stafford et al. 2001; Watkins et al. 2000), although this population is severely depleted or has been extirpated (Gilpatrick and Perryman. 2009). However, acoustic recordings made off Oahu showed bimodal peaks of blue whales, suggesting migration into the area during summer and winter (McDonald and Fox 1999; Thompson and Friedl 1982a).

Indian Ocean. Populations (based upon different call types) appear to segregate themselves into separate geographic areas within the Indian Ocean (Samaran et al. 2013). Blue whale sightings have occurred in the Gulf of Aden, Persian Gulf, Arabian Sea, and across the Bay of Bengal to Burma and the Strait of Malacca (Clapham et al. 1999; Mikhalev 1997;

Mizroch et al. 1984). Individuals appear to feed in the Arabian Sea off Somalia and the Arabian Peninsula during the monsoon season (May-October) when strong upwelling events affect the region (Anderson et al. 2012a). A secondary feeding area may also exist along the southwest coast of India and west coast of Sri Lanka (Anderson et al. 2012a). At other times of year, whales disperse within the Indian Ocean and exploit local, transient foraging opportunities, such as along the east coast of Sri Lanka, the waters west of the Maldives, the vicinity of the Indus Canyon, and the southern Indian Ocean (Anderson et al. 2012a). Some whales that feed off the east coast of Sri Lanka in the northeast monsoon may also feed in the Arabian Sea during the southwest monsoon, producing a migration past the Maldives and southern Sri Lanka eastwards during December–January, returning westwards in about April–May (Anderson et al. 2012a; Anderson et al. 2012b). Presence around Sri Lanka has been documented year-round (Ilangakoon and Sathasivam 2012).

Southern Hemisphere. Blue whales range from the edge of the Antarctic pack ice (40^{o}-78^{o} S) during the austral summer north to Ecuador, Brazil, South Africa, Australia, and New Zealand during the austral winter (Shirihai 2002). Occurrence in Antarctic waters appears to be highest during February-May as well as in November (Gedamke and Robinson 2010; Sirovic et al. 2009). Gedamke and Robinson (2010) found blue whales to be particularly numerous and/or vocal north of Prydz Bay, Antarctica based upon sonobuoy deployments. Pygmy blue whales were also frequently heard in Antarctic waters, further south than they had previously been documented (Gedamke and Robinson 2010). Other than a single vocal record in Atlantic waters off Angola, pygmy blue whales have been exclusively documented in the Indian Ocean or western Pacific (Cerchio et al. 2010a; Mccauley and Jenner 2010).

Age distribution. Blue whales may reach 70–80 years of age (COSEWIC 2002; Yochem and Leatherwood 1985).

Reproduction. Gestation takes 10-12 months, followed by a 6-7 month nursing period. Sexual maturity occurs at 5-15 years of age and calves are born at 2-3 year intervals (COSEWIC 2002; NMFS 1998b; Yochem and Leatherwood 1985). Recent data from illegal Russian whaling for Antarctic and pygmy blue whales support sexual maturity at 23 m and 19-20 m, respectively (Branch and Mikhalev 2008). The mean intercalving interval in the Gulf of California is roughly two and half years (Sears et al. 2014). Once mature, females return to the same areas where they were born to give birth themselves (Sears et al. 2014).

Movement. Satellite tagging indicates that, for blue whales tagged off Southern California, movement is more linear and faster (3.7 km/h) while traveling versus while foraging (1.7 km/h)(Bailey et al. 2009). Residency times in what are likely prey patches averages 21 days and constituted 29% of an individual's time overall, although foraging could apparently occur at any time of year for tagged individuals (Bailey et al. 2009). Broad scale movements also varied greatly, likely in response to oceanographic conditions influencing prey abundance and distribution (Bailey et al. 2009). Blue whales along Southern California were found to be traveling 85% of the time and milling 11% (Bacon et al. 2011). Blue whales are highly mobile, and their migratory patterns are not well known (Perry et al. 1999; Reeves et al. 2004). Blue whales migrate toward the warmer waters of the subtropics in fall to reduce energy costs, avoid ice entrapment, and reproduce (NMFS 1998a). In the eastern Central Atlantic, blue whales appear to migrate from areas along Greenland and Iceland to the Azores over and east of the Mid-Atlantic Ridge, apparently engaging in some random movement along the way (Anil et al. 2013).

Feeding. Data indicate that some summer feeding takes place at low latitudes in upwelling-modified waters, and that some whales remain year-round at either low or high latitudes (Clarke and Charif 1998b; Hucke-Gaete et al. 2004; Reilly and Thayer 1990; Yochem and Leatherwood 1985). Prey availability likely dictates blue whale distribution for most of the year (Burtenshaw et al. 2004; Clapham et al. 1999; Sears 2002 as cited in NMFS 2006a). The large size of blue whales requires higher energy requirements than smaller whales and potentially prohibits fasting Mate et al. (1999). Blue whales typically occur alone or in groups of up to five animals, although larger foraging aggregations of up to 50 have been reported including aggregations mixed with other rorquals such as fin whales (Corkeron et al. 1999; Shirihai 2002). While feeding, blue whales show slowed and less obvious avoidance behavior then when not feeding (Sears et al. 1983 as cited in NMFS 2005b).

Diving. Blue whales spend greater than 94% of their time underwater (Lagerquist et al. 2000). Generally, blue whales dive 5-20 times at 12-20 sec intervals before a deep dive of 3-30 min (Croll et al. 1999; Leatherwood et al. 1976; Mackintosh 1965; Maser et al. 1981; Strong 1990; Yochem and Leatherwood 1985). Average foraging dives are 140 m deep and last for 7.8 min (Croll et al. 2001). Non-foraging dives are shallower and shorter, averaging 68 m and 4.9 min (Croll et al. 2001). However, dives of up to 300 m are known (Calambokidis et al. 2003). Nighttime dives are generally shallower (50 m). Blue whales near Sri Lanka averaged 18 sec between breaths during surfacing dives, but went an average of 640 sec during deep dives (de Vos et al. 2013).

Blue whales occur singly or in groups of two or three (Aguayo 1974; Mackintosh 1965; Nemoto 1964; Pike and MacAskie 1969; Ruud 1956; Slijper 1962). However, larger foraging aggregations, even with other species such as fin whales, are regularly reported (Fiedler et al. 1998; Schoenherr 1991).

Vocalization and hearing. Blue whales produce prolonged low-frequency vocalizations that include moans in the range from 12.5-400 Hz, with dominant frequencies from 16-25 Hz, and songs that span frequencies from 16-60 Hz that last up to 36 sec repeated every 1 to 2 min (see Cummings and Thompson 1971; Cummings and Thompson 1977; Edds-Walton 1997a; Edds 1982; McDonald et al. 1995a; Thompson and Friedl 1982b). Berchok et al. (2006) examined vocalizations of St. Lawrence blue whales and found mean peak frequencies ranging from 17.0-78.7 Hz. Reported source levels are 180-188 dB re 1μPa, but may reach 195 dB re 1μPa (Aburto et al. 1997; Clark and Ellison 2004; Ketten 1998b; McDonald et al. 2001). Samaran et al. (2010) estimated Antarctic blue whale calls in the Indian Ocean at 179 ± 5 dB re 1 μPa_{rms} in the 17-30 Hz range and pygmy blue whale calls at 175± 1 dB re 1 μPa_{rms} in the 17-50 Hz range.

In temperate waters, intense bouts of long patterned sounds are very common from fall through spring, but these also occur to a lesser extent during the summer in high latitude feeding areas. Short sequences of rapid calls in the 30-90 Hz band are associated with animals in social groups. The seasonality and structure of long patterned sounds suggest that these sounds are male displays for attracting females, competing with other males, or both. The context for the 30-90 Hz calls suggests that they are communicative but not related to a reproductive function. Vocalizations attributed to blue whales have been recorded in presumed foraging areas, along migration routes, and during the presumed breeding season (Beamish and Mitchell 1971; Cummings et al. 1972; Cummings and Thompson 1971; Cummings and Thompson 1977; Cummings and Thompson 1994; Rivers 1997; Thompson et al. 1996).

As with other baleen whale vocalizations, blue whale vocalization function is unknown, although numerous hypotheses exist (maintaining spacing between individuals, recognition, socialization, navigation, contextual information transmission, and location of prey resources (Edds-Walton 1997b; Payne and Webb 1971; Thompson et al. 1992a). Intense bouts of long, patterned sounds are common from fall through spring in low latitudes, but these also occur less frequently while in summer high-latitude feeding areas. Short, rapid sequences of 30-90 Hz calls are associated with socialization and may be displays by males based upon call seasonality and structure.

Blue whale calls appear to vary between western and eastern North Pacific regions, suggesting possible structuring in populations (Rivers 1997; Stafford et al. 2001).

Direct studies of blue whale hearing have not been conducted, but it is assumed that blue whales can hear the same frequencies that they produce (low-frequency) and are likely most sensitive to this frequency range (Ketten 1997; Richardson et al. 1995c).

Status and trends. Blue whales (including all subspecies) were originally listed as endangered in 1970 (35 FR 18319), and this status continues since the inception of the ESA in 1973.

Table 3 contains historic and current estimates of blue whales by region. Globally, blue whale abundance has been estimated at between 5,000-13,000 animals (COSEWIC 2002; Yochem and Leatherwood 1985); a fraction of the 200,000 or more that are estimated to have populated the oceans prior to whaling (Maser et al. 1981; U.S. Department of Commerce 1983). Consideration of the status of populations outside of the action area is important under the present analysis to determine the how the risk to the affected population(s) bears on the status of the species as a whole.

Table 3. Summary of past and present blue whale abundance.

Region	Population, stock, or study area	Pre-exploitation estimate	95% CI	Current estimate	95% CI	Source
Global	~~	200,000	~~	11,200-13,000	~~	(DOC 1983; Maser et al. 1981)
	~~	~~	~~	5,000-12,000	~~	(COSEWIC 2002)
North Atlantic	Basinwide	1,100-1,500	~~	100-555	~~	(Braham 1991; Gambell 1976)
	~~			1,000-2,000		(Sigurjonsson 1995)
	NMFS-western North Atlantic stock	~~	~~	440	~~	(Waring et al. 2013)
	Central and northeast Atlantic	~~	~~	855	351-1,589	(Pike et al. 2009b)
North Pacific	Basinwide	4,900	~~	1,400-1,900	~~	
	~~	4,900		1,600		(Gambell 1976)

	~~	~~	~~	3,300	~~	(Wade and Gerrodette 1993) and (Barlow 1997a) as combined in(Perry et al. 1999)
	Eastern tropical Pacific	~~	~~	1,415	1,078-2,501	(Wade and Gerrodette 1993)
	Costa Rica EEZ	~~	~~	48	22-102*	(Gerrodette and Palacios 1996)
	Central American EEZs north of Costa Rica	~~	~~	94	34-257*	(Gerrodette and Palacios 1996)
	Eastern North Pacific	~~	~~	2,997	2,175-3,819	(Calambokidis and Barlow 2004)
	NMFS-eastern North Pacific stock	~~	~~	2,497	CV=0.24	(Carretta et al. 2013)
Southern Hemisphere	Basinwide	150,000-210,000		5,000-6,000	~~	(Gambell 1976; Yochem and Leatherwood 1985)
	~~	300,000	~~	~~	~~	(COSEWIC 2002)
	~~	~~	~~	400-1,400	400-1,400	IWC, for years 1980-2000
	~~	~~	~~	1,700	860-2,900	(IWC 2005c), point estimate for 1996
	Within IWC survey areas	~~	~~	1,255	~~	(IWC 1996)
	~~	10,000	~~	5,000	~~	(Gambell 1976)
	~~	13,000	~~	6,500	~~	(Zemsky and Sazhinov 1982)
	South of 60° S			1,700		(Branch et al. 2007)

*Note: Confidence Intervals (C.I.) not provided by the authors were calculated from Coefficients of Variation (C.V.) where available, using the computation from Gotelli and Ellison (2004).

North Atlantic. Commercial hunting had a severe effect on blue whales, such that they remain rare in some formerly important habitats, notably in the northern and northeastern North Atlantic (Sigurjónsson and Gunnlaugsson 1990). Sigurjónsson and Gunnlaugsson (1990) estimated that at least 11,000 blue whales were harvested from all whaling areas from the late-nineteenth to mid-twentieth centuries.

Current trends are unknown, although an increasing annual trend of 4.9% was reported for 1969–1988 off western and southwestern Iceland (Sigurjónsson and Gunnlaugsson 1990). Sigurjónsson and Gunnlaugsson (1990) concluded that the blue whale population had been increasing since the late 1950s. In the northeastern Atlantic, blue whales are most common west and south of Iceland and may be the largest concentration of blue whales in the North Atlantic (Pike et al. 2009b). In this area, the population may be recovering at a rate of 4-5% (Pike et al. 2009b). Punt (2010) estimated the rate of increase for blue whales in the central North Atlantic to be 9% annually (3.83 SE) between 1987 and 2001.

North Pacific. Estimates of blue whale abundance are uncertain. Prior to whaling, Gambell (1976) reported there may have been as many as 4,900 blue whales. Blue whales were hunted in the Pacific Ocean, where 5,761 killed from 1889–1965 (Perry et al. 1999). This estimate does not account for under-reporting by Soviet whalers, who took approximately 800 more individuals than were reported (Ivashchenko et al. 2013). The IWC banned commercial whaling in the North Pacific in 1966, although Soviet whaling continued after the ban. Although blue whale abundance has likely increased since its protection in 1966, the possibility of unauthorized harvest by Soviet whaling vessels, incidental ship strikes, and gillnet mortalities make this uncertain. Punt (2010) estimated the rate of increase for blue whales in the eastern North Pacific to be 3.2% annually (1.4 SE) between 1991 and 2005, while Calambokidis et al. (2010) estimated a growth rate of 3% annually.

Southern Hemisphere. Estimates of 4-5% for an average rate of population growth have been proposed (Yochem and Leatherwood 1985). However, a recent estimate of population growth for Antarctic blue whales throughout the region was 7.3% (Branch et al. 2007). Punt (2010) estimated the rate of increase for blue whales in the Southern Hemisphere to be 8.2% annually (3.37 SE) between 1978 and 2004. Antarctic blue whales remain severely depleted with the 1996 estimate only 0.7% of pre-whaling levels (IWC 2005). Blue whales along Chile have been estimated to number between 7 and 9% of historical abundance (Williams et al. 2011). Genetic diversity remains reasonable considering the extreme bottleneck that the population experienced (Sremba et al. 2012).

Blue whales were the mainstay of whaling in the region once the explosive harpoon was developed in the late-nineteenth century (Shirihai 2002). During the early 1900s, the species became a principal target of the whaling industry throughout the world, with the majority killed in the Southern Hemisphere. Approximately 330,000–360,000 blue whales were harvested from 1904 to 1967 in the Antarctic alone, reducing their abundance to <3% of their original numbers (Perry et al. 1999; Reeves et al. 2003). Blue whales were protected in portions of the Southern Hemisphere beginning in 1939, and received full protection in the Antarctic in 1966.

Natural threats. As the world's largest animals, blue whales are only occasionally known to be killed by killer whales (Sears et al. 1990; Tarpy 1979). Blue whales engage in a flight response to evade killer whales, which involves high energetic output, but show little resistance if overtaken (Ford and Reeves 2008). Blue whales are known to become infected with the nematode *Carricauda boopis*, which are believed to have caused mortality in fin whale due to renal failure (Lambertsen 1986).

Anthropogenic threats. Blue whales have faced threats from several historical and current sources. Blue whale populations have been severely depleted due to historical whaling activity.

Shipstrike is a concern in the North Pacific (Figure 8). In the California/Mexico stock of blue whales, annual incidental mortality due to ship strikes averaged one whale every five years, but we cannot determine if this reflects the actual number of blue whales struck and killed by ships (i.e., individuals not observed when struck and those who do not strand; Barlow et al. (1997a)). Ship strikes have recently averaged roughly one every other year (eight ship strike incidents are known (Jensen and Silber 2004a)), but in September 2007, ships struck five blue whales within a few-day period off southern California (Calambokidis pers. comm. 2008)(Berman-Kowalewski et al. 2010). Dive data support a surface-oriented behavior during nighttime that would make blue whales particularly vulnerable to ship strikes during this time. Ship strikes were implicated in the deaths of five blue whales, from 2004-2008 (Carretta et al. 2012). Four of these deaths occurred in 2007, the highest number recorded for any year other that 2007. During 2004-2008, there were an additional eight injuries of unidentified large whales attributed to ship strikes. Several blue whales have been photographed in California with large gashes in their dorsal surface that appear to be from ship strikes (J. Calambokidis, pers. comm.). Ship strike is an issue for blue whales near Sri Lanka engaged in foraging in shipping lanes, with several individuals stranding or being found with evidence of being struck (Ilangakoon 2012).

Figure 8. A near collision between a blue whale and a commercial cargo vessel in the Santa Barbara Channel Traffic Separation Scheme. Photo credit: NOAA Channel Islands National Marine Sanctuary, 2002 (Permit CINMS-2002-001).

Additional mortality from ship strikes probably goes unreported because the whales do not strand or, if they do, they do not always have obvious signs of trauma. Studies have shown that blue whales respond to approaching ships in a variety of ways, depending on the behavior of the animals at the time of approach, and speed and direction of the approaching vessel. While feeding, blue whales react less rapidly and with less obvious avoidance behavior than whales that are not feeding (Sears 1983).

Increasing noise in the ocean may impair blue whale behavior. Although available data do not presently support traumatic injury from sonar, the general trend in increasing ambient low-frequency noise in the deep oceans of the world, primarily from ship engines, could impair the ability of blue whales to communicate or navigate through these vast expanses (Aburto et al. 1997; Clark 2006). Blue whales off California altered call levels and rates in association with changes in local vessel traffic (McKenna 2011). Either due to ship strike, vessel noise, whale watching, or a combination of these factors displacement from preferred habitat may be occurring off Sri Lanka (Ilangakoon 2012).

There is a paucity of contaminant data related to blue whales. Available information indicates that organochlorines, including dichloro-diphenyl-trichloroethane (DDT), polychlorinated biphenyls (PCB), benzene hexachloride (HCH), hexachlorobenzene (HCB), chlordane, dieldrin, methoxychlor, and mirex have been isolated from blue whale blubber and liver samples (Gauthier et al. 1997c; Metcalfe et al. 2004). Contaminant transfer between mother and calf occurs, meaning that young often start life with concentrations of contaminants equal to their mothers, before accumulating additional contaminant loads during life and passing higher loads to the next generation (Gauthier et al. 1997b; Metcalfe et al. 2004). This is supported by ear plug data showing maternal transfer of pesticides and flame retardants in the first year of life (Trumble et al. 2013). These data also support pulses of mercury in body tissues of the male studied (Trumble et al. 2013).

Critical habitat. The NMFS has not designated critical habitat for blue whales.

6.2 Fin whale

Subspecies. There are two recognized subspecies of fin whales, *Balaenoptera physalus physalus*, which occurs in the North Atlantic Ocean, and *B. p. quoyi*, which occurs in the Southern Ocean. These subspecies and North Pacific fin whales appear to be organized into separate populations, although there is a lack of consensus in the published literature as to population structure.

Population structure. Population structure has undergone only a rudimentary framing. Genetic studies by Bérubé et al. (1998) indicate that there are significant genetic differences among fin whales in differing geographic areas (Sea of Cortez, Gulf of St. Lawrence, and Gulf of Maine). Further, individuals in the Sea of Cortez may represent an isolated population from other eastern North Pacific fin whales (Berube et al. 2002). Even so, mark-recapture studies also demonstrate that individual fin whales migrate between management units designated by the IWC (Mitchell 1974; Sigujónsson and Gunnlaugsson 1989).

North Atlantic. Fin whales are common off the Atlantic coast of the U.S. in waters immediately off the coast seaward to the continental shelf (about the 1,800 m contour). Fin whales occur during the summer from Baffin Bay to near Spitsbergen and the Barents Sea, south to Cape Hatteras in North Carolina and off the coasts of Portugal and Spain (Rice 1998a). In areas north of Cape Hatteras, fin whales account for about 46% of the large whales observed in 1978-1982 surveys (CETAP 1982a). Little is known about the winter habitat of fin whales, but in the western North Atlantic, the species has been found from Newfoundland south to the Gulf of Mexico and Greater Antilles, and in the eastern North Atlantic their winter range extends from the Faroes and Norway south to the Canary Islands. Fin whales in the eastern North Atlantic have been found in highest densities in the Irminger Sea between Iceland and Greenland (Víkingsson et al. 2009). The singing location of fin whales in the Davis Strait and Greenland has been correlated with sea ice fronts; climate change may impact fin whale distribution and movement by altering sea ice conditions (Simon et al. 2010). A general fall migration from the Labrador and Newfoundland region, south past Bermuda, and into the West Indies has been theorized (Clark 1995). Historically, fin whales were by far the most common large whale found off Portugal (Brito et al. 2009).

Fin whales are also endemic to the Mediterranean Sea, where (at least in the western Mediterranean), individuals tend to aggregate during summer and disperse in winter over large spatial scales (Cotte et al. 2009), although this seasonal trend is reversed in the Bonifacio Strait (Arcangeli et al. 2013a). Mediterranean fin whales are genetically distinct from fin whales in the rest of the North Atlantic at the population level (Berube et al. 1999). However, some fin whales from the northeastern North Atlantic have been tracked into the Mediterranean during winter and overlap in time and space with the Mediterranean population may exist (Castellote et al. 2010). Individuals also tend to associate with colder, saltier water, where steep changes in temperature, and where higher northern krill densities would be expected (Cotte et al. 2009). A genetically distinct population resides year-round in the Ligurian Sea (IWC 2006a). Fin whales seem to track areas of high productivity in the Mediterranean, particularly along coastal areas of France, northern Italy, and the southern and middle Adriatic (Druon et al. 2012). Hundreds of sightings have been made along New Jersey during the approximate time frame of the proposed seismic survey (NSF 2014).

North Pacific. Fin whales undertake migrations from low-latitude winter grounds to high-latitude summer grounds and extensive longitudinal movements both within and between years (Mizroch et al. 1999a). Fin whales are sparsely distributed during November-April, from 60° N, south to the northern edge of the tropics, where mating and calving may take place (Mizroch et al. 1999a). However, fin whales have been sighted as far as 60° N throughout winter (Mizroch et al. 1999b). A resident fin whale population may exist in the Gulf of California (Tershy et al. 1993).

Southern Hemisphere. Fin whales range from near 40° S (Brazil, Madagascar, western Australia, New Zealand, Colombia, Peru, and Chile) during the austral winter southward to Antarctica (Rice 1998a). Fin whales appear to be present in Antarctic waters only from February-July and were not detected in the Ross Sea during year-round acoustic surveys (Sirovic et al. 2009).

Age distribution. Aguilar and Lockyer (1987) suggested annual natural mortality rates in northeast Atlantic fin whales may range from 0.04 to 0.06. Fin whales live 70-80 years (Kjeld et al. 2006).

Reproduction. Fin whales reach sexual maturity between 5-15 years of age (COSEWIC 2005; Gambell 1985a; Lockyer 1972). Mating and calving occurs primarily from October-January, gestation lasts ~11 months, and nursing occurs for 6-11 months (Boyd et al. 1999; Hain et al. 1992). The average calving interval in the North Atlantic is estimated at about 2-3 years (Agler et al. 1993; Christensen et al. 1992a). The location of winter breeding grounds is uncertain but mating is assumed to occur in pelagic mid-latitude waters (Perry et al. 1999). This was recently contradicted by acoustic surveys in the Davis Strait and off Greenland, where singing by fin whales peaked in November through December; the authors suggested that mating may occur prior to southbound migration (Simon et al. 2010). Although seasonal migration occurs between presumed foraging and breeding locations, fin whales have been acoustically detected throughout the North Atlantic Ocean and Mediterranean Sea year-round, implying that not all individuals follow a set migratory pattern (Notarbartolo-Di-Sciara et al. 1999; Simon et al. 2010). Reductions in pregnancy rates appear correlated with reduced blubber thickness and prey availability (Williams et al. 2013).

Movement. In the eastern Central Atlantic, fin whales appear to migrate from areas along

Iceland to the Azores east of the Mid-Atlantic Ridge, apparently traveling directly without random movement patterns in between (Anil et al. 2013).

Behavior. Fin whales along Southern California were found to be traveling 87% of the time and milling 5% in groups that averaged 1.7 individuals (Bacon et al. 2011). Fin whales tend to avoid tropical and pack-ice waters, with the high-latitude limit of their range set by ice and the lower-latitude limit by warm water of approximately 15° C (Sergeant 1977). Fin whale concentrations generally form along frontal boundaries or mixing zones between coastal and oceanic waters, which corresponds roughly to the 200 m isobath (the continental shelf edge (Cotte et al. 2009; Nasu 1974)).

Feeding. Fin whales in the North Atlantic eat pelagic crustaceans (mainly krill and schooling fish such as capelin, herring, and sand lance (Borobia and Béland 1995; Christensen et al. 1992a; Hjort and Ruud 1929; Ingebrigtsen 1929; Jonsgård 1966; Mitchell 1974; Overholtz and Nicolas 1979; Sergeant 1977; Shirihai 2002; Watkins et al. 1984)). Fin whales frequently forage along cold eastern current boundaries (Perry et al. 1999). Feeding may occur in waters as shallow as 10 m when prey are at the surface, but most foraging is observed in high-productivity, upwelling, or thermal front marine waters (Gaskin 1972; Nature Conservancy Council 1979 as cited in ONR 2001; Panigada et al. 2008; Sergeant 1977). While foraging, fin whales in the Mediterranean Sea have been found to move through restricted territories in a convoluted manner (Lafortuna et al. 1999). Fin whales in the central Tyrrhenian Sea appear to ephemerally exploit the area for foraging during summer, particularly areas of high primary productivity (Arcangeli et al. 2013b).

Diving. The amount of time fin whales spend at the surface varies. Some authors have reported that fin whales make 5-20 shallow dives, each of 13-20 sec duration, followed by a deep dive of 1.5-15 min (Gambell 1985a; Lafortuna et al. 2003; Stone et al. 1992). Other authors have reported that the fin whale's most common dives last 2-6 min (Hain et al. 1992; Watkins 1981). The most recent data support average dives of 98 m and 6.3 min for foraging fin whales, while non-foraging dives are 59 m and 4.2 min (Croll et al. 2001). Foraging dives in excess of 150 m are known (Panigada et al. 1999). In waters off the U.S. Atlantic Coast, individuals or duos represented about 75% of sightings (Hain et al. 1992). Individuals or groups of less than five individuals represented about 90% of observations.

Vocalization and hearing. Fin whales produce a variety of low-frequency sounds in the 10-200 Hz range (Edds 1988; Thompson et al. 1992a; Watkins 1981; Watkins et al. 1987b). Typical vocalizations are long, patterned pulses of short duration (0.5-2 s) in the 18-35 Hz range, but only males are known to produce these (Croll et al. 2002; Patterson and Hamilton 1964). Richardson et al. (1995b) reported the most common sound as a 1 sec vocalization of about 20 Hz, occurring in short series during spring, summer, and fall, and in repeated stereotyped patterns during winter. Au (2000b) reported moans of 14-118 Hz, with a dominant frequency of 20 Hz, tonal vocalizations of 34-150 Hz, and songs of 17-25 Hz (Cummings and Thompson 1994; Edds 1988; Watkins 1981). Source levels for fin whale vocalizations are 140-200 dB re 1μPa·m (Clark and Ellison. 2004; Erbe 2002b). The source depth of calling fin whales has been reported to be about 50 m (Watkins et al. 1987b). In temperate waters, intense bouts of long patterned sounds are very common from fall through spring, but also occur to a lesser extent during the summer in high latitude feeding areas (Clarke and Charif 1998a). Short sequences of rapid pulses in the 20-70 Hz band are associated with animals in social groups (McDonald et al. 1995b). Each pulse lasts on the order of one second and contains twenty cycles (Tyack 1999).

Although their function is still debated, low-frequency fin whale vocalizations travel over long distances and may aid in long-distance communication (Edds-Walton 1997b; Payne and Webb 1971). During the breeding season, fin whales produce pulses in a regular repeating pattern, which have been proposed to be mating displays similar to those of humpbacks (Croll et al. 2002). These vocal bouts last for a day or longer (Tyack 1999). The seasonality and stereotype of the bouts of patterned sounds suggest that these sounds are male reproductive displays (Watkins et al. 1987a), while the individual counter-calling data of McDonald et al. (1995b) suggest that the more variable calls are contact calls. Some authors feel there are geographic differences in the frequency, duration and repetition of the pulses (Thompson et al. 1992b).

Direct studies of fin whale hearing have not been conducted, but it is assumed that fin whales can hear the same frequencies that they produce (low) and are likely most sensitive to this frequency range (Ketten 1997; Richardson et al. 1995c).

Status and trends. Fin whales were originally listed as endangered in 1970 (35 FR 18319), and this status continues since the inception of the ESA in 1973. Although fin whale population structure remains unclear, various abundance estimates are available (Table 4). Consideration of the status of populations outside of the action area is important under the present analysis to determine the how the risk to the affected population(s) bears on the status of the species as a whole. Historically, worldwide populations were severely depleted by commercial whaling, with more than 700,000 whales harvested in the twentieth century (Cherfas 1989b; Cherfas 1989a).

Table 4. Summary of past and present fin whale abundance.

Region	Population, stock, or study area	Pre-exploitation estimate	95% CI	Recent estimate	95% CI	Source
Global	~~	>464,000	~~	119,000	~~	(Braham 1991)
North Atlantic	Basinwide	30,000-50,000	~~	~~	~~	(Sergeant 1977)
	~~	360,000	249,000-481,000	~~	~~	(Roman and Palumbi 2003)
	~~			>50,000		(Sigurjonsson 1995)
	Eastern North Atlantic			25,000		(2009) circa 2001
	Central and northeastern Atlantic	~~	~~	30,000	23,000-39,000	(IWC 2007)
	Western North Atlantic	~~	~~	3,590-6,300	~~	(Braham 1991)
	NMFS-western North Atlantic stock	~~	~~	3,985	CV=0.24	(NMFS 2008a; Waring et al. 2012)(NMFS 2008a; Waring et al. 2012)(NMFS 2008a; Waring et al. 2012)(NMFS

						2008a; Waring et al. 2012)(NMFS 2008a; Waring et al. 2012)(NMFS 2008a; Waring et al. 2012)(NMFS 2008a; Waring et al. 2012)(NMFS 2008a; Waring et al. 2012)(NMFS 2008a; Waring et al. 2012)(NMFS 2008a; Waring et al. 2012)(NMFS 2008a; Waring et al. 2012)
	Northeastern U.S. Atlantic cont'l shelf	~~	~~	2,200-5,000	~~	(Hain et al. 1992; Waring et al. 2000)
	IWC-Newfoundland-Labrador stock	~~	~~	13,253	0-50,139*	(IWC 1992)
	Bay of Biscay			7,000-8,000		(Goujon et al. 1994)
	IWC-British Isles, Spain, and Portugal stock	10,500	9,600-11,400	4,485	3,369-5,600	(Braham 1991)
	~~	~~	~~	17,355	10,400-28,900	(Buckland et al. 1992)
	IWC-east Greenland to Faroe Islands	~~	~~	22,000	16,000-30,000	(IWC 2014)
	IWC-west Greenland stock	~~	~~	4,500	1,900-10,000	(IWC 2014)
	Mediterranean Sea			3,583	2,130-6,027	(Forcada 1996)
North Pacific	Basinwide	42,000-45,000	~~	16,625	14,620-18,630	(Braham 1991; Ohsumi and Wada 1974)
	Central Bering Sea	~~	~~	4,951	2,833-8,653	(Moore et al. 2002)
	NMFS-northeast Pacific stock, west of Kenai Peninsula	~~	~~	5,700	~~	(Angliss and Allen 2007)
	NMFS-CA/OR/WA	~~	~~	3,044	CV=0.18	(Carretta et al.

	stock					2008; Carretta et al. 2012)
	NMFS-HI stock	~~	~~	174	CV=0.72	(Carretta et al. 2012)
Southern Hemisphere	Basinwide	400,000	~~	85,200	~~	(Braham 1991; IWC 1979)
	South of 60S	~~	~~	1,735	514-2,956	(IWC 1996)
	South of 30S	~~	~~	15,178	~~	(IWC 1996)
	Scotia Sea and Antarctic Peninsula	~~	~~	4,672	792-8,552	(Hedley et al. 2001; Reilly et al. 2004)

*Note: Confidence Intervals (C.I.) not provided by the authors were calculated from Coefficients of Variation (C.V.) where available, using the computation from Gotelli and Ellison (2004).

North Atlantic. Over 48,000 fin whales were caught between 1860-1970 (Braham 1991). Although protected by the IWC, from 1988-1995 there have been 239 fin whales harvested from the North Atlantic. Recently, Iceland resumed whaling of fin whales despite the 1985 moratorium imposed by the International Whaling Commission (IWC). Vikingsson et al. (2009) concluded that actual numbers were likely higher due to negative bias in their analysis, and that the population(s) were increasing at 4% annually. The abundance of fin whales in the Baffin Bay-Davis Strait summer feeding area is believed to be increasing (Heide-Jorgensen et al. 2010).

North Pacific. The status and trend of fin whale populations is largely unknown. Over 26,000 fin whales were harvested between 1914-1975 (Braham 1991 as cited in Perry et al. 1999), although Soviet whalers overestimated their catch by roughly 1,300 individuals (Ivashchenko et al. 2013). Punt (2010) estimated the rate of increase for fin whales in the eastern North Pacific to be 4.8% annually (3.24 SE) between 1987 and 2003.

Southern Hemisphere. The Southern Hemisphere population was one of the most heavily exploited whale populations under commercial whaling. From 1904 to 1975, over 700,000 fin whales were killed in Antarctic whaling operations (IWC 1990). Harvests increased substantially upon the introduction of factory whaling ships in 1925, with an average of 25,000 caught annually from 1953-1961 (Perry et al. 1999). Current estimates are a tiny fraction of former abundance.

Natural threats. Natural sources and rates of mortality are largely unknown, but Aguilar and Lockyer (1987) suggested annual natural mortality rates might range from 0.04 to 0.06 for northeast Atlantic fin whales. The occurrence of the nematode *Crassicauda boopis* appears to increase the potential for kidney failure and may be preventing some fin whale populations from recovering (Lambertsen 1992). Adult fin whales engage in a flight responses (up to 40 km/h) to evade killer whales, which involves high energetic output, but show little resistance if overtaken (Ford and Reeves 2008). Shark attacks may also result in serious injury or death in very young and sick individuals (Perry et al. 1999).

Anthropogenic threats. Fin whales have undergone significant exploitation, but are currently protected under the IWC. In the Antarctic Ocean, fin whales are hunted by Japanese whalers who have been allowed to kill up to 10 fin whales each ear for the 2005-2006 and 2006-2007 seasons under an Antarctic Special Permit NMFS (2006b). Japanese whalers plan to kill 50 whales per year starting in the 2007-2008 season and continuing for the next 12 years (IWC 2006b; Nishiwaki et al. 2006).

Increased noise in the ocean stemming from shipping seems to alter the acoustic patterns of singing fin whales, possibly hampering reproductive parameters across wide regions (Castellote et al. 2012).

The organochlorines DDE, DDT, and PCBs have been identified from fin whale blubber, but levels are lower than in toothed whales due to the lower level in the food chain that fin whales feed at (Aguilar and Borrell 1988; Borrell 1993; Borrell and Aguilar 1987; Henry and Best 1983; Marsili and Focardi 1996). Females contained lower burdens than males, likely due to mobilization of contaminants during pregnancy and lactation (Aguilar and Borrell 1988; Gauthier et al. 1997b; Gauthier et al. 1997c). Contaminant levels increase steadily with age until sexual maturity, at which time levels begin to drop in females and continue to increase in males (Aguilar and Borrell 1988).

Climate change also presents a potential threat to fin whales, particularly in the Mediterranean Sea, where fin whales appear to rely exclusively upon northern krill as a prey source. These krill occupy the southern extent of their range and increases in water temperature could result in their decline and that of fin whales in the Mediterranean Sea (Gambaiani et al. 2009).

Critical habitat. The NMFS has not designated critical habitat for fin whales.

6.3 Humpback whale

Population designations. Populations have been relatively well defined for humpback whales

North Atlantic. Humpback whales range from the mid-Atlantic Bight and the Gulf of Maine across the southern coast of Greenland and Iceland to Norway in the Barents Sea. Whales migrate to the western coast of Africa (Waerebeek et al. 2013), the Cape Verde Islands, and the Caribbean Sea during the winter. Humpback whales aggregate in four summer feeding areas: Gulf of Maine and eastern Canada, west Greenland, Iceland, and Norway (Boye et al. 2010; Katona and Beard 1990; Smith et al. 1999).

Increasing range and occurrence in the Mediterranean Sea coincides with population growth and may represent reclaimed habitat from pre-commercial whaling (Frantzis et al. 2004; Genov et al. 2009). The principal breeding range for Atlantic humpback whales lies from the Antilles and northern Venezuela to Cuba (Balcomb III and Nichols 1982; Whitehead and Moore 1982; Winn et al. 1975). The largest breeding aggregations occur off the Greater Antilles where humpback whales from all North Atlantic feeding areas have been photo-identified (Clapham et al. 1993; Katona and Beard 1990; Mattila et al. 1994; Palsbøll et al. 1997; Smith et al. 1999; Stevick et al. 2003b). However, the possibility of historic and present breeding further north remains enigmatic but plausible (Smith and G.Pike 2009). Winter aggregations also occur at the Cape Verde Islands in the eastern North Atlantic and along Angola (Cerchio et al. 2010b; Reeves et al. 2002; Reiner et al. 1996; Weir 2007). Accessory and historical aggregations also occur in the eastern Caribbean (Levenson and Leapley 1978; Mitchell and Reeves 1983; Reeves et al. 2001a; Reeves et al. 2001b; Schwartz 2003; Smith and Reeves 2003; Swartz et al. 2003; Winn et al. 1975). To further highlight the "open" structure of humpback whales, a humpback whale migrated from the Indian Ocean to the South Atlantic Ocean, demonstrating that interoceanic movements can occur (Pomilla and Rosenbaum 2005). Genetic exchange at low-latitude breeding groups between Northern and Southern Hemisphere individuals and wider-range movements by males has been suggested to explain observed global gene flow (Rizzo and Schulte 2009). However, there is little genetic support for wide-scale interchange of individuals between ocean basins or across the equator. Dozens of sightings have been made along New Jersey during the approximate time frame of the proposed seismic survey (NSF 2014).

North Pacific. Based on genetic and photo-identification studies, the NMFS currently recognizes four stocks, likely corresponding to populations, of humpback whales in the North Pacific Ocean: two in the eastern North Pacific, one in the central North Pacific, and one in the western Pacific (Hill and DeMaster 1998a). Gene flow between them may exist. Humpback whales summer in coastal and inland waters from Point Conception, California, north to the Gulf of Alaska and the Bering Sea, and west along the Aleutian Islands to the Kamchatka Peninsula and into the Sea of Okhotsk (Ashe et al. 2013; Johnson and Wolman 1984; Nemoto 1957; Tomilin 1967). These whales migrate to Hawaii, southern Japan, the Mariana Islands, and Mexico during winter. However, more northerly penetrations in Arctic waters occur on occasion (Hashagen et al. 2009). The central North Pacific population winters in the waters around Hawaii while the eastern North Pacific population (also called the California-Oregon-Washington-Mexico stock) winters along Central America and Mexico (Rasmussen et al. 2012). However, Calambokidis et al. (1997) identified individuals from several populations wintering (and potentially breeding) in the areas of other populations, highlighting the potential fluidity of population structure. Humpback whales were recently found to migrate to the northwestern Hawaiian Islands, where singing has been recorded; this may represent an as yet undescribed breeding group, or expansion of breeding from the main Hawaiian Islands (Lammers et al. 2011). Herman (1979) presented extensive evidence that humpback whales associated with the main Hawaiian Islands immigrated there only in the past 200 years. Winn and Reichley (1985) identified genetic exchange between the humpback whales that winter off Hawaii and Mexico (with further mixing on feeding areas in Alaska) and suggested that humpback whales that winter in Hawaii may have emigrated from Mexican wintering areas. A "population" of humpback whales winters in the South China Sea east through the Philippines, Ryukyu Retto, Ogasawara Gunto, Mariana Islands, and Marshall Islands, with occurrence in the Mariana Islands, Guam, Rota, and Saipan from January-March (Darling and Mori 1993; Eldredge 1991; Eldredge 2003; Rice 1998a; Silberg et al. 2013). During summer, whales from this population migrate to the Kuril Islands, Bering Sea, Aleutian Islands, Kodiak, Southeast Alaska, and British Columbia to feed (Angliss and Outlaw 2007; Calambokidis 1997; Calambokidis et al. 2001).

Arabian Sea. A separate population of humpback whales appears to reside in the Arabian Sea in the Indian Ocean off the coasts of Oman, Pakistan, and India and movements of this group are poorly known (Mikhalev 1997; Rasmussen et al. 2007). Areas of the Mozambique Channel appear to be significant calving and wintering areas for humpback whales (Kiszka et al. 2010). Occurrence is year-round, with an even sex ratio (Minton et al. 2011). The Gulf of Masirah may be an important feeding area (feeding observed in October-November and February-March) while the Dhofar region is valuable breeding/nursery habitat (Minton et al. 2011). No photo-ID matches with individuals from other Indian Ocean populations have been identified (Minton et al. 2011).

Southern Hemisphere. Eight proposed stocks, or populations, of humpback whales occur in waters off Antarctica (Figure 9). Individuals from these stocks winter and breed in separate areas and are known to return to the same areas. However, the degree (if any) of gene flow (i.e., adult individuals wintering in different breeding locations) is uncertain (Carvalho et al.

2011). Genetic relatedness is high between eastern and western Australian breeding populations (Schmitt et al. 2014). Individuals from breeding grounds in Ecuador are somewhat heterogeneous from individuals in other breeding areas, but appear to maintain a genetic linkage (Felix et al. 2009). Based upon recent satellite telemetry, a revision of stocks A and G may be warranted to reflect stock movements within and between feeding areas separated east of 50º W (Dalla Rosa et al. 2008). In addition to being a breeding area, the west coast of South Africa also appears to serve as a foraging ground due to upwelling of the Benguela Current (Barendse et al. 2010). Females appear in this area in large numbers well before their male counterparts, frequently accompanied by calves (Barendse et al. 2010). Low-level movement between breeding locations across years has been documented, bringing into question the genetic discreteness of at least Southern Hemisphere populations (particularly between Oceania groups and Australia)(Garrigue et al. 2011a; Garrigue et al. 2011b; Stevick et al. 2011). However, mixing between some populations has not been found (such as between B2 and C1 groups). Sao Tome appears to be primarily a resting, nursing, and calving area with very little breeding occurring (Carvalho et al. 2011). At least two stop over sites along Madagascar for the C stock exist (Fossette et al. 2014).

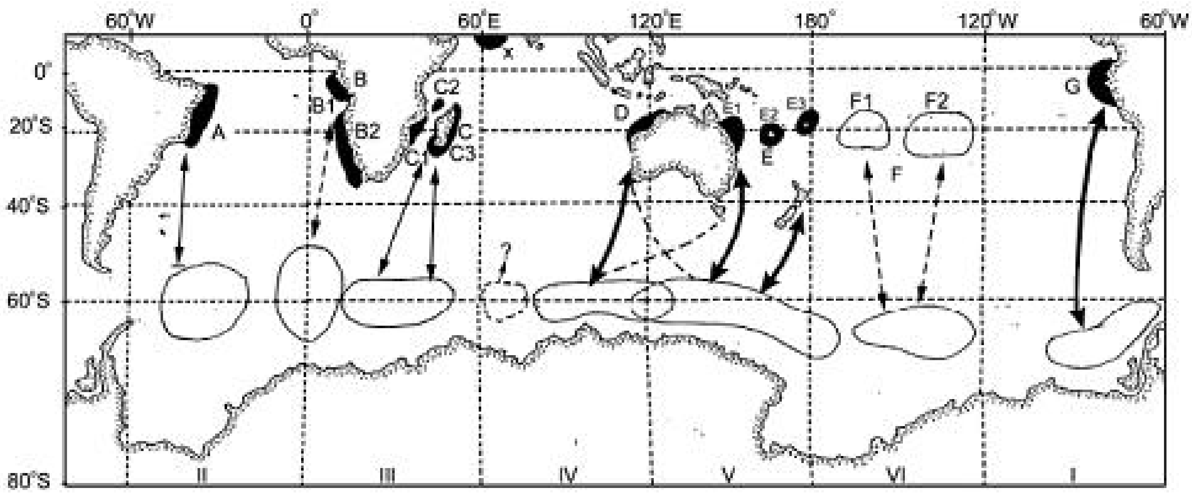

Figure 9. Southern Hemisphere humpback stocks (populations)(IWC 2005).

Distribution. Humpback whales are a cosmopolitan species that occur in the Atlantic, Indian, Pacific, and Southern oceans. Humpback whales migrate seasonally between warmer, tropical or sub-tropical waters in winter months (where they breed and give birth to calves, although feeding occasionally occurs) and cooler, temperate or sub-Arctic waters in summer months (where they feed; (Gendron and Urban 1993). In both regions, humpback whales tend to occupy shallow, coastal waters. However, migrations are undertaken through deep, pelagic waters (Winn and Reichley 1985). Humpback whales wintering in the West Indies migrate relatively directly to the Gulf of Maine and areas around Iceland and Norway (Kennedy et al. 2013). Some individuals may not migrate, or species occurrence in foraging areas may extend beyond summer months (Van Opzeeland et al. 2013).

Reproduction and growth. Humpback whale calving and breeding generally occurs during winter at lower latitudes. Gestation takes about 11 months, followed by a nursing period of up to one year (Baraff and Weinrich 1993). Sexual maturity is reached at between 5-7 years of age in the western North Atlantic, but may take as long as 11 years in the North Pacific, and perhaps over 11 years (e.g., southeast Alaska, Gabriele et al. 2007). Females usually breed every 2-3 years, although consecutive calving is not unheard of (Clapham and Mayo 1987; 1990; Glockner-Ferrari and Ferrari 1985 as cited in NMFS 2005b; Weinrich et al. 1993). Males appear to return to breeding grounds more frequently than do females (Herman et al. 2011). Larger females tend to produce larger calves that may have a greater chance of survival (Pack et al. 2009). Females appear to preferentially select larger-sized males (Pack et al. 2012). In some Atlantic areas, females tend to prefer shallow nearshore waters for calving and rearing, even when these areas are extensively trafficked by humans (Picanco et al. 2009). Offspring appear to return to the same breeding areas at which they were born one they are independent (Baker et al. 2013).

In calving areas, males sing long complex songs directed towards females, other males, or both. The breeding season can best be described as a floating lek or male dominance polygamy (Clapham 1996). Calving occurs in the shallow coastal waters of continental shelves and oceanic islands worldwide (Perry et al. 1999). Males “cort” females in escort groups and compete for proximity and presumably access to reproduce females (particularly larger females)(Pack et al. 2009). Although long-term relationships do not appear to exist between males and females, mature females do pair with other females; those individuals with the longest standing relationships also have the highest reproductive output, possibly as a result of improved feeding cooperation (Ramp et al. 2010). Site fidelity off Brazilian breeding grounds was extremely low, both within and between years (Baracho-Neto et al. 2012).

Generation time for humpback whales is estimated at 21.5 years, with individuals surviving from 80-100 years (COSEWIC 2011).

Diving. In Hawaiian waters, humpback whales remain almost exclusively within the 1,800 m isobath and usually within water depths of less than 182 m. Maximum diving depths are approximately 170 m (but usually <60 m), with a very deep dive (240 m) recorded off Bermuda (Hamilton et al. 1997). Dives can last for up to 21 min, although feeding dives ranged from 2.1-5.1 min in the North Atlantic (Dolphin 1987). In southeast Alaska, average dive times were 2.8 min for feeding whales, 3.0 min for non-feeding whales, and 4.3 min for resting whales (Dolphin 1987). In the Gulf of California, humpback whale dive durations averaged 3.5 min (Strong 1990). Because most humpback prey is likely found within 300 m of the surface, most humpback dives are probably relatively shallow. In Alaska, capelin are the primary prey of humpback and are found primarily between 92 and 120 m; depths to which humpbacks apparently dive for foraging (Witteveen et al. 2008).

Feeding. During the feeding season, humpback whales form small groups that occasionally aggregate on concentrations of food that may be stable for long-periods of times. Humpbacks use a wide variety of behaviors to feed on various small, schooling prey including krill and fish (Hain et al. 1982; Hain et al. 1995; Jurasz and Jurasz 1979; Weinrich et al. 1992; Witteveen et al. 2011). The principal fish prey in the western North Atlantic are sand lance, herring, and capelin (Kenney et al. 1985a). There is good evidence of some territoriality on feeding and calving areas (Clapham 1994; Clapham 1996; Tyack 1981). Humpback whales are generally believed to fast while migrating and on breeding grounds, but some individuals apparently feed while in low-latitude waters normally believed to be used exclusively for reproduction and calf-rearing (Danilewicz et al. 2009; Pinto De Sa Alves et al. 2009). Some individuals, such as juveniles, may not undertake migrations at all (Findlay and Best. 1995). Additional evidence, such as songs sung in northern latitudes during winter, provide additional support to plastic seasonal distribution (Smith and G.Pike 2009). Relatively high rates of resighting in foraging sites suggest whales return to the same areas year after year (Ashe et al. 2013; Kragh Boye et al. 2010). This trend appears to be maternally linked, with offspring returning to the same areas their mothers brought them to once calves are independent (Baker et al. 2013; Barendse et al. 2013). Humpback whales in foraging areas may forage largely or exclusively at night when prey are closer to the surface (Friedlaender et al. 2013).

Vocalization and hearing. Humpback whale vocalization is much better understood than is hearing. Different sounds are produced that correspond to different functions: feeding, breeding, and other social calls (Dunlop et al. 2008). Males sing complex sounds while in low-latitude breeding areas in a frequency range of 20 Hz to 4 kHz with estimated source levels from 144-174 dB (Au 2000b; Au et al. 2006; Frazer and Mercado 2000; Payne 1970; Richardson et al. 1995c; Winn et al. 1970). Both mature and immature males sing in breeding areas (Herman et al. 2013). Males also produce sounds associated with aggression, which are generally characterized as frequencies between 50 Hz to 10 kHz and having most energy below 3 kHz (Silber 1986; Tyack 1983). Such sounds can be heard up to 9 km away (Tyack and Whitehead 1983). Other social sounds from 50 Hz to 10 kHz (most energy below 3 kHz) are also produced in breeding areas (Richardson et al. 1995c; Tyack and Whitehead 1983). While in northern feeding areas, both sexes vocalize in grunts (25 Hz to 1.9 kHz), pulses (25-89 Hz), and songs (ranging from 30 Hz to 8 kHz but dominant frequencies of 120 Hz to 4 kHz) which can be very loud (175-192 dB re 1 μPa at 1 m; (Au 2000b; Erbe 2002a; Payne and Payne 1985; Richardson et al. 1995c; Thompson et al. 1986; Vu et al. 2012). However, humpbacks tend to be less vocal in northern feeding areas than in southern breeding areas, possibly due to foraging (Richardson et al. 1995c; Vu et al. 2012). During migration, social vocalizations are generated at 123 to 183 dB re 1 μPa at1 m with a median of 158 dB re 1 μPa at 1 m (Dunlop et al. 2013).

Status and trends. Humpback whales were originally listed as endangered in 1970 (35 FR 18319), and this status remains under the ESA. (Winn and Reichley 1985) argued that the global humpback whale population consisted of at least 150,000 whales in the early 1900s, mostly in the Southern Ocean. Consideration of the status of populations outside of the action area is important under the present analysis to determine the risk to the affected population(s) bears on the status of the species as a whole. Table 5 provides estimates of historic and current abundance for ocean regions.

Table 5. Summary of past and present humpback whale abundance.

Region	Population, stock, or study area	Pre-exploitation estimate	95% CI	Recent estimate	95% CI	Source
Global	~~	1,000,000	~~	~~	~~	(Roman and Palumbi 2003)
North Atlantic				10,000		(NMFS 1987)
	Basinwide	240,000	156,000-401,000*	11,570	10,005-13,135*	(Stevick et al. 2003a)
	~~	~~	~~	>5,500	~~	(Sigurjonsson 1995)
	Basinwide-females	~~	~~	2,804	1,776-4,463	(Palsbøll et al. 1997)
	Basinwide-males	~~	~~	4,894	3,374-7,123	(Palsbøll et al. 1997)

	Western North Atlantic	~~	~~	11,600	10,000-13,000	(IWC 2014)
	Western North Atlantic from Davis Strait, Iceland, to the West Indies	>4,685*	~~	~~	~~	*circa 1865; (Mitchell and Reeves 1983)
	West Greenland	~~	~~	2,154	CV=0.36	(Heide-Jorgensen et al. 2012)
	Iceland	~~	~~	5,000	~~	(Pike et al. 2009a)
	NMFS-Gulf of Maine stock	~~	~~	847	CV=0.55	(Waring et al. 2012)
	NMFS-Gulf of Maine stock including portions of the Scotian Shelf	~~	~~	902	177-1,627	(Clapham et al. 2003)
	Barents and Norwegian Seas	~~	~~	889	331-1,447*	(Øien 2001) *in* (Waring et al. 2004)
North Pacific	Basinwide	15,000	~~	6,000-8,000	~~	(Calambokidis et al. 1997)
	~~	~~	~~	18,300	~~	(Calambokidis et al. 2008a)
	~~	~~	~~	20,800	~~	(Barlow et al. 2009)
	NMFS-western North Pacific stock	~~	~~	394	329-459*	(Angliss and Allen 2007)
	NMFS-central North Pacific stock	~~	~~	4,005	3,259-4,751*	(Angliss and Allen 2007)
	NMFS-eastern North Pacific stock	~~	~~	1,391	1,331-1,451*	(Carretta et al. 2008)
	NMFS-CA/OR/WA stock	~~	~~	2,043	CV=0.10	(Carretta et al. 2013)
Indian Ocean	Arabian Sea	~~	~~	56	35-255	Minton et al. (Minton et al. 2003) *in* (Bannister 2005)
Southern Hemisphere	Basinwide	100,000	~~	19,851	~~	(Gambell 1976; IWC 1996)
	Gabon	~~	~~	>1,200	~~	(Strindberg et al. 2011)
	Oceania			2,300-3,500		(Constantine et al. 2010)
	~~	~~	~~	4,329	3,345-	(Constantine et al. 2012) circa 2005

				5,313	
Western Australia	~~	~~	26,100[2]	20,152-33,272	(Kent et al. 2012)
Mozambique	~~	~~	6,808	CV=0.14	(Findlay et al. 2011)
American Samoa	~~	~~	150	~~	(Carretta et al. 2012)
Brazil			6,404		(Andriolo et al. 2010)
South of 60°S	~~	~~	42,000	34,000-52,000	(IWC 2007)

*Note: Confidence Intervals (C.I.) not provided by the authors were calculated from Coefficients of Variation (C.V.) where available, using the computation from Gotelli and Ellison (2004).

North Atlantic. Historical estimates have ranged from 40,000-250,000 (Smith and G.Pike 2009). Smith and Reeves (2010) estimated that roughly 31,000 individuals were removed from the North Atlantic due to whaling since the 1600s. Estimates of animals on Caribbean breeding grounds exceed 2,000 individuals (Balcomb III and Nichols 1982). Several researchers report an increasing trend in abundance for the North Atlantic population, which is supported by increased sightings within the Gulf of Maine feeding aggregation (Barlow 1997b; Katona and Beard 1990; Smith et al. 1999; Waring et al. 2001). The rate of increase varies from 3.2-9.4%, with rates of increase slowing over the past two decades (Barlow 1997b; Katona and Beard 1990; Stevick et al. 2003a). If the North Atlantic population has grown according to the estimated instantaneous rate of increase ($r = 0.0311$), this would lead to an estimated 18,400 individual whales in 2008 (Stevick et al. 2003a). Punt (2010) estimated the rate of increase for humpback whales in the Gulf of Maine to be 6.3% annually (1.2 SE). Pike et al. (2009a) suggested that the eastern and northeastern waters off Iceland are areas of significant humpback utilization for feeding, estimating nearly 5,000 whales in 2001 and proposing an annual growth rate of 12% for the area. The authors suggest that humpback whales in the area had probably recovered from whaling. However, recent data suggest that the upward growth may have slowed or ceased around Iceland according to analysis of survey data there (Pike et al. 2010). The Gulf of Maine stock is estimated to be increasing at a rate of 3.1% annually (Waring et al. 2013). Humpback whales summering off West Greenland appear to be increasing at a rate of 9.4% annually (Heide-Jorgensen et al. 2012).

North Pacific. It is estimated that 15,000 humpback whales resided in the North Pacific in 1905 (Rice 1978a). However, from 1905 to 1965, nearly 28,000 humpback whales were harvested in whaling operations, reducing the number of all North Pacific humpback whale to roughly 1,000 (Perry et al. 1999). This estimate does not account for under-reporting by Soviet whalers, who took approximately 2,700 more individuals than were reported (Ivashchenko et al. 2013). Estimates have risen over time from 1,407-2,100 in the 1980s to 6,010 in 1997 (Baker 1985; Baker and Herman 1987; Calambokidis et al. 1997; Darling and Morowitz 1986). Because estimates vary by methodology, they are not directly comparable and it is not clear which of these estimates is more accurate or if the change from 1,407 to 6,010 is the result of a real increase or an artifact of model assumptions. Tentative estimates of the eastern North Pacific

2 Accounting for perception bias, 33,300 Kent, C. S., C. Jenner, M. Jenner, P. Bouchet, and E. Rexstad. 2012. Southern Hemisphere Breeding Stock D humpback whale population estimates from North West Cape, Western Australia. Journal of Cetacean Research and Management 12(1):29-38.

stock suggest an increase of 6-7% annually, but fluctuations have included negative growth in the recent past (Angliss and Outlaw 2005). Barlow et al. (2009) estimated an annual growth rate of 4.9%. Punt (2010) estimated the rate of increase for humpback whales in the eastern North Pacific to be 6.4% annually (0.9 SE) between 1992 and 2003 and 10.0% for Hawaii (3.32 SE). Modeled abundance increase in southeastern Alaska was 5.1% annually from 1986 to 2008 (Hendrix et al. 2012); a more specific estimate from Glacier Bay, the site of a long-term monitoring study over roughly the same time frame found a rate of increase of 4.4% (Saracco et al. 2013). For Asia, an annual rate of growth of 6.7% has been estimated (Calambokidis et al. 2008b).

Arabian Sea. The population inhabiting the Arabian Sea likely numbers a few hundred individuals at most (Minton et al. 2008). This population likely was much larger prior to exploitation in 1966 by Soviet whaling, with individuals found along not only Oman, but Yemen, Iran, Pakistan, and India (Mikhalev 2000; Minton et al. 2008; Reeves et al. 1991; Slijper et al. 1964; Wray and Martin. 1983).

Southern Hemisphere. The IWC recently compiled population data on humpback whales in the Southern Hemisphere. Humpback whales in this region experienced severe whaling pressure. Based upon whaling logs, particularly by Soviet vessels, at least 75,542 humpback whales were harvested from Antarctic waters from 1946 through 1973, largely from management areas IV, V, and VI (Clapham et al. 2009). One-third of these catches occurred from 1959-1961 in Area V. These numbers support Southern Hemisphere humpbacks being well below their carrying capacities (Clapham et al. 2009). A 2009 spike in calf mortality along western Australia brings into question whether carrying capacity has been reached by this population or other factors have increased mortality (Coughran and Gales 2010). Some vital rates of the humpback whale population summering off eastern Australia (E1) were recently estimated, including adult annual survival of 0.925 and subadult survival of 0.70 (Hoffman et al. 2010). Growth rates for certain age classes included 10.7% for adult females and 12.4% for juveniles (Hoffman et al. 2010). Punt (2010) estimated the rate of increase for humpback whales off eastern and western Australia to be 10.9 and 10.1% annually, respectively (0.23 and 4.69 SE, respectively). Kent et al. (2012) provided an even higher estimate of 13% from 2000-2008. Humpback whales off Mozambique appear to be more numerous now than when surveyed in the 1990s (Findlay et al. 2011). Population growth of humpback whales along Brazil showed a growth rate of 7.4% annually between 1995-1998 (Ward et al. 2011).

Natural threats. Natural sources and rates of mortality of humpback whales are not well known. Based upon prevalence of tooth marks, attacks by killer whales appear to be highest among humpback whales migrating between Mexico and California, although populations throughout the Pacific Ocean appear to be targeted to some degree (Steiger et al. 2008). Juveniles appear to be the primary age group targeted. Humpback whales engage in grouping behavior, flailing tails, and rolling extensively to fight off attacks. Calves remain protected near mothers or within a group and lone calves have been known to be protected by presumably unrelated adults when confronted with attack (Ford and Reeves 2008).

Parasites and biotoxins from red-tide blooms are other potential causes of mortality (Perry et al. 1999). The occurrence of the nematode *Crassicauda boopis* appears to increase the potential for kidney failure in humpback whales and may be preventing some populations from recovering (Lambertsen 1992). Studies of 14 humpback whales that stranded along Cape Cod between November 1987 and January 1988 indicate they apparently died from a toxin produced by dinoflagellates during this period. One-quarter of humpback whales of the Arabian Sea population show signs of tattoo skin disease, which may reduce the fitness of afflicted individuals (Baldwin et al. 2010).

Anthropogenic threats. Three human activities are known to represent major threats to humpback whales: whaling, commercial fishing, and shipping. Historically, whaling represented the greatest threat to every population of whales and was ultimately responsible for several species being listed as endangered.

Humpback whales are also killed or injured during interactions with commercial fishing gear. Along the Pacific coast of Canada, 40 humpback whales have been reported as entangled since 1980, four of which are known to have died (COSEWIC 2011; Ford et al. 2009). Between 30 and 40% of humpback whales in the Arabian Sea show scarring from entanglements, with fishing effort on the rise (Baldwin et al. 2010). Alava et al. (2012) reported that 0.53% of humpback whale populations breeding along Ecuador are bycaught annually in commercial fishing gear (mortality of 15-33 individuals per year). From 2004-2008, 18 humpback whales were observed to be entangled along the U.S. west coast, of which 14 were considered seriously injured and two are known to have died (Carretta et al. 2013). From 1996-2000, 22 humpback whales of the Central North Pacific population were found entangled in fishing gear (Angliss and Lodge. 2004). In 1996, a vessel from the Pacific Missile Range Facility in Hawaii rescued an entangled humpback, removing two crabpot floats from the whale. A photography study of humpback whales in southeastern Alaska in 2003 and 2004 found at least 53% of individuals showed some kind of scarring from fishing gear entanglement (Neilson et al. 2005). There are also reports of entangled humpback whales from the Hawaiian Islands. In 1991, a humpback whale was observed entangled in longline gear and released alive (Hill et al. 1997). In 1995, a humpback whale in Maui waters was found trailing numerous lines (not fishery-related) and entangled in mooring lines. The whale was successfully released, but subsequently stranded and was attacked and killed by tiger sharks in the surf zone. From 2001 through 2006, there were 23 reports of entangled humpback whales in Hawaiian waters; 16 of these reports were from 2005 and 2006. Ten humpback whales were found entangled in gill nets or long lines between 1995 and 2002 off Peru (Garcia-Godos et al. 2013).

Many of the entangled humpback whales observed in Hawaiian waters brought the gear with them from higher latitude feeding grounds; for example, the whale the U.S. Navy rescued in 1996 had been entangled in gear that was traced to a recreational fisherman in southeast Alaska. Thus far, six of the entangled humpback whales observed in the Hawaiian Islands have been confirmed to be entangled in gear from Alaska. Nevertheless, humpback whales are also entangled in fishing gear in the Hawaiian Islands. Since 2001, there have been five observed interactions between humpback whales and gear associated with the Hawaii-based longline fisheries (NMFS 2008b). In each instance, however, all of the whales were disentangled and released or they were able to break free from the gear without reports of impairment of the animal's ability to swim or feed.

More humpback whales are killed in collisions with ships than any other whale species except fin whales (Jensen and Silber 2003). From 1975-2011, 68 collisions were actually witnessed in the main Hawaiian Islands, 63% involving calves and subadults, with the rate of collisions increasing over time even accounting for higher numbers of whales present (Lammers et al. 2013). Of these reports, 13 were confirmed as ship strikes and in seven cases, ship strike was determined to be the cause of death. Along Pacific Canada, 21 reports of ship strikes involving humpback whales were reported from 2001-2008 (COSEWIC 2011; Ford et al. 2009). From 2006-2010, 10 instances of mortality stemming from vessel collision were documented on the Pacific coast, a humpback whale is known to be killed about every other year by ship strikes (Barlow et al. 1997b). The humpback whale calf that was found stranded on Oahu with evidence of vessel collision (propeller cuts) in 1996 suggests that ship collisions might kill adults, juvenile, and calves (NMFS unpublished data). Although data for actual strikes is lacking off Pacific Panama, study of shipping data and satellite tag data on humpback whales showed that 8 of 15 whales tagged came within 200 m of 81 different ships on 98 occasions in a period of 11 days (Guzman et al. 2013).

Organochlorines, including PCB and DDT, have been identified in humpback whale blubber (Gauthier et al. 1997b). Higher PCB levels have been observed in western Atlantic waters versus Pacific waters along the United States and levels tend to increase with individual age (Elfes et al. 2010); eastern Atlantic individuals fall between these two in contaminant burden (Ryan et al. 2014) . Although humpback whales in the Gulf of Maine and off Southern California tend to have the highest PCB concentrations, overall levels are on par with other baleen whales, which are generally lower than odontocete cetaceans (Elfes et al. 2010). These contaminants are transferred to young through the placenta, leaving newborns with contaminant loads equal to that of mothers before bioaccumulating additional contaminants during life and passing the additional burden to the next generation (Metcalfe et al. 2004). Contaminant levels are relatively high in humpback whales as compared to blue whales. Humpback whales feed higher on the food chain, where prey carry higher contaminant loads than the krill that blue whales feed on.

Critical habitat. The NMFS has not designated critical habitat for humpback whales.

6.4 North Atlantic right whale

Population. All North Atlantic right whales compose a single population. Although not all individuals undergo the same migratory pattern, no subpopulation structuring has been identified.

Distribution. Right whales occur in sub-polar to temperate waters in all major ocean basins in the world, with a clear migratory pattern of high latitudes in summer and lower latitudes in winter (Cummings 1985; Perry et al. 1999; Rice 1998b). The historical range of North Atlantic right whales extended as far south as Florida and northwestern Africa, and as far north as Labrador, southern Greenland, Iceland, and Norway (Cummings 1985; Reeves et al. 1978; Rice 1998b). Recent sightings have been made through some of the broader historical range, including Iceland, Greenland, Norway, and the Azores (Hamilton et al. 2009; Hamilton et al. 2007; Jacobsen et al. 2004; Silva et al. 2012). Additional rare sightings have been made in the Gulf of Mexico (Moore and Clark 1963; Schmidly et al. 1972). Most sightings in the western North Atlantic are concentrated within five primary habitats or high-use areas: coastal waters of the southeastern U.S., Cape Cod and Massachusetts Bays, the Great South Channel, the Bay of Fundy, and the Scotian Shelf (Winn et al. 1986). In 1994, the first three of these areas were designated as critical habitat for the North Atlantic right whale.

North Atlantic right whales have been observed from the mid-Atlantic Bight northward through the Gulf of Maine year-round, but are primarily found along the northeast U.S. during summer and Florida during winter, with migratory routes in between. In New England, peak abundance of North Atlantic right whales in feeding areas occurs in Cape Cod Bay beginning in late winter.

In early spring (late February to April), peak North Atlantic right whale abundance occurs in Jordan and Wilkinson Basins to the Great South Channel (Kenney et al. 1995; Nichols et al. 2008; Pace III and Merrick 2008). In late June and July, North Atlantic right whale distribution gradually shifts to the northern edge of Georges Bank. In late summer (August) and fall, much of the population is found in waters in the Bay of Fundy, the western Gulf of Maine and around Roseway Basin (Kenney et al. 2001; Kenney et al. 1995; Pace III and Merrick 2008; Winn et al. 1986). However, year-to-year variation in space and time are known and likely result from patchy prey distribution (Nichols et al. 2008). Variation in the abundance and development of suitable food patches appears to modify the general patterns of movement by reducing peak numbers, stay durations, and specific locales (Brown et al. 2001; Kenney 2001). In particular, large changes in the typical pattern of food abundance will dramatically change the general pattern of North Atlantic right whale habitat use (Kenney 2001). Several sightings have been made along New Jersey during the approximate time frame of the proposed seismic survey (NSF 2014).

Migration and movement. North Atlantic right whales exhibit extensive migratory patterns, traveling along the eastern seaboard of the U.S. and Canada between calving grounds off Georgia and Florida to northern feeding areas off the northeast U.S. and Canada in March/April and the reverse direction in November/December. The longest tracking of a North Atlantic right whale was a migration of 1,200 miles in 23 days the Bay of Fundy to Georgia (Mate and Baumgartner 2001). Migrations are typically within 30 nautical miles of the coastline and in waters less than 160 feet deep. Although this pattern is well-known, most of the population, particularly the males and non-pregnant females, is not found in the calving area and may not follow this pattern. It is unknown where the majority of the non-calving population spends the winter. Whales may remain in their foraging habitat during winter (Morano et al. 2012).

There have been a few recent sightings of North Atlantic right whales far offshore, including those from Dutch ships indicating some individuals occur between 40° and 50° N, in waters influenced by the North Atlantic Current (the broad, eastward-flowing extension of the Gulf Stream). Right whales have been sighted offshore (greater than 30 miles) during surveys flown off the coast of northeastern Florida and southeastern Georgia from 1996 to 2001. These include three sightings in 1996, one in 1997, 13 in 1998, six in 1999, 11 in 2000, and six in 2001 (within each year, some were repeat sightings). Mate et al. (1997) recorded radio-tagged animals making extensive movements from the Gulf of Maine into deeper waters off the continental shelf (Mate et al. 1997). The frequency with which North Atlantic right whales occur in offshore waters in the southeastern U. S. remains unclear. Occasionally, individuals are observed in distant locations, including the Gulf of Mexico, Bermuda, Azores, the Gulf of St. Lawrence, Newfoundland, Greenland, Iceland, and northern Norway (an area known as a historical North Atlantic right whale feeding area Silva et al. 2012; Smith et al. 2006). The Norwegian sighting (September 1992) represents one of only two sightings this century of a right whale in Norwegian waters, and the first since 1926. Together, these long-range matches indicate an extended range for at least some individuals and perhaps the existence of important habitat areas not presently well described.

Reproduction, growth, and demography. Data through the 1990s suggests that mean calving interval increased since 1992 from 3.67 years to more than five years, a significant trend that hampers North Atlantic right whale recovery (Best et al. 2001a; Kraus et al. 2007). This reproductive rate was approximately half that reported from studied populations of southern right whales (Best et al. 2001b). This has been attributed to several possible causes, including higher abortion or perinatal losses (Browning et al. 2009). An analysis of the age structure of North Atlantic right whales suggests that the population contains a smaller proportion of juvenile whales than expected, which may reflect lowered recruitment and/or high juvenile mortality (Best et al. 2001a; Hamilton et al. 1998). In addition, it is possible that the apparently low reproductive rate is due in part to unstable age structure or to reproductive senescence on the part of some females. However, knowledge on either factor is poor. Even though investment in calves is high for North Atlantic right whales, an incident of calf exchange (probably accidentally and soon after birth) and subsequent adoption through weaning has been found (Frasier et al. 2010). Although North Atlantic right whales historically separated from their calves within one year, a shift appears to have taken place around 2001 where mothers (particularly less experienced mothers) return to wintering grounds with their yearling at a much greater frequency (71% overall)(Hamilton and Cooper. 2010). The significance of this change is unknown.

Calves reach roughly three-quarters of their adult body size by the time they wean at 12 months, roughly doubling their original body size and gaining about 36 kg daily (Fortune et al. 2012).

Habitat. Available evidence from North Atlantic right whale foraging and habitat studies shows that North Atlantic right whales focus foraging activities where physical oceanographic features such as water depth, current, and mixing fronts combine to concentrate copepods (Baumgartner et al. 2003; Davies et al. 2014; Mayo and Marx 1990; Murison and Gaskin 1989; Wishner et al. 1988).

Feeding. North Atlantic right whales fast during the winter and feed during the summer, although some may opportunistically feed during migration. North Atlantic right whales use their baleen to sieve copepods from dense patches, found in highly variable and spatially unpredictable locations in the Bay of Fundy, Roseway Basin, Cape Cod Bay, the Great South Channel, and other areas off of northern U.S. and Canada (Pendleton et al. 2009). The primary prey of North Atlantic right whales is zooplankton, especially shrimp-like copepods such as *Calanus* (Beardsley et al. 1996; Kenney et al. 1985b). North Atlantic right whales feed largely by skimming these prey from the ocean surface (Mayo and Marx 1990; Pivorunas 1979), but may feed anywhere in the water column (Goodyear 1993; Watkins and Schevill 1976; Watkins and Schevill 1979; Winn et al. 1995). Feeding behavior has only been observed in northern areas and not on calving grounds or during migration (Kraus et al. 1993).

Diving. Although North Atlantic right whales are known to be primarily surface feeders, foraging dives frequently extend to the deepest layers of the water column (Baumgartner et al. 2003; Goodyear 1993; Mate et al. 1997). North Atlantic right whale feeding dives are characterized by a rapid descent from the surface to between 80 and 175 m, where dives level off and individuals remain for 5 to 14 min before rapidly ascending back to the surface (Baumgartner and Mate 2003). Dive depth has been shown to be strongly correlated with the depth of peak copepod abundance (Baumgartner and Mate 2003). Prolonged periods at the surface have been noted for mothers and calves (Baumgartner and Mate 2003). Shallow foraging dives in the Great South Channel average 2 min and 6 to 8 m (Winn et al. 1995). However, dives along the outer shelf average 7 min (CETAP 1982b). Although North Atlantic right whales are not champion divers, they can dive to over 300 m (Mate et al. 1992). Group size varies, but is generally less than one dozen and singletons and pairs are most frequently observed (Jefferson et al. 1993).

North Atlantic right whales produce a variety of calls from 159-192 dB re: 1 μPa while in surface active groups on breeding grounds (Tryonis et al. 2013).

Vocalization and hearing. Right whales vocalize to communicate over long distances and for social interaction, including communication apparently informing others of prey patch presence (Biedron et al. 2005; Tyson and Nowacek 2005). Vocalization patterns amongst all right whale species are generally similar, with six major call types: scream, gunshot, blow, up call, warble, and down call (McDonald and Moore 2002; Parks and Tyack 2005). A large majority of vocalizations occur in the 300-600 Hz range with up- and down sweeping modulations (Vanderlaan et al. 2003). Vocalizations below 200 Hz and above 900 Hz were rare (Vanderlaan et al. 2003). Calls tend to be clustered, with periods of silence between clusters (Vanderlaan et al. 2003). Gunshot bouts last 1.5 hours on average and up to seven hours (Parks et al. 2012a). Blows are associated with ventilation and are generally inaudible underwater (Parks and Clark 2007). Up calls are 100-400 Hz (Gillespie and Leaper 2001). Gunshots appear to be a largely or exclusively male vocalization (Parks et al. 2005b). Smaller groups vocalize more than larger groups and vocalization is more frequent at night (Matthews et al. 2001). Moans are usually produced within 10 m of the surface (Matthews et al. 2001). Up calls were detected year-round in Massachusetts Bay except July and August and peaking in April (Mussoline et al. 2012). Individuals remaining in the Gulf of Maine through winter continue to call, showing a strong diel pattern of up call and gunshot vocalizations from November through January possibly associated with mating (Bort et al. 2011; Morano et al. 2012; Mussoline et al. 2012). Estimated source levels of gunshots in non-surface active groups are 201 dB re 1 μPa p-p (Hotchkin et al. 2011). While in surface active groups, females produce scream calls and males produce up calls and gunshot calls as threats to other males; calves (at least female calves) produce warble sounds similar top their mothers' screams (Parks et al. 2003; Parks and Tyack 2005). Source levels for these calls in surface active groups range from 137-162 dB rms re: 1 μPa-m, except for gunshots, which are 174-192 dB rms re: 1 μPa-m (Parks and Tyack 2005). Up calls may also be used to reunite mothers with calves (Parks and Clark 2007). Atlantic right whales shift calling frequencies, particularly of up calls, as well as increase call amplitude over both long and short term periods due to exposure to vessel noise (Parks and Clark 2007; Parks et al. 2005a; Parks et al. 2007a; Parks et al. 2011a; Parks et al. 2010; Parks et al. 2012b; Parks et al. 2006), particularly the peak frequency (Parks et al. 2009). North Atlantic right whales respond to anthropogenic sound designed to alert whales to vessel presence by surfacing (Nowacek et al. 2003; Nowacek et al. 2004b).

No direct measurements of right whale hearing have been undertaken (Parks and Clark 2007). Models based upon right whale auditory anatomy suggest a hearing range of 10 Hz to 22 kHz (Parks et al. 2007b).

Status and trends. The Northern right whale was originally listed as endangered in 1970 (35 FR 18319), and this status remained since the inception of the ESA in 1973. The early listing included both the North Atlantic and the North Pacific populations, although subsequent genetic studies conducted by Rosenbaum (2000) resulted in strong evidence that North Atlantic and North Pacific right whales are separate species. Following a comprehensive status review, NMFS concluded that North Atlantic and North Pacific right whales are separate species. In March 2008, NMFS published a final rule listing North Pacific and North Atlantic right whales as separate species (73 FR 12024).

North Atlantic right whales were formerly abundant, with an estimated 5,500 individuals present in the 16th century throughout the North Atlantic (Reeves 2001; Reeves et al. 2007). However, genetic evidence suggests a much large historical population size of 112,000 individuals (95 % CI 45,000–235,000)(Ruegg et al. 2013). A review of the photo-id recapture database in June 2006, indicated that only 313 individually recognized North Atlantic right whales were observed during 2001. Recent additions to the photo-ID catalog lead to a minimum population estimate of 444 individuals (Waring et al. 2013). This represents a nearly complete census, and the estimated minimum population size. However, no estimate of abundance with an associated coefficient of variation has been calculated for the population. Furthermore, 55% of fathers have not been genetically identified, suggesting the population may be significantly larger than presently thought (Frasier 2005). This also suggests the occurrence of right whales in as yet unidentified habitats (Frasier 2005). The population growth rate reported for the period 1986 to 1992 by Knowlton et al. (1994) was 2.5%, suggesting the stock was showing signs of slow recovery. However, work by Caswell et al. (1999) suggested that crude survival probability declined from about 0.99 in the early 1980's to about 0.94 in the late 1990s. Additional work conducted in 1999 showed that survival had indeed declined in the 1990s, particularly for adult females (Best et al. 2001a). Another workshop in September 2002 further confirmed the decline in this population (Clapham 2002). The best available estimate of population trajectory suggests the population is increasing at a rate of 2.6% over the 1990-2009 timeframe (Waring et al. 2013).

Natural threats. Several researchers have suggested that the recovery of North Atlantic right whales has been impeded by competition with other whales for food (Rice 1974a; Scarff 1986). Mitchell (1975) analyzed trophic interactions among baleen whales in the western North Atlantic and noted that the foraging grounds of North Atlantic right whales overlapped with the foraging grounds of sei whales. Both species feed preferentially on copepods. Mitchell (1975) argued that the North Atlantic right whale population had been depleted by several centuries of whaling before steam-driven boats allowed whalers to hunt sei whales; from this, he hypothesized that the decline of the right whale population made more food available to sei whales and helped their population to grow. He then suggested that competition with the sei whale population impedes or prevents the recovery of the right whale population. Shark predation has been repeatedly documented on right whales calves along the southeastern U.S., some of which may be fatal (Taylor et al. 2013).

Other natural factors influencing right whale recovery are possible, but unquantified. Right whales have been subjects of killer whale attacks and, because of their robust size and slow swimming speed, tend to fight killer whales when confronted (Ford and Reeves 2008). Similarly, mortality or debilitation from disease and red tide events are not known, but have the potential to be significant problems in the recovery of right whales because of their small population size.

Anthropogenic threats. Several human activities are known to threaten North Atlantic right whales: whaling, commercial fishing, shipping, and environmental contaminants. Historically, whaling represented the greatest threat to every population of right whales and was ultimately responsible for listing right whales as an endangered species. As its legacy, whaling reduced North Atlantic right whales to about 300 individuals in the western North Atlantic Ocean; the number of North Atlantic right whales in the eastern North Atlantic Ocean is probably much smaller, if present at all.

Concern also exists over climate change and its effect on the ability of North Atlantic right whales to recover (Greene et al. 2003b). Specifically, the variations in oceanography resulting from current shifts and water temperatures can significantly affect the occurrence of the North Atlantic right whale's primary food, copepod crustaceans. If climate changes such that current feeding areas cannot sustain North Atlantic right whales, the population may have to shift to reflect changes in prey distribution, pursue other prey types, or face prey shortage. Changes in calving intervals with sea surface temperature have already been documented for southern right whales (Leaper et al. 2006).

North Atlantic right whales, as with many marine mammals, are exposed to numerous toxins in their environment, many of which are introduced by humans. Levels of chromium in North Atlantic right whale tissues are sufficient to be mutagenic and cause cell death in lung, skin, or testicular cells and are a concern for North Atlantic right whale recovery (Chen et al. 2009; Wise et al. 2008). The organochlorines DDT, DDE, PCBs, dieldrin, chlordane, HCB, and heptachlor epoxide have been isolated from blubber samples and reported concentrations may underestimate actual levels (Woodley et al. 1991). Mean PCB levels in North Atlantic right whales are greater than any other baleen whale species thus far measured, although less than one-quarter of the levels measured in harbor porpoises (Gauthier et al. 1997a; Van Scheppingen et al. 1996). Organochlorines and pesticides, although variable in concentration by season, do not appear to currently threaten North Atlantic right whale health and recovery (Weisbrod et al. 2000). Flame retardants such as polybrominated diphenyl ethers (PBDEs) (known to be carcinogenic) have also been measured in North Atlantic right whales (Montie et al. 2010).

Critical habitat. Critical habitat is designated for right whales in the North Atlantic. NMFS designated three areas in June 1994 as critical habitat for *Eubalaena glacialis* for feeding and calving (59 FR 28805). The critical habitats for feeding cover portions of the Great South Channel (east of Cape Cod), Massachusetts Bay and Cape Cod Bay, and Stellwagen Bank. Northern critical habitat was designated because of the concentration of right whales that feed in the area, apparently associated with complex oceanographic features that drive prey density and distribution. This area has come under considerable scrutiny within the past few years because of the concern over ship strikes in this area. Boston serves as a major port facility and vessels transiting to and from the port cross critical habitat where North Atlantic right whale mortality occurs. Shipping traffic has generally increased in the recent past and could be considered to degrade the habitat due to the additional mortality and injury risk now present in the area. Although voluntary regulations are in place, these are frequently ignored and mandatory regulations are under consideration. The southern critical habitats are along Georgia and northeastern Florida coasts (waters from the coast out 15 nautical miles between the latitudes of 31°15' N and 30°15' N and from the coast out five nautical miles between 30°15' N and 28°00' N). Southern critical habitat is designated to protected calving and breeding grounds for North Atlantic right whales, which generally calve and breed in shallow coastal waters. This critical habitat has generally fared better than northern critical habitat and significant degradation has not been clearly identified. Modeling efforts suggest water temperature and depth are driving factors for right whale occurrence along the coasts of Florida and Georgia during winter, some of which occur in designated critical habitat and some of which do not (Keller et al. 2012).

6.5 Sei whale

Population designations. The population structure of sei whales is unknown and populations herein assume (based upon migratory patterns) population structuring is discrete by ocean basin (north and south), except for sei whales in the Southern Ocean, which may form a ubiquitous population or several discrete ones.

North Atlantic. In the western North Atlantic, a major portion of the sei whale population occurs in northern waters, potentially including the Scotian Shelf, along Labrador and Nova Scotia, south into the U. S. EEZ, including the Gulf of Maine and Georges Bank (Mitchell and Chapman 1977; Waring et al. 2004). These whales summer in northern areas before migrating south to waters along Florida, in the Gulf of Mexico, and the northern Caribbean Sea (Gambell 1985b; Mead 1977). Sei whales may range as far south as North Carolina. In the U. S. EEZ, the greatest abundance occurs during spring, with most sightings on the eastern edge of Georges Bank, in the Northeast Channel, and in Hydrographer Canyon (CETAP 1982a). In 1999, 2000, and 2001, the NMFS aerial surveys found sei whales concentrated along the northern edge of Georges Bank during spring (Waring et al. 2004). Surveys in 2001 found sei whales south of Nantucket along the continental shelf edge (Waring et al. 2004). During years of greater prey abundance (e.g., copepods), sei whales are found in more inshore waters, such as the Great South Channel (1987 and 1989), Stellwagen Bank (1986), and the Gulf of Maine (Payne et al. 1990a; Schilling et al. 1992). In the eastern Atlantic, sei whales occur in the Norwegian Sea, occasionally occurring as far north as Spitsbergen Island, and migrate south to Spain, Portugal, and northwest Africa (Gambell 1985b; Jonsgård and Darling 1977). Sei whales have rarely been sighted along New Jersey during the approximate time frame of the proposed seismic survey (NSF 2014).

North Pacific. Some mark-recapture, catch distribution, and morphological research indicate more than one population may exist – one between 155°-175° W, and another east of 155° W (Masaki 1976; Masaki 1977). Sei whales have been reported primarily south of the Aleutian Islands, in Shelikof Strait and waters surrounding Kodiak Island, in the Gulf of Alaska, and inside waters of southeast Alaska and south to California to the east and Japan and Korea to the west (Leatherwood et al. 1982; Nasu 1974). Sightings have also occurred in Hawaiian waters (Smultea et al. 2010). Sei whales have been occasionally reported from the Bering Sea and in low numbers on the central Bering Sea shelf (Hill and DeMaster 1998a). Whaling data suggest that sei whales do not venture north of about 55° N (Gregr et al. 2000). Masaki (1977) reported sei whales concentrating in the northern and western Bering Sea from July-September, although other researchers question these observations because no other surveys have reported sei whales in the northern and western Bering Sea. Horwood (1987) evaluated Japanese sighting data and concluded that sei whales rarely occur in the Bering Sea. Horwood (1987) reported that 75-85% of the North Pacific population resides east of 180°.

Southern Hemisphere. Sei whales occur throughout the Southern Ocean during the austral summer, generally between 40°-50° S (Gambell 1985b). During the austral winter, sei whales occur off Brazil and the western and eastern coasts of southern Africa and Australia, although all of the 20 sightings off Argentina occurred in August or September (Iniguez et al. 2010). However, sei whales generally do not occur north of 30º S in the Southern Hemisphere (Reeves et al. 1999). However, confirmed sighting records exist for Papua New Guinea and New Caledonia, with unconfirmed sightings in the Cook Islands (Programme) 2007).

There is little information on the population structure of sei whales in the Antarctic; some degree of isolation appears to exist, although sei whale movements are dynamic and individuals move between stock designation areas (Donovan 1991; IWC 1980a).

Movement. The migratory pattern of this species is thought to encompass long distances from high-latitude feeding areas in summer to low-latitude breeding areas in winter; however, the location of winter areas remains largely unknown (Perry et al. 1999). Sei whales are often associated with deeper waters and areas along continental shelf edges (Hain et al. 1985). This general offshore pattern is disrupted during occasional incursions into shallower inshore waters (Waring et al. 2004). The species appears to lack a well-defined social structure and individuals are usually found alone or in small groups of up to six whales (Perry et al. 1999). When on feeding grounds, larger groupings have been observed (Gambell 1985b).

Reproduction. Very little is known regarding sei whale reproduction. Reproductive activities for sei whales occur primarily in winter. Gestation is about 12.7 months, calves are weaned at 6-9 months, and the calving interval is about 2-3 years (Gambell 1985b; Rice 1977). Sei whales become sexually mature at about age 10 (Rice 1977). Of 32 adult female sei whales harvested by Japanese whalers, 28 were found to be pregnant while one was pregnant and lactating during May-July 2009 cruises in the western North Pacific (Tamura et al. 2009).

Feeding. Sei whales are primarily planktivorous, feeding mainly on euphausiids and copepods, although they are also known to consume fish (Waring et al. 2006). In the Northern Hemisphere, sei whales consume small schooling fish such as anchovies, sardines, and mackerel when locally abundant (Konishi et al. 2009; Mizroch et al. 1984; Rice 1977).

Vocalization and hearing. Data on sei whale vocal behavior is limited, but includes records off the Antarctic Peninsula of broadband sounds in the 100-600 Hz range with 1.5 sec duration and tonal and upsweep calls in the 200-600 Hz range of 1-3 sec durations (McDonald et al. 2005). Source levels of 189 ±5.8 dB re 1 µPa at 1m have been established for sei whales in the northeastern Pacific (Weirathmueller et al. 2013). Differences may exist in vocalizations between ocean basins (Rankin and Barlow 2007a). The first variation consisted of sweeps from 100 to 44 Hz, over 1.0 sec. During visual and acoustic surveys conducted in the Hawaiian Islands in 2002, Rankin and Barlow (2007b) recorded 107 sei whale vocalizations, which they classified as two variations of low-frequency downswept calls. The second variation, which was more common (105 out of 107) consisted of low frequency calls which swept from 39 to 21 Hz over 1.3 sec. These vocalizations are different from sounds attributed to sei whales in the Atlantic and Southern Oceans but are similar to sounds that had previously been attributed to fin whales in Hawaiian waters. Vocalizations from the North Atlantic consisted of paired sequences (0.5-0.8 sec, separated by 0.4-1.0 sec) of 10-20 short (4 ms) FM sweeps between 1.5-3.5 kHz (Thomson and Richardson 1995).

Status and trends. The sei whale was originally listed as endangered in 1970 (35 FR 18319), and this status remained since the inception of the ESA in 1973. Consideration of the status of populations outside of the action area is important under the present analysis to determine the how risk the risk to the affected population(s) bears on the status of the species as a whole. Table 6 provides estimates of historic and current abundance for ocean regions.

Table 6. Summary of past and present sei whale abundance.

Region	Population, stock, or study area	Pre-exploitation estimate	95% CI	Recent estimate	95% CI	Source
Global	--	>105,000	--	25,000	--	(Braham 1991)
North Atlantic	Basinwide	--	--	>4000	--	(Braham 1991)
	~~			>13,500		(Sigurjonsson 1995)
	NMFS-Nova Scotia stock	--	--	386	--	(NMFS 2008a; Waring et al. 2012)
	Northeast Atlantic	--	--	10,300	0.268	(Cattanach et al. 1993)
North Pacific	Basinwide	42,000	--	7,260-12,620*	--	(Tillman 1977); *circa 1974
	NMFS-eastern North Pacific stock	--	--	126	CV=0.53	(Carretta et al. 2012)
	NMFS-HI stock	--	--	77	CV=1.06	(Carretta et al. 2012)
Southern Hemisphere	Basinwide	63,100	--	--	--	(Mizroch et al. 1984)
	Basinwide	65,000	--	--	--	(Braham 1991)
	South of 60°S	--	--	626	553-699	(IWC 1996)
	South of 30°S	--	--	9,718	--	(IWC 1996)

*Note: Confidence Intervals (C.I.) not provided by the authors were calculated from Coefficients of Variation (C.V.) where available, using the computation from Gotelli and Ellison (2004).

North Atlantic. No information on sei whale abundance exists prior to commercial whaling (Perry et al. 1999). Between 1966 and 1972, whalers from land stations on the east coast of Nova Scotia engaged in extensive hunts of sei whales on the Nova Scotia shelf, killing about 825 individuals (Mitchell and Chapman 1977). In 1974, the North Atlantic stock was estimated to number about 2,078 individuals, including 965 whales in the Labrador Sea group and 870 whales in the Nova Scotia group (Mitchell and Chapman 1977). In the northwest Atlantic, Mitchell and Chapman (1977) estimated the Nova Scotia stock to contain 1,393-2,248 whales; an aerial survey program conducted from 1978 to 1982 on the continental shelf and edge between Cape Hatteras, North Carolina, and Nova Scotia generated an estimate of 280 sei whales (CETAP 1982a). These two estimates are more than 30 years out of date and likely do not reflect the current true abundance; in addition, the CETAP estimate has a high degree of uncertainty and is considered statistically unreliable (Perry et al. 1999; Waring et al. 2004; Waring et al. 1999). The total number of sei whales in the U. S. Atlantic EEZ remains unknown (Waring et al. 2006). Rice (1977) estimated total annual mortality for adult females as 0.088 and adult males as 0.103.

North Pacific. Ohsumi and Fukuda (1975) estimated that sei whales in the North Pacific numbered about 49,000 whales in 1963, had been reduced to 37,000-38,000 whales by 1967, and reduced again to 20,600-23,700 whales by 1973. From 1910-1975, approximately 74,215 sei whales were caught in the entire North Pacific Ocean (Horwood 1987; Perry et al. 1999). From the early 1900s, Japanese whaling operations consisted of a large proportion of sei whales: 300-600 sei whales were killed per year from 1911-1955. The sei whale catch peaked in 1959, when 1,340 sei whales were killed. In 1971, after a decade of high sei whale catch numbers, sei whales were scarce in Japanese waters. Japanese and Soviet catches of sei whales in the North Pacific and Bering Sea increased from 260 whales in 1962 to over 4,500 in 1968-1969, after which the sei whale population declined rapidly (Mizroch et al. 1984). This estimate does not account for over-reporting by Soviet whalers, who took approximately 3,700 fewer individuals than were reported (Ivashchenko et al. 2013). When commercial whaling for sei whales ended in 1974, the population in the North Pacific had been reduced to 7,260-12,620 animals (Tillman 1977). There have been no direct estimates of sei whale populations for the eastern Pacific Ocean (or the entire Pacific). Between 1991-2001, during aerial surveys, there were two confirmed sightings of sei whales along the U. S. Pacific coast.

Natural threats. Andrews (1916) suggested that killer whales attacked sei whales less frequently than fin and blue whales in the same areas. Sei whales engage in a flight responses to evade killer whales, which involves high energetic output, but show little resistance if overtaken (Ford and Reeves 2008). Endoparasitic helminths (worms) are commonly found in sei whales and can result in pathogenic effects when infestations occur in the liver and kidneys (Rice 1977).

Anthropogenic threats. Human activities known to threaten sei whales include whaling, commercial fishing, and maritime vessel traffic. Historically, whaling represented the greatest threat to every population of sei whales and was ultimately responsible for listing sei whales as an endangered species. Sei whales are thought to not be widely hunted, although harvest for scientific whaling or illegal harvesting may occur in some areas. In 2009, 100 sei whales were killed during western North Pacific surveys (Bando et al. 2010).

Sei whales are known to accumulate DDT, DDE, and PCBs (Borrell 1993; Borrell and Aguilar 1987; Henry and Best 1983). Males carry larger burdens than females, as gestation and lactation transfer these toxins from mother to offspring.

Critical habitat. The NMFS has not designated critical habitat for sei whales.

6.6 Sperm whale

Populations. There is no clear understanding of the global population structure of sperm whales (Dufault et al. 1999). Recent ocean-wide genetic studies indicate low, but statistically significant, genetic diversity and no clear geographic structure, but strong differentiation between social groups (Lyrholm and Gyllensten 1998; Lyrholm et al. 1996; Lyrholm et al. 1999). Chemical analysis also suggest significant differences in diet for animals captured in different regions of the North Atlantic. However, vocal dialects indicate parent-offspring transmission that support differentiation in populations (Rendell et al. 2011). Therefore, population-level differences may be more extensive than are currently understood.

The IWC currently recognizes four sperm whale stocks: North Atlantic, North Pacific, northern Indian Ocean, and Southern Hemisphere (Dufault et al. 1999; Reeves and Whitehead 1997). The NMFS recognizes six stocks under the MMPA- three in the Atlantic/Gulf of Mexico and three in the Pacific (Alaska, California-Oregon-Washington, and Hawaii; (Perry et al. 1999; Waring et al. 2004)). Genetic studies indicate that movements of both sexes through expanses of ocean basins are common, and that males, but not females, often breed in different ocean basins than the ones in which they were born (Whitehead 2003). Sperm whale populations appear to be structured socially, at the level of the clan, rather than geographically (Whitehead 2003; Whitehead et al.

2008). Matrilinear groups in the eastern Pacific share nuclear DNA within broader clans, but North Atlantic matrilinear groups do not share this genetic heritage (Whitehead et al. 2012).

North Atlantic. In the western North Atlantic, sperm whales range from Greenland south into the Gulf of Mexico and the Caribbean, where they are common, especially in deep basins off of the continental shelf (Romero et al. 2001; Wardle et al. 2001). The northern distributional limit of female/immature pods is probably around Georges Bank or the Nova Scotian shelf (Whitehead et al. 1991). Seasonal aerial surveys confirm that sperm whales are present in the northern Gulf of Mexico in all seasons (Hansen et al. 1996; Mullin et al. 1994). Sperm whale distribution follows a distinct seasonal cycle, concentrating east-northeast of Cape Hatteras in winter and shifting northward in spring when whales are found throughout the mid-Atlantic Bight. Distribution extends further northward to areas north of Georges Bank and the Northeast Channel region in summer and then south of New England in fall, back to the Mid-Atlantic Bight. A long-term study of sperm whales along Dominica, West Indies supports 17 discreet groups habituating this area (Gero et al. 2013). In the eastern Atlantic, mature male sperm whales have been recorded as far north as Spitsbergen (Øien 1990). Recent observations of sperm whales and stranding events involving sperm whales from the eastern North Atlantic suggest that solitary and paired mature males predominantly occur in waters off Iceland, the Faroe Islands, and the Norwegian Sea (Christensen et al. 1992a; Christensen et al. 1992b; Gunnlaugsson and Sigurjónsson 1990; Øien 1990). Hundreds of sightings have been made along New Jersey during the approximate time frame of the proposed seismic survey (NSF 2014).

Gulf of Mexico. Although movement between the North Atlantic and Gulf of Mexico have been documented, Gulf of Mexico individuals are genetically distinct from the Mediterranean and North Atlantic relatives (Engelhaupt 2004; Waring et al. 2013). The acoustic dialect used by this group is also different from other sperm whales in the North Atlantic (Waring et al. 2013).

North Pacific. Sperm whales are found throughout the North Pacific and are distributed broadly in tropical and temperate waters to the Bering Sea as far north as Cape Navarin in summer, and occur south of 40^{o} N in winter (Gosho et al. 1984; Miyashita et al. 1995 as cited in Carretta et al. 2005; Rice 1974b). Sperm whales are found year-round in Californian and Hawaiian waters (Barlow 1995; Dohl et al. 1983; Forney et al. 1995; Lee 1993; Mobley Jr . et al. 2000; Rice 1960; Shallenberger 1981), but they reach peak abundance from April through mid-June and from the end of August through mid-November (Rice 1974b). They are seen in every season except winter (December-February) off Washington and Oregon (Green et al. 1992). Summer/fall surveys in the eastern tropical Pacific (Wade and Gerrodette 1993) show that although sperm whales are widely distributed in the tropics, their relative abundance tapers off markedly towards the middle of the tropical Pacific and northward towards the tip of Baja California (Carretta et al. 2006). Sperm whales occupying the California Current region are genetically distinct from those in the eastern tropical Pacific and Hawaiian waters (Mesnick et al. 2011), although occurrence seems to be continuance from California through Hawaii (Barlow and Taylor 2005). The discreteness of the latter two areas remains uncertain (Mesnick et al. 2011).

Mediterranean. Sperm whales are found from the Alboran Sea to the Levant Basin, primarily over steep slope and deep offshore waters. Sperm whales are rarely sighted in the Sicilian Channel, and are vagrants to the northern Adriatic and Aegean seas (Notarbartolo di Sciara and Demma 1997). In Italian seas, sperm whales are more frequently associated with the continental slope off western Liguria, western Sardinia, northern and eastern Sicily, and both coasts of Calabria. This represents a genetically distinct population from the Atlantic (Notarbartolo-Di-Sciara 2013).

Southern Hemisphere. All sperm whales of the Southern Hemisphere are treated as a single stock with nine divisions, although this designation has little biological basis and is more in line with whaling records (Donovan 1991). Sperm whales that occur off the Galapagos Islands, mainland Ecuador, and northern Peru may be distinct from other sperm whales in the Southern Hemisphere (Dufault and Whitehead 1995; Rice 1977; Wade and Gerrodette 1993). Gaskin (1973) found females to be absent in waters south of 50º and decrease in proportion to males south of 46-47º.

Indian Ocean. Sperm whales have been found to be particularly abundant south of the Maldives (Clark et al. 2012).

Movement. Mature males range between 70º N in the North Atlantic and 70º S in the Southern Ocean (Perry et al. 1999; Reeves and Whitehead 1997), whereas mature females and immature individuals of both sexes are seldom found higher than 50º N or S (Reeves and Whitehead 1997). In winter, sperm whales migrate closer to equatorial waters (Kasuya and Miyashita 1988; Waring et al. 1993) where adult males join them to breed. Males identified in the Azores have been resighted in Norwegian waters (Steiner et al. 2012). In the North Pacific, female sperm whales and their calves are usually found in tropical and temperate waters year round, while it is generally understood that males move north in the summer to feed in the Gulf of Alaska, Bering Sea, and waters off of the Aleutian Islands (Kasuya and Miyashita 1988). Movement patterns of Pacific female and immature male groups appear to follow prey distribution and, although not random, movements are difficult to anticipate and are likely associated with feeding success, perception of the environment, and memory of optimal foraging areas (Whitehead et al. 2008). However, no sperm whale in the Pacific has been known to travel to points over 5,000 km apart and only rarely have been known to move over 4,000 km within a time frame of several years. This means that although sperm whales do not appear to cross from eastern to western sides of the Pacific (or vice-versa), significant mixing occurs that can maintain genetic exchange. Movements of several hundred kilometers are common (i.e. between the Galapagos Islands and the Pacific coastal Americas). Movements appear to be group or clan specific, with some groups traveling straighter courses than others over the course of several days. However, general transit speed averages about 4 km/h. Sperm whales in the Caribbean region appear to be much more restricted in their movements, with individuals repeatedly sighted within less than 160 km of previous sightings.

Habitat. Sperm whales have a strong preference for waters deeper than 1,000 m (Reeves and Whitehead 1997; Watkins 1977), although Berzin (1971) reported that they are restricted to waters deeper than 300 m. While deep water is their typical habitat, sperm whales are rarely found in waters less than 300 m in depth (Clarke 1956; Rice 1989c). Sperm whales have been observed near Long Island, New York, in water between 40-55 m deep (Scott and Sadove 1997). When they are found relatively close to shore, sperm whales are usually associated with sharp increases in topography where upwelling occurs and biological production is high, implying the presence of a good food supply (Clarke 1956). Such areas include oceanic islands and along the outer continental shelf.

Sperm whales are frequently found in locations of high productivity due to upwelling or steep underwater topography, such as continental slopes, seamounts, or canyon features (Jaquet and

Whitehead 1996; Jaquet et al. 1996). Cold-core eddy features are also attractive to sperm whales in the Gulf of Mexico, likely because of the large numbers of squid that are drawn to the high concentrations of plankton associated with these features (Biggs et al. 2000; Davis et al. 2000c; Davis et al. 2000d; Davis et al. 2000e; Davis et al. 2002; Wormuth et al. 2000). Surface waters with sharp horizontal thermal gradients, such as along the Gulf Stream in the Atlantic, may also be temporary feeding areas for sperm whales (Griffin 1999; Jaquet et al. 1996; Waring et al. 1993). Sperm whales over George’s Bank were associated with surface temperatures of 23.2-24.9° C (Waring et al. 2003).

Reproduction. Female sperm whales become sexually mature at an average of 9 years or 8.25-8.8 m (Kasuya 1991). Males reach a length of 10 to 12 m at sexual maturity and take 9-20 years to become sexually mature, but require another 10 years to become large enough to successfully breed (Kasuya 1991; Würsig et al. 2000). Mean age at physical maturity is 45 years for males and 30 years for females (Waring et al. 2004). Adult females give birth after roughly 15 months of gestation and nurse their calves for 2-3 years (Waring et al. 2004). The calving interval is estimated to be every 4-6 years between the ages of 12 and 40 (Kasuya 1991; Whitehead et al. 2008). It has been suggested that some mature males may not migrate to breeding grounds annually during winter, and instead may remain in higher latitude feeding grounds for more than one year at a time (Whitehead and Arnbom 1987).

Sperm whale age distribution is unknown, but sperm whales are believed to live at least 60 years (Rice 1978b). Estimated annual mortality rates of sperm whales are thought to vary by age, but previous estimates of mortality rate for juveniles and adults are now considered unreliable (IWC 1980b). In addition to anthropogenic threats, there is evidence that sperm whale age classes are subject to predation by killer whales (Arnbom et al. 1987; Pitman et al. 2001).

Stable, long-term associations among females form the core of sperm whale societies (Christal et al. 1998). Up to about a dozen females usually live in such groups, accompanied by their female and young male offspring. Young individuals are subject to alloparental care by members of either sex and may be suckled by non-maternal individuals (Gero et al. 2009). Group sizes may be smaller overall in the Caribbean Sea (6-12 individuals; 7-9 along Dominica) versus the Pacific (25-30 individuals)(Gero et al. 2013; Jaquet and Gendron 2009). Groups may be stable for long periods, such as for 80 days in the Gulf of California (Jaquet and Gendron 2009). Males start leaving these family groups at about six years of age, after which they live in “bachelor schools,” but this may occur more than a decade later (Pinela et al. 2009). The cohesion among males within a bachelor school declines with age. During their breeding prime and old age, male sperm whales are essentially solitary (Christal and Whitehead 1997).

Diving. Sperm whales are one of the deepest and longest diving mammalian species, with dives to 3 km down and durations in excess of 2 hours (Clarke 1976; Watkins et al. 1993; Watkins et al. 1985). However, dives are generally shorter (25- 45 min) and shallower (400-1,000 m). Dives are separated by 8-11 min rests at the surface (Gordon 1987; Jochens et al. 2006; Papastavrou et al. 1989; Watwood et al. 2006; Würsig et al. 2000). Sperm whales typically travel ~3 km horizontally and 0.5 km vertically during a foraging dive (Whitehead 2003). Differences in night and day diving patterns are not known for this species, but, like most diving air-breathers for which there are data (rorquals, fur seals, and chinstrap penguins), sperm whales probably make relatively shallow dives at night when prey are closer to the surface.

Feeding. Sperm whales appear to feed regularly throughout the year (NMFS 2006c). It is estimated they consume about 3-3.5% of their body weight daily (Lockyer 1981). They seem to forage mainly on or near the bottom, often ingesting stones, sand, sponges, and other non-food items (Rice 1989c). A large proportion of a sperm whale's diet consists of low-fat, ammoniacal, or luminescent squids (Clarke 1996; Clarke 1980b; Martin and Clarke 1986). While sperm whales feed primarily on large and medium-sized squids, the list of documented food items is fairly long and diverse. Prey items include other cephalopods, such as octopi, and medium- and large-sized demersal fishes, such as rays, sharks, and many teleosts (Angliss and Lodge 2004; Berzin 1972; Clarke 1977; Clarke 1980a; Rice 1989c). The diet of large males in some areas, especially in high northern latitudes, is dominated by fish (Rice 1989c). In some areas of the North Atlantic, however, males prey heavily on the oil-rich squid *Gonatus fabricii*, a species also frequently eaten by northern bottlenose whales (Clarke 1997).

Vocalization and hearing. Sound production and reception by sperm whales are better understood than in most cetaceans. Sperm whales produce broad-band clicks in the frequency range of 100 Hz to 20 kHz that can be extremely loud for a biological source (200-236 dB re 1μPa), although lower source level energy has been suggested at around 171 dB re 1 μPa (Goold and Jones 1995; Møhl et al. 2003; Weilgart and Whitehead 1993; Weilgart and Whitehead 1997). Most of the energy in sperm whale clicks is concentrated at around 2-4 kHz and 10-16 kHz (Goold and Jones 1995; NMFS 2006d; Weilgart and Whitehead 1993). The highly asymmetric head anatomy of sperm whales is likely an adaptation to produce the unique clicks recorded from these animals (Cranford 1992; Norris and Harvey 1972; Norris and Harvey. 1972). Long, repeated clicks are associated with feeding and echolocation (Goold and Jones 1995; Weilgart and Whitehead 1993; Weilgart and Whitehead 1997). However, clicks are also used in short patterns (codas) during social behavior and intragroup interactions (Weilgart and Whitehead 1993). They may also aid in intra-specific communication. Another class of sound, "squeals", are produced with frequencies of 100 Hz to 20 kHz (e.g., Weir et al. 2007).

Our understanding of sperm whale hearing stems largely from the sounds they produce. The only direct measurement of hearing was from a young stranded individual from which auditory evoked potentials were recorded (Carder and Ridgway 1990). From this whale, responses support a hearing range of 2.5-60 kHz. However, behavioral responses of adult, free-ranging individuals also provide insight into hearing range; sperm whales have been observed to frequently stop echolocating in the presence of underwater pulses made by echosounders and submarine sonar (Watkins et al. 1985; Watkins and Schevill 1975). They also stop vocalizing for brief periods when codas are being produced by other individuals, perhaps because they can hear better when not vocalizing themselves (Goold and Jones 1995). Because they spend large amounts of time at depth and use low-frequency sound, sperm whales are likely to be susceptible to low frequency sound in the ocean (Croll et al. 1999).

Status and trends. Sperm whales were originally listed as endangered in 1970 (35 FR 18319), and this status remained with the inception of the ESA in 1973. Although population structure of sperm whales is unknown, several studies and estimates of abundance are available. Consideration of the status of populations outside of the action area is important under the present analysis to determine how the risk to the affected population(s) bears on the status of the species as a whole. Table 7 contains historic and current estimates of sperm whales by region. Sperm whale populations probably are undergoing the dynamics of small population sizes, which is a threat in and of itself. In particular, the loss of sperm whales to directed Soviet whaling likely inhibits recovery due to the loss of adult females and their calves, leaving sizeable gaps in demographic and age structuring (Whitehead 2003). Small changes in reproductive parameters, such as the loss of adult females, can significantly alter the population trajectory of sperm whale populations (Chiquet et al. 2013).

Table 7. Summary of past and present sperm whale abundance.

Region	Population, stock, or study area	Pre-exploitation estimate	95% CI	Recent estimate	95% CI	Source
Global	~~	~~	~~	900,000	~~	(Würsig et al. 2000)
	~~	1,110,000	672,000-1,512,000	360,000	105,984-614,016*	(Whitehead 2002)
North Atlantic	Basinwide-females	224,800	~~	22,000	~~	(Gosho et al. 1984; Würsig et al. 2000)
	Northeast Atlantic, Faroes, Iceland, and U.S. East coast	~~	~~	13,190	~~	(Whitehead 2002)
	NMFS-North Atlantic stock	>4,685*	~~	4,804	1,226-8,382*	(Waring et al. 2012)
	Iceland	~~	~~	1,234	823-1,645*	(Gunnlaugsson and Sigurjónsson 1990)
	Faroe Islands	~~	~~	308	79-537*	(Gunnlaugsson and Sigurjónsson 1990)
	Norwegian Sea	~~	~~	5,231	2,053-8,409*	(Christensen et al. 1992b)
	Northern Norway to Spitsbergen	15,000	~~	2,548	1,200-3,896*	(Øien 1990)
Gulf of Mexico	NMFS-Gulf of Mexico stock	~~	~~	763	CV=0.38	(NMFS 2008a) (Waring et al. 2013)
	Off Mississippi River Delta	~~	~~	398	253-607	(Jochens et al. 2006)
	North-central and northwestern Gulf of Mexico	~~	~~	87	52-146	(Mullin et al. 2004)
North Pacific	Basinwide	620,400	~~	472,100	~~	(Gosho et al. 1984)
	~~	~~	~~	930,000	~~	(Rice 1989c)
	Eastern tropical Pacific	~~	~~	26,053	13,797-38,309	(Whitehead 2003)
	Costa Rica	~~	~~	1,360	832-2,248*	(Gerrodette and Palacios 1996)
	Central America	~~	~~	333	125-890*	(Gerrodette and

	north of Costa Rica					Palacios 1996)
	Eastern tropical Pacific, eastern North Pacific, Hawaii, and western North Pacific	~~	~~	76,803	~~	(Whitehead 2002)
	Hawaii	~~	~~	5,531	~~	(Carretta et al. 2007)
	Western North Pacific	~~	~~	29,674	~~	(Whitehead 2002)
	Eastern North Pacific	~~	~~	1,719	~~	(Carretta et al. 2007)
	Eastern temperate North Pacific	~~	~~	26,300	0-68,054*	(Barlow and Taylor 2005)
	~~	~~	~~	32,100	9,450-54,750*	(Barlow and Taylor 2005)
	NMFS-CA/OR/WA stock	~~	~~	971	CV=0.31*	(Carretta et al. 2008; Carretta et al. 2013)
	NMFS-HI stock	~~	~~	6,919	CV=0.81	(Carretta et al. 2008; Carretta et al. 2013)
Southern Hemisphere	Basinwide	547,600	~~	299,400	~~	(Gosho et al. 1984; IWC 1988; Perry et al. 1999)
	South of 60°S	~~	~~	14,000	8,786-19,214*	(Butterworth et al. 1995) as cited in (Perry et al. 1999)
	South of 60°S	~~	~~	12,069	~~	(Whitehead 2002b)
	South of 30°S	~~	~~	128,000	17,613-238,387*	(Butterworth et al. 1995) as cited in (Perry et al. 1999)

*Note: Confidence Intervals (C.I.) not provided by the authors were calculated from Coefficients of Variation (C.V.) where available, using the computation from Gotelli and Ellison (2004).

North Atlantic. 190,000 sperm whales were estimated to have been in the entire North Atlantic, but CPUE data from which this estimate is derived are unreliable according to the IWC (Perry et al. 1999). The total number of sperm whales in the western North Atlantic is unknown (Waring et al. 2008). Sperm whale were widely harvested from the northeastern Caribbean (Romero et al. 2001) and the Gulf of Mexico where sperm whale fisheries operated during the late 1700s to the early 1900s (NMFS 2006c; Townsend 1935).

North Pacific. There was a dramatic decline in the number of females around the Galapagos Islands during 1985-1999 versus 1978-1992 levels, likely due to migration to nearshore waters of South and Central America (Whitehead 2003).

Hill and DeMaster (1999) concluded that about 258,000 sperm whales were harvested in the North Pacific between 1947-1987. This estimate does not account for under-reporting by Soviet whalers, who took approximately 31,000 more individuals than were reported (Ivashchenko et al. 2013). Although the IWC protected sperm whales from commercial harvest in 1981, Japanese whalers continued to hunt sperm whales in the North Pacific until 1988 (Reeves and Whitehead 1997). In 2000, the Japanese Whaling Association announced plans to kill 10 sperm whales in the Pacific Ocean for research. Although consequences of these deaths are unclear, the paucity of population data, uncertainly regarding recovery from whaling, and re-establishment of active programs for whale harvesting pose risks for the recovery and survival of this species. Sperm whales are also hunted for subsistence purposes by whalers from Lamalera, Indonesia, where a traditional whaling industry has been reported to kill up to 56 sperm whales per year.

Southern Hemisphere. Whaling in the Southern Hemisphere averaged roughly 20,000 whales between 1956-1976 (Perry et al. 1999). Population size appears to be stable (Whitehead 2003).

Natural threats. Sperm whales are known to be occasionally predated upon by killer whales (Jefferson and Baird 1991; Pitman et al. 2001) and large sharks (Best et al. 1984) and harassed by pilot whales (Arnbom et al. 1987; Palacios and Mate 1996; Rice 1989b; Weller et al. 1996; Whitehead 1995). Strandings are also relatively common events, with one to dozens of individuals generally beaching themselves and dying during any single event. Although several hypotheses, such as navigation errors, illness, and anthropogenic stressors, have been proposed (Goold et al. 2002; Wright 2005), direct widespread causes of strandings remain unclear. Calcivirus and papillomavirus are known pathogens of this species (Lambertsen et al. 1987; Smith and Latham 1978).

Anthropogenic threats. Sperm whales historically faced severe depletion from commercial whaling operations. From 1800 to 1900, the IWC estimated that nearly 250,000 sperm whales were killed by whalers, with another 700,000 from 1910 to 1982 (IWC Statistics 1959-1983). However, other estimates have included 436,000 individuals killed between 1800-1987 (Carretta et al. 2005). All of these estimates are likely underestimates due to illegal and inaccurate killings by Soviet whaling fleets between 1947-1973. In the Southern Hemisphere, these whalers killed an estimated 100,000 whales that they did not report to the IWC (Yablokov et al. 1998), with smaller harvests in the Northern Hemisphere, primarily the North Pacific, that extirpated sperm whales from large areas (Yablokov and Zemsky 2000). Additionally, Soviet whalers disproportionately killed adult females in any reproductive condition (pregnant or lactating) as well as immature sperm whales of either gender.

Following a moratorium on whaling by the IWC, significant whaling pressures on sperm whales were eliminated. However, sperm whales are known to have become entangled in commercial fishing gear and 17 individuals are known to have been struck by vessels (Jensen and Silber 2004a). Japan maintains an active whaling fleet, killing up to 10 sperm whales annually (IWC 2008). In 2009, one sperm whale was killed during western North Pacific surveys (Bando et al. 2010).

Whale-watching vessels are known to influence sperm whale behavior (Richter et al. 2006).

In U. S. waters in the Pacific Ocean, sperm whales are known to have been incidentally captured only in drift gillnet operations, which killed or seriously injured an average of 9 sperm whales per year from 1991-1995 (Barlow et al. 1997b). Interactions between longline fisheries and sperm whales in the Gulf of Alaska have been reported over the past decade (Hill and Demaster 1998b; Rice 1989a). Observers aboard Alaskan sablefish and halibut longline vessels have documented sperm whales feeding on fish caught in longline gear in the Gulf of Alaska. During 1997, the first entanglement of a sperm whale in Alaska's longline fishery was recorded, although the animal was not seriously injured (Hill and Demaster 1998b). The available evidence does not indicate sperm whales are being killed or seriously injured as a result of these interactions, although the nature and extent of interactions between sperm whales and long-line gear is not yet clear.

Contaminants have been identified in sperm whales, but vary widely in concentration based upon life history and geographic location, with northern hemisphere individuals generally carrying higher burdens (Evans et al. 2004). Contaminants include dieldrin, chlordane, DDT, DDE, PCBs, HCB and hexachlorocyclohexane (HCHs) in a variety of body tissues (Aguilar 1983; Evans et al. 2004), as well as several heavy metals (Law et al. 1996). However, unlike other marine mammals, females appear to bioaccumulate toxins at greater levels than males, which may be related to possible dietary differences between females who remain at relatively low latitudes compared to more migratory males (Aguilar 1983; Wise et al. 2009). Chromium levels from sperm whales skin samples worldwide have varied from undetectable to 122.6 μg Cr/g tissue, with the mean (8.8 μg Cr/g tissue) resembling levels found in human lung tissue with chromium-induced cancer (Wise et al. 2009). Older or larger individuals do not appear to accumulate chromium at higher levels.

Ingestion of marine debris can have fatal consequences even for large whales. In 1989, a stranded sperm whale along the Mediterranean was found to have died from ingesting plastic that blocked its' digestive tract. A sperm whale examined in Iceland had a lethal disease thought to have been caused by the complete obstruction of the gut with plastic marine debris (Lambertsen 1990). The stomach contents of two sperm whales that stranded separately in California included extensive amounts of discarded fishing netting (NMFS 2009). A fifth individual from the Pacific was found to contain nylon netting in its stomach when it washed ashore in 2004 (NMFS 2009). In March 2012, a sperm whale stranded dead, apparently dying as a result of plastic ingestion (de Stephanis et al. 2013).

There have not been any recent documented ship strikes involving sperm whales in the eastern North Pacific, although there are a few records of ship strikes in the 1990s. Two whales described as "possibly sperm whales" are known to have died in U.S. Pacific waters in 1990 after being struck by vessels (Barlow et al. 1997a). There is an anecdotal record from 1997 of a fishing vessel that struck a sperm whale in southern Prince William Sound in Alaska, although the whale did not appear to be injured (Laist et al. 2001). More recently in the Pacific, two sperm whales were struck by a ship in 2005, but it is not known if these ship strikes resulted in injury or mortality (NMFS 2009). The lack of recent evidence should not lead to the assumption that no mortality or injury from collisions with vessels occurs as carcasses that do not drift ashore may go unreported, and those that do strand may show no obvious signs of having been struck by a ship (NMFS 2009). Worldwide, sperm whales are known to have been struck 17 times out of a total record of 292 strikes of all large whales, 13 of which resulted in mortality (Jensen and Silber 2003; Laist et al. 2001). Given the current number of reported cases of injury and mortality, it does not appear that ship strikes are a significant threat to sperm whales (Whitehead 2003).

Critical habitat. The NMFS has not designated critical habitat for sperm whales.

6.7 Green sea turtle

Populations. Populations are distinguished generally by ocean basin and more specifically by nesting location (Table 8).

Table 8. Locations and most recent abundance estimates of threatened green sea turtles as annual nesting females (AF), annual nests (AN), annual egg production (EP), and annual egg harvest (EH).

Location	Most recent abundance	Reference
Western Atlantic Ocean		
Tortuguero, Costa Rica	17,402-37,290 AF	(Troëng and Rankin 2005)
Aves Island, Venezuela	335-443 AF	(Vera 2007)
Galibi Reserve, Suriname	1,803 AF	(Weijerman et al. 1998)
Isla Trindade, Brazil	1,500-2,000 AF	(Moreira and Bjorndal 2006)
Central Atlantic Ocean		
Ascension Island, UK	3,500 AF	(Broderick et al. 2006)
Eastern Atlantic Ocean		
Poilao Island, Guinea-Bissau	7,000-29,000 AN	(Catry et al. 2009)
Bioko Island, Equatorial Guinea	1,255-1,681 AN	(Tomas et al. 1999)
Mediterranean Sea		
Turkey	214-231 AF	(Broderick et al. 2002)
Cyprus	121-127 AF	(Broderick et al. 2002)
Israel / Palestine	1-3 AF	(Kuller 1999)
Syria	100 AN	(Rees et al. 2005)
Western Indian Ocean		
Eparces Islands	2,000-11,000 AF	(Le Gall et al. 1986)
Comoros Islands	5,000 AF	S. Ahamada, pers. comm. 2001
Seychelles Islands	3,535-4,755 AF	J. Mortimer, pers. comm. 2002
Kenya	200-300 AF	(Okemwa and Wamukota 2006)
Northern Indian Ocean		
Ras al Hadd, Oman	44,000 AN	S. Al-Saady, pers. comm. 2007
Sharma, Yemen	15 AF	(Saad 1999)
Karan Island, Saudi Arabia	408-559 AF	(Pilcher 2000)
Jana and Juraid Islands, Saudi Arabia	643 AN	(Pilcher 2000)
Hawkes Bay and Sandspit, Pakistan	600 AN	(Asrar 1999)
Gujarat, India	461 AN	(Sunderraj et al. 2006)
Sri Lanka	184 AF	(Kapurisinghe 2006)

Eastern Indian Ocean		
Thamihla Kyun, Myanmar	<250,000 EH	(Thorbjarnarson et al. 2000)
Pangumbahan, Indonesia	400,000 EH	(Schulz 1987)
Suka Made, Indonesia	395 AN	C. Limpus, pers. comm. 2002
Western Australia	3,000-30,000 AN	R. Prince, pers. comm. 2001
Southeast Asia		
Gulf of Thailand	250 AN	Charuchinda pers. comm. 2001
Vietnam	239 AF	(Hamann et al. 2006b)
Berau Islands, Indonesia	4,000-5,000 AF	(Schulz 1984)
Turtle Islands, Philippines	1.4 million EP	(Cruz 2002)
Sabah Turtle Islands, Malaysia	8,000 AN	(Chan 2006)
Sipadan, Malaysia	800 AN	(Chan 2006)
Sarawak, Malaysia	2,000 AN	(Liew 2002)
Enu Island (Aru Islands)	540 AF	Dethmers, in preparation
Terengganu, Malaysia	2,200 AN	(Chan 2006)
Western Pacific Ocean		
Heron Island and southern Great Barrier Reef areas, Australia	5,000-10,000 AF	(Maison et al. 2010)
Raine Island and northern Great Barrier Reef areas, Australia	10,000-25,000 AF	(Limpus et al. 2003; Maison et al. 2010)
Coringa-Herald National Nature Reserve, Australia	1,445 AF	(Maison et al. 2010)
Guam	45 AF	(Cummings 2002)
Phoenix Islands, Kiribati	100-300 AF	(Maison et al. 2010)
Ogasawara Islands, Japan	500 AF	(Chaloupka et al. 2007)
Micronesia	500-1,000 AF	(Maison et al. 2010)
Marshall Islands	100-500 AF	(Maison et al. 2010)
New Caledonia	1,000-2,000 AF	(Maison et al. 2010)
Central and Eastern Pacific Ocean		
French Frigate Shoals, Hawaii	400 AF	(Balazs and Chaloupka 2006)
Michoacán, Mexico	1,395 AF	C. Delgado, pers. comm. 2006
Central American Coast	184-344 AN	(López and Arauz 2003)
Galapagos Islands, Ecuador	1,650 AF	(Zárate et al. 2006)

Based upon genetic differences, two or three distinct regional clades may exist in the Pacific: western Pacific and South Pacific islands, eastern Pacific, and central Pacific, including the rookery at French Frigate Shoals, Hawaii (Dutton 1996). In the eastern Pacific, green sea turtles forage from San Diego Bay, California to Mejillones, Chile. Individuals along the southern foraging area originate from Galapagos Islands nesting beaches, while those in the Gulf of California originate primarily from Michoacán. Green turtles foraging in San Diego Bay and along the Pacific coast of Baja California originate primarily from rookeries of the Islas Revillagigedos (Dutton 2003a).

Distribution. Green sea turtles have a circumglobal distribution, occurring throughout tropical, subtropical waters, and, to a lesser extent, temperate waters. Several sightings have been made along New Jersey during the approximate time frame of the proposed seismic survey (NSF 2014).

Growth and reproduction. Most green sea turtles exhibit particularly slow growth rates, which have been attributed to their largely plant-eating diet (Bjorndal 1982). Growth rates of juveniles vary substantially among populations, ranging from <1 cm/year (Green 1993) to >5 cm/year (McDonald Dutton and Dutton 1998), likely due to differences in diet quality, duration of foraging season (Chaloupka et al. 2004), and density of turtles in foraging areas (Balazs and Chaloupka 2004; Bjorndal et al. 2000; Seminoff et al. 2002b). Hart et al. (2013a) found growth rates of green sea turtles in the U.S. Virgin Islands to range from 0-9.5 cm annually (mean of 4.1, SD 2.4). The largest growth rates were in the 30-39 cm class. If individuals do not feed sufficiently, growth is stunted and apparently does not compensate even when greater-than-needed resources are available (Roark et al. 2009). In general, there is a tendency for green sea turtles to exhibit monotonic growth (declining growth rate with size) in the Atlantic and non-monotonic growth (growth spurt in mid-size classes) in the Pacific, although this is not always the case (Balazs and Chaloupka 2004; Chaloupka and Musick 1997; Seminoff et al. 2002b). It is estimated that green sea turtles reach a maximum size just under 100 cm in carapace length (Tanaka 2009). A female-bias has been identified from studies of green sea turtles (Wibbels 2003).

Consistent with slow growth, age-to-maturity for green sea turtles appears to be the longest of any sea turtle species and ranges from ~20-40 years or more (Balazs 1982; Chaloupka et al. 2004; Chaloupka and Musick 1997; Frazer and Ehrhart 1985a; Hirth 1997b; Limpus and Chaloupka 1997; Seminoff et al. 2002b; Zug et al. 2002; Zug and Glor 1998). Estimates of reproductive longevity range from 17 to 23 years (Carr et al. 1978; Chaloupka et al. 2004; Fitzsimmons et al. 1995). Considering that mean duration between females returning to nest ranges from 2 to 5 years (Hirth 1997b), these reproductive longevity estimates suggest that a female may nest 3 to 11 seasons over the course of her life. Each female deposits 1-7 clutches (usually 2-3) during the breeding season at 12-14 day intervals. Mean clutch size is highly variable among populations, but averages 110-115 eggs/nest. Females usually have 2-4 or more years between breeding seasons, whereas males may mate every year (Balazs 1983). Based on reasonable means of three nests per season and 100 eggs per nest (Hirth 1997b), a female may deposit 9 to 33 clutches, or about 900 to 3,300 eggs, during her lifetime. Nesting sites appear to be related to beaches with relatively high exposure to wind or wind-generated waves (Santana Garcon et al. 2010).

Once hatched, sea turtles emerge and orient towards a light source, such as light shining off the ocean. They enter the sea in a “frenzy” of swimming activity, which decreases rapidly in the first few hours and gradually over the first several weeks (Ischer et al. 2009; Okuyama et al. 2009). Factors in the ocean environment have a major influence on reproduction (Chaloupka 2001; Limpus and Nicholls 1988; Solow et al. 2002). It is also apparent that during years of heavy nesting activity, density dependent factors (beach crowding and digging up of eggs by nesting females) may impact hatchling production (Tiwari et al. 2005; Tiwari et al. 2006). Precipitation, proximity to the high tide line, and nest depth can also significantly affect nesting success (Cheng et al. 2009). Precipitation can also be significant in sex determination, with greater nest moisture resulting in a higher proportion of males (Leblanc and Wibbels 2009).

Green sea turtles often return to the same foraging areas following nesting migrations (Broderick et al. 2006; Godley et al. 2002). Once there, they move within specific areas, or home ranges, where they routinely visit specific localities to forage and rest (Godley et al. 2003; Makowski et al. 2006; Seminoff and Jones 2006; Seminoff et al. 2002a; Taquet et al. 2006). It is also apparent that some green sea turtles remain in pelagic habitats for extended periods, perhaps never recruiting to coastal foraging sites (Pelletier et al. 2003).

In general, survivorship tends to be lower for juveniles and subadults than for adults. Adult survivorship has been calculated to range from 0.82-0.97 versus 0.58-0.89 for juveniles (Chaloupka and Limpus 2005; Seminoff et al. 2003; Troëng and Chaloupka 2007), with lower values coinciding with areas of human impact on green sea turtles and their habitats (Bjorndal et al. 2003; Campbell and Lagueux 2005).

Migration and movement. Green sea turtles are highly mobile and undertake complex movements through geographically disparate habitats during their lifetimes (Musick and Limpus 1997; Plotkin 2003). The periodic migration between nesting sites and foraging areas by adults is a prominent feature of their life history. After departing as hatchlings and residing in a variety of marine habitats for 40 or more years (Limpus and Chaloupka 1997), green sea turtles make their way back to the same beach from which they hatched (Carr et al. 1978; Meylan et al. 1990). At approximately 20-25 cm carapace length, juveniles leave pelagic habitats and enter benthic foraging areas (Bjorndal 1997a). Green sea turtles spend the majority of their lives in coastal foraging grounds (MacDonald et al. 2012). These areas include both open coastline and protected bays and lagoons. While in these areas, green sea turtles rely on marine algae and seagrass as their primary dietary constituents, although some populations also forage heavily on invertebrates. Although green sea turtles in tropical areas seem to undergo a sudden, permanent switch in habitat from oceanic to neritic habitats, individuals in more temperate areas seem to utilize a wider array of habitats dependent upon oceanographic conditions (González Carman et al. 2012). There is some evidence that individuals move from shallow seagrass beds during the day to deeper areas at night (Hazel 2009). However, avoidance of areas of greater than 10 m when moderate depths of 5-10 m with sea grass beds has been found, with speed and displacement from capture locations being similar at night as during the daytime (Senko et al. 2010a). East Pacific adults migrate along coastal corridors between Central American nesting and foraging locations (Blanco et al. 2012).

Habitat. Green turtles appear to prefer waters that usually remain around 20º C in the coldest month, but may occur considerably north of these regions during warm-water events, such as El Niño. Stinson (1984a) found green turtles to appear most frequently in U. S. coastal waters with temperatures exceeding 18º C. Further, green sea turtles seem to occur preferentially in drift lines or surface current convergences, probably because of the prevalence of cover and higher prey densities that associate with flotsam. For example, in the western Atlantic Ocean, drift lines commonly containing floating *Sargassum* spp. are capable of providing juveniles with shelter (NMFS and USFWS 1998). Underwater resting sites include coral recesses, the underside of ledges, and sand bottom areas that are relatively free of strong currents and disturbance. Available information indicates that green turtle resting areas are near feeding areas (Bjorndal and Bolten 2000). Strong site fidelity appears to be a characteristic of juvenile green sea turtles along the Pacific Baja coast (Senko et al. 2010b).

Feeding. While offshore and sometimes in coastal habitats, green sea turtles are not obligate plant-eaters as widely believed, and instead consume invertebrates such as jellyfish, sponges, sea pens, and pelagic prey (Godley et al. 1998; Hart et al. 2013b; Hatase et al. 2006; Heithaus et al. 2002; Parker and Balazs in press; Seminoff et al. 2002a). A shift to a more herbivorous diet occurs when individuals move into neritic habitats, as vegetable mater replaces an omnivorous diet at around 59 cm in carapace length off Mauritania (Cardona et al. 2009). This transition may occur rapidly starting at 30 cm carapace length, but animal prey continue to constitute an important nutritional component until individuals reach about 62 cm (Cardona et al. 2010). Foraging within seagrass ecosystems by green sea turtles can be significant enough to alter habitat and ecological parameters, such as species composition (Lal et al. 2010). Although populations can consume a variety of prey and be considered generalists as a whole, individuals maintain a highly-selective diet over long time frames (Vander Zanden et al. 2013).

Diving. Based on the behavior of post-hatchlings and juvenile green turtles raised in captivity, we presume that those in pelagic habitats live and feed at or near the ocean surface, and that their dives do not normally exceed 7 m in depth (Hazel et al. 2009; NMFS and USFWS 1998). Recent data from Australia indicate green sea turtles rarely dive deep, staying in upper 8 m of the water column (Hazel et al. 2009). Here, daytime dives were shorter and shallower than were nighttime dives. Also, time spent resting and dive duration increased significantly with decreases in seasonal water temperatures. The maximum recorded dive depth for an adult green turtle was just over 106 m (Berkson 1967), while subadults routinely dive to 20 m for 9-23 min, with a maximum recorded dive duration of over 1 h (Brill et al. 1995; I-Jiunn 2009). Green sea turtles along Taiwan may rest during long, shallow dives (I-Jiunn 2009). Dives by females may be shorter in the period leading up to nesting (I-Jiunn 2009).

Vocalization and hearing. Sea turtles are low-frequency hearing specialists, typically hearing frequencies from 30 to 2,000 Hz, with a range of maximum sensitivity between 100 and 800 Hz (Bartol et al. 1999; Lenhardt 2002; Lenhardt 1994b; Moein Bartol and Ketten 2006; Ridgway et al. 1969). Piniak et al. (2012) found green sea turtle juveniles capable of hearing underwater sounds at frequencies of 50-1,600 Hz (maximum sensitivity at 200-400 Hz). Hearing below 80 Hz is less sensitive but still possible (Lenhardt 1994b). Based upon auditory brainstem responses green sea turtles have been measured to hear in the 50-1600 Hz range (Dow et al. 2008), with greatest response at 300 Hz (Yudhana et al. 2010); a value verified by Moein Bartol and Ketten (2006). Other studies have found greatest sensitivities are 200-400 Hz for the green turtle with a range of 100-500 Hz (Moein Bartol and Ketten 2006; Ridgway et al. 1969) and around 250 Hz or below for juveniles (Bartol et al. 1999). However, Dow et al. (2008) found best sensitivity between 50 and 400 Hz.

These hearing sensitivities are similar to those reported for two terrestrial species: pond and wood turtles. Pond turtles respond best to sounds between 200 and 700 Hz, with slow declines below 100 Hz and rapid declines above 700 Hz, and almost no sensitivity above 3 kHz (Wever and Vernon 1956). Wood turtles are sensitive up to about 500 Hz, followed by a rapid decline above 1 kHz and almost no responses beyond 3 or 4 kHz (Patterson 1966).

Status and trends. Federal listing of the green sea turtle occurred on July 28, 1978, with all populations listed as threatened except for the Florida and Pacific coast of Mexico breeding populations, which are endangered (43 FR 32800).

Consideration of the status of populations outside of the action area is important under the present analysis to determine the how risk the risk to the affected population(s) bears on the status of the species as a whole. No trend data are available for almost half of important nesting sites, where numbers are based on recent trends and do not span a full green sea turtle generation, and impacts occurring over four decades ago that caused a change in juvenile recruitment rates may have yet to be manifested as a change in nesting abundance. The numbers also only reflect one segment of the population (nesting females), who are the only segment of the population for which reasonably good data are available and are cautiously used as one measure of the possible trend of populations.

Based on the mean annual reproductive effort, 108,761-150,521 females nest each year among 46 worldwide sites. Overall, of the 26 sites for which data enable an assessment of current trends, 12 nesting populations are increasing, 10 are stable, and four are decreasing. Long-term continuous datasets of 20 years are available for 11 sites, all of which are either increasing or stable. Despite the apparent global increase in numbers, the positive overall trend should be viewed cautiously because trend data are available for just over half of all sites examined and very few data sets span a full green sea turtle generation (Seminoff 2004a).

Long-term capture rates have increased exponentially for green sea turtles in the Laguna Madre of Texas from 1991-2010, although average size seems to be declining (Metz and Landry Jr. 2013). These trends may be due to increasing nest output from Mexican and Florida beaches, with juveniles recruiting into the neritic Texas coast (Metz and Landry Jr. 2013). Similarly, average turtle length has declined over the course of a long-term study along cape Canaveral, Florida, as has recapture rate, likely for the same reasons (Redfoot and Ehrhart 2013).

Pacific Ocean. Green turtles are thought to be declining throughout the Pacific Ocean, with the exception of Hawaii, from a combination of overexploitation and habitat loss (Eckert 1993b; Seminoff et al. 2002a). In the western Pacific, the only major (>2,000 nesting females) populations of green turtles occur in Australia and Malaysia, with smaller colonies throughout the area. Indonesian nesting is widely distributed, but has experienced large declines over the past 50 years. Hawaii green turtles are genetically distinct and geographically isolated, and the population appears to be increasing in size despite the prevalence of fibropapillomatosis and spirochidiasis (Aguirre et al. 1998).

The East Island nesting beach in Hawaii is showing a 5.7% annual growth rate over >25 years (Chaloupka et al. 2008a). In the Eastern Pacific, mitochondrial DNA analysis has indicated three key nesting populations: Michoacán, Mexico; Galapagos Islands, Ecuador; and Islas Revillagigedos, Mexico (Dutton 2003b). The number of nesting females per year exceeds 1,000 females at each site (NMFS and USFWS 2007a). However, historically, >20,000 females per year are believed to have nested in Michoacán alone (Clifton et al. 1982; NMFS and USFWS 2007a). Thus, the current number of nesting females is still far below historical levels. Datasets over 25 years in Chichi-jima, Japan; Heron Island, Australia; and Raine Island, Australia, show increases in abundance (Chaloupka et al. 2008a).

Atlantic Ocean. Primary sites for green sea turtle nesting in the Atlantic/Caribbean include: (1) Yucatán Peninsula, Mexico; (2) Tortuguero, Costa Rica; (3) Aves Island, Venezuela; (4) Galibi Reserve, Suriname; (5) Isla Trindade, Brazil; (6) Ascension Island, United Kingdom; (7) Bioko Island, Equatorial Guinea; and (8) Bijagos Achipelago, Guinea-Bissau (NMFS and USFWS 2007a). Nesting at all of these sites was considered to be stable or increasing with the exception of Bioko Island and the Bijagos Archipelago where the lack of sufficient data precludes a meaningful trend assessment for either site (NMFS and USFWS 2007a). Seminoff (2004b) reviewed green sea turtle nesting data for eight sites in the western, eastern, and central Atlantic. Seminoff (2004b) concluded that all sites in the central and western Atlantic showed increased nesting, with the exception of nesting at Aves Island, Venezuela, while both sites in the eastern Atlantic demonstrated decreased nesting. These sites are not inclusive of all green sea turtle nesting in the Atlantic. However, other sites are not believed to support nesting levels high enough that would change the overall status of the species in the Atlantic (NMFS and USFWS 2007a).

By far, the most important nesting concentration for green sea turtles in the western Atlantic is in Tortuguero, Costa Rica (NMFS and USFWS 2007a). Nesting in the area has increased considerably since the 1970s and nest count data from 1999-2003 suggest nesting by 17,402-37,290 females per year (NMFS and USFWS 2007a). The number of females nesting per year on beaches in the Yucatán, at Aves Island, Galibi Reserve, and Isla Trindade number in the hundreds to low thousands, depending on the site (NMFS and USFWS 2007a).

The vast majority of green sea turtle nesting within the southeastern U. S. occurs in Florida (Johnson and Ehrhart 1994; Meylan et al. 1995). Green sea turtle nesting in Florida has been increasing since 1989 (Florida Fish and Wildlife Conservation Commission, Florida Marine Research Institute Index Nesting Beach Survey Database). Since establishment of index beaches in 1989, the pattern of green turtle nesting shows biennial peaks in abundance with a generally positive trend during the ten years of regular monitoring. This is perhaps due to increased protective legislation throughout the Caribbean (Meylan et al. 1995). A total statewide average (all beaches, including index beaches) of 5,039 green turtle nests were laid annually in Florida between 2001 and 2006, with a low of 581 in 2001 and a high of 9,644 in 2005 (NMFS and USFWS 2007a). Data from index nesting beaches substantiate the dramatic increase in nesting. In 2007, there were 9,455 green turtle nests found just on index nesting beaches, the highest since index beach monitoring began in 1989. The number fell back to 6,385 in 2008, further dropping under 3,000 in 2009, but that consecutive drop was a temporary deviation from the normal biennial nesting cycle for green turtles, as 2010 saw an increase back to 8,426 nests on the index nesting beaches (FWC Index Nesting Beach Survey Database). Occasional nesting has been documented along the Gulf coast of Florida (Meylan et al. 1995). More recently, green turtle nesting occurred on Bald Head Island, North Carolina; just east of the mouth of the Cape Fear River; on Onslow Island; and on Cape Hatteras National Seashore. In 2010, a total of 18 nests were found in North Carolina, six nests in South Carolina, and six nests in Georgia (nesting databases maintained on www.seaturtle.org). Increased nesting has also been observed along the Atlantic coast of Florida, on beaches where only loggerhead nesting was observed in the past (Pritchard 1997). Recent modeling by Chaloupka et al. (2008a) using data sets of 25 years or more has resulted in an estimate of the Florida nesting stock at the Archie Carr National Wildlife Refuge growing at an annual rate of 13.9%, and the Tortuguero, Costa Rica, population growing at 4.9%.

There are no reliable estimates of the number of immature green sea turtles that inhabit coastal areas of the southeastern U. S. However, information on incidental captures of immature green sea turtles at the St. Lucie Power Plant in St. Lucie County, Florida, shows that the annual number of immature green sea turtles captured by their offshore cooling water intake structures has increased significantly. Green sea turtle annual captures averaged 19 for 1977-1986, 178 for 1987-1996, and 262 for 1997-2001 (Florida Power and Light Company St. Lucie Plant 2002). More recent unpublished data shows 101 captures in 2007, 299 in 2008, 38 in 2009 (power output was cut—and cooling water intake concomitantly reduced—for part of that year) and 413 in 2010. Ehrhart et al. (2007) documented a significant increase in in-water abundance of green turtles in the Indian River Lagoon area.

Indian Ocean. One of the largest nesting sites for green sea turtles worldwide occurs on the beaches of Oman where an estimated 20,000 green sea turtles nest annually (Hirth 1997a). Only the Comoros Island index site in the western Indian Ocean showed evidence of increased nesting (Seminoff 2004b).

Natural threats. Herons, gulls, dogfish, and sharks prey upon hatchlings. Adults face predation primarily by sharks and to a lesser extent by killer whales. Predators (primarily of eggs and hatchlings) also include dogs, pigs, rats, crabs, sea birds, reef fishes, and groupers (Bell et al. 1994; Witzell 1981).

For unknown reasons, the frequency of a disease called fibropapillomatosis is much higher in green sea turtles than in other species and threatens a large number of existing subpopulations. Extremely high incidence has been reported in Hawaii, where affliction rates peaked at 47-69% in some foraging areas (Murakawa et al. 2000). A to-date unidentified virus may aid in the development of fibropapillomatosis (Work et al. 2009). Green sea turtles with an abundance of barnacles have been found to have a much greater probability of having health issues (Flint et al. 2009). The fungal pathogens *Fusarium falciforme* and *F. keratoplasticum* can kill in excess of 90% of sea turtle embryos they infect and may constitute a major threat to nesting productivity under some conditions (Sarmiento-Ramırez et al. 2014).

All sea turtles except leatherbacks can undergo “cold stunning” if water temperatures drop below a threshold level, which can be lethal.

Anthropogenic threats. Major anthropogenic impacts to the nesting and marine environment affect green sea turtle survival and recovery. At nesting beaches, green sea turtles rely on intact dune structures, native vegetation, and normal beach temperatures for nesting (Ackerman 1997). Structural impacts to nesting habitat include the construction of buildings and pilings, beach armoring and renourishment, and sand extraction (Bouchard et al. 1998; Lutcavage et al. 1997b). These factors may directly, through loss of beach habitat, or indirectly, through changing thermal profiles and increasing erosion, serve to decrease the amount of nesting area available to females, and may evoke a change in the natural behaviors of adults and hatchlings (Ackerman 1997; Witherington et al. 2003; Witherington et al. 2007). On the Pacific coast of Mexico in the mid-1970s, >70,000 green turtle eggs were harvested every night. Hundreds of mostly immature green sea turtles were killed between 2006 and 2008 due to bycatch and direct harvest along Baja California Sur (Senko et al. 2014). The presence of lights on or adjacent to nesting beaches alters the behavior of nesting adults (Witherington 1992) and is often fatal to emerging hatchlings as they are attracted to light sources and drawn away from the water (Witherington and Bjorndal 1991). In addition to impacting the terrestrial zone, anthropogenic disturbances also threaten coastal marine habitats, particularly areas rich in seagrass and marine algae. These impacts include contamination from herbicides, pesticides, oil spills, and other chemicals, as well as structural degradation from excessive boat anchoring and dredging (Francour et al. 1999; Lee Long et al. 2000; Waycott et al. 2005). Ingestion of plastic and other marine debris is another source of morbidity and mortality (Stamper et al. 2009). Green sea turtles stranded in Brazil were all found to have ingested plastics or fishing debris (n=34), although mortality appears to have resulted in three cases (Tourinho et al. 2009). Low-level bycatch has also been documented in longline fisheries (Petersen et al. 2009). Further, the introduction of alien algae species threatens the stability of some coastal ecosystems and may lead to the elimination of preferred dietary species of green sea turtles (De Weede 1996). Very few green sea turtles are bycaught in U. S. fisheries (Finkbeiner et al. 2011). However, a legal fishery operates in Madagascar that harvested about 10,000 green turtles annually in the mid-1990s. Green sea turtles are killed because they are seen as competitors for fishery resources in parts of India (Arthur et al. 2013).

Sea level rise may have significant impacts upon green turtle nesting on Pacific atolls. These low-lying, isolated locations could be inundated by rising water levels associated with global warming, eliminating nesting habitat (Baker et al. 2006; Fuentes et al. 2010). Fuentes et al. (2010) predicted that rising temperatures would be a much greater threat in the long term to the hatching success of sea turtles in general and green sea turtles along northeastern Australia particularly. Green sea turtles emerging from nests at cooler temperatures likely absorb more yolk that is converted to body tissue than do hatchlings from warmer nests (Ischer et al. 2009). Predicted temperature rises may approach or exceed the upper thermal tolerance limit of sea turtle incubation, causing widespread failure of nests (Fuentes et al. 2010). Although the timing of loggerhead nesting depends upon sea-surface temperature, green sea turtles do not appear to be affected (Pike 2009).

Green sea turtles have been found to contain the organochlorines chlordane, lindane, endrin, endosulfan, dieldrin, DDT and PCB (Gardner et al. 2003; Miao et al. 2001). Levels of PCBs found in eggs are considered far higher than what is fit for human consumption (Van de Merwe et al. 2009). The heavy metals copper, lead, manganese, cadmium, and nickel have also been found in various tissues and life stages (Barbieri 2009). Arsenic also occurs in very high levels in green sea turtle eggs (Van de Merwe et al. 2009). These contaminants have the potential to cause deficiencies in endocrine, developmental, and reproductive health, and depress immune function in loggerhead sea turtles (Keller et al. 2006; Storelli et al. 2007). Exposure to sewage effluent may also result in green sea turtle eggs harboring antibiotic-resistant strains of bacteria (Al-Bahry et al. 2009). DDE has not been found to influence sex determination at levels below cytotoxicity (Keller and McClellan-Green 2004; Podreka et al. 1998). To date, no tie has been found between pesticide concentration and susceptibility to fibropapillomatosis, although degraded habitat and pollution have been tied to the incidence of the disease (Aguirre et al. 1994; Foley et al. 2005). Flame retardants have been measured from healthy individuals (Hermanussen et al. 2008). It has been theorized that exposure to tumor-promoting compounds produced by the cyanobacteria *Lyngbya majuscule* could promote the development of fibropapillomatosis (Arthur et al. 2008). It has also been theorized that dinoflagellates of the genus *Prorocentrum* that produce the tumorogenic compound okadoic acid may influence the development of fibropapillomatosis (Landsberg et al. 1999).

Critical habitat. On September 2, 1998, critical habitat for green sea turtles was designated in coastal waters surrounding Culebra Island, Puerto Rico (63 FR 46693). Aspects of these areas that are important for green sea turtle survival and recovery include important natal development habitat, refuge from predation, shelter between foraging periods, and food for green sea turtle prey. The proposed action does not co-occur with this critical habitat.

6.8 Hawksbill sea turtle

Populations. Populations are distinguished generally by ocean basin and more specifically by nesting location. Our understanding of population structure is relatively poor. For example, genetic analysis of hawksbill sea turtles foraging off the Cape Verde Islands identified three closely-related haplotypes in a large majority of individuals sampled that did not match those of any known nesting population in the western Atlantic, where the vast majority of nesting has been documented (McClellan et al. 2010; Monzon-Arguello et al. 2010). Hawksbills in the Caribbean seem to have dispersed into separate populations (rookeries) after a bottleneck roughly 100,000-300,000 years ago based upon genetic data (Leroux et al. 2012). Nesting in the northwestern Hawaiian Islands has been rarely found (partly stemming from poor observer effort), but is believed to have been greater historically (Van Houtan et al. 2012).

Distribution. The hawksbill has a circumglobal distribution throughout tropical and, to a lesser extent, subtropical waters of the Atlantic, Indian, and Pacific Oceans. Satellite tagged turtles have shown significant variation in movement and migration patterns. In the Caribbean, distance traveled between nesting and foraging locations ranges from a few kilometers to a few hundred kilometers (Byles and Swimmer 1994; Hillis-Starr et al. 2000; Horrocks et al. 2001; Lagueux et al. 2003; Miller et al. 1998; Prieto et al. 2001). A handful of sightings have been made along New Jersey during the approximate time frame of the proposed seismic survey (NSF 2014).

Migration and movement. Upon first entering the sea, neonatal hawksbills in the Caribbean are believed to enter an oceanic phase that may involve long distance travel and eventual recruitment to nearshore foraging habitat (Boulon Jr. 1994). In the marine environment, the oceanic phase of juveniles (i.e., the "lost years") remains one of the most poorly understood aspects of hawksbill life history, both in terms of where turtles occur and how long they remain oceanic. Nesting site selection in the southwest Pacific appears to favor sites with higher wind and wave exposure, possibly as a means to aid hatchling dispersal (Garcon et al. 2010). Subadult hawksbill sea turtles satellite tracked in the Dry Tortugas National Park showed high-degrees of site fidelity for extended periods, although all three eventually moved to other areas outside the park (Hart et al. 2012). The same trend was found for adults tracked after nesting in the Dominican Republic, with some remaining for extended periods in the nesting area and other migrating to Honduras and Nicaragua (Hawkes et al. 2012). Satellite tracking for these individuals showed repeated returns to the same Dominican and Central American areas (Hawkes et al. 2012). Home ranges tend to be small (a few square kilometers)(Berube et al. 2012).

Habitat. Hawksbill sea turtles are highly migratory and use a wide range of broadly separated localities and habitats during their lifetimes (Musick and Limpus 1997; Plotkin 2003). Small juvenile hawksbills (5-21 cm straight carapace length) have been found in association with *Sargassum* spp. in both the Atlantic and Pacific Oceans (Musick and Limpus 1997) and observations of newly hatched hawksbills attracted to floating weed have been made (Hornell 1927; Mellgren and Mann 1996; Mellgren et al. 1994). Post-oceanic hawksbills may occupy a range of habitats that include coral reefs or other hard-bottom habitats, sea grass, algal beds, mangrove bays and creeks (Bjorndal and Bolten 2010; Musick and Limpus 1997), and mud flats (R. von Brandis, unpublished data in NMFS and USFWS 2007d). Eastern Pacific adult females have recently been tracked in saltwater mangrove forests along El Salvador and Honduras, a habitat that this species was not previously known to occupy (Gaos et al. 2011). Individuals of multiple breeding locations can occupy the same foraging habitat (Bass 1999; Bowen et al. 1996; Bowen et al. 2007; Diaz-Fernandez et al. 1999; Velez-Zuazo et al. 2008). As larger juveniles, some individuals may associate with the same feeding locality for more than a decade, while others apparently migrate from one site to another (Blumenthal et al. 2009a; Mortimer et al. 2003; Musick and Limpus 1997). Larger individuals may prefer deeper habitats than their smaller counterparts (Blumenthal et al. 2009a). Nesting sites appear to be related to beaches with relatively high exposure to wind or wind-generated waves (Santana Garcon et al. 2010).

Within U. S. Caribbean territories and dependencies, hawksbill sea turtles nest principally in Puerto Rico and the U.S. Virgin Islands, particularly on Mona Island and Buck Island. They also nest on other beaches on St. Croix, Culebra Island, and Vieques Island, mainland Puerto Rico, St. John, and St. Thomas. Within the continental United States, hawksbill sea turtles nest only on beaches along the southeast coast of Florida and in the Florida Keys.

Growth and reproduction. The best estimate of age at sexual maturity for hawksbill sea turtles is 20-40 years (Chaloupka and Limpus 1997; Crouse 1999). Reproductive females undertake periodic (usually non-annual) migrations to their natal beaches to nest. Movements of reproductive males are less well known, but are presumed to involve migrations to their nesting beach or to courtship stations along the migratory corridor (Meylan 1999). Females nest an average of 3-5 times per season (Meylan and Donnelly 1999; Richardson et al. 1999a). Clutch sizes are up to 250 eggs; larger than that of other sea turtles (Hirth 1980). Reproductive females may exhibit a high degree of fidelity to their nest sites.

The life history of hawksbills consists of a pelagic stage that lasts from hatching until they are approximately 22-25 cm in straight carapace length (Meylan 1988; Meylan and Donnelly 1999), followed by residency in coastal developmental habitats. Growth accelerates early on until turtles reach 65-70 cm in curved carapace length, after which it slows to negligible amounts after 80 cm (Bell and Pike 2012). As with other sea turtles, growth is variable and likely depends upon nutrition available (Bell and Pike 2012). Juvenile hawksbills along the British Virgin Islands grow at a relatively rapid rate of roughly 9.3 cm per year and gain 3.9 kg annually (Hawkes et al. 2014).

Feeding. Dietary data from oceanic stage hawksbills are limited, but indicate a combination of plant and animal material (Bjorndal 1997b). Sponges and octocorals are common prey off Honduras (Berube et al. 2012; Hart et al. 2013b).

Diving. Hawksbill diving ability varies with age and body size. As individuals increase with age, diving ability in terms of duration and depth increases (Blumenthal et al. 2009b). Studies of hawksbills in the Caribbean have found diurnal diving behavior, with dive duration nearly twice as long during nighttime (35-47 min) compared to daytime (19-26 min Blumenthal et al. 2009b; Van Dam and Diez 1997). Daytime dives averaged 5 m, while nighttime dives averaged 43 m (Blumenthal et al. 2009b). However, nocturnal differences were not observed in the eastern Pacific (Gaos et al. 2012).

Hawksbills have long dive durations, although dive depths are not particularly deep. Adult females along St. Croix reportedly have average dive times of 56 min, with a maximum time of 73.5 min (Starbird et al. 1999). Average day and night dive times were 34–65 and 42–74 min, respectively. Immature individuals have much shorter dives of 8.6–14 min to a mean depth of 4.7 m while foraging (Van Dam and Diez 1997).

Vocalization and hearing. Sea turtles are low-frequency hearing specialists, typically hearing frequencies from 30 to 2,000 Hz, with a range of maximum sensitivity between 100 and 800 Hz (Bartol et al. 1999; Lenhardt 2002; Lenhardt 1994b; Moein Bartol and Ketten 2006; Ridgway et al. 1969). Piniak et al. (2012) found hawksbill hatchlings capable of hearing underwater sounds at frequencies of 50-1,600 Hz (maximum sensitivity at 200-400 Hz). Hearing below 80 Hz is less sensitive but still possible (Lenhardt 1994b).

These hearing sensitivities are similar to those reported for two terrestrial species: pond and wood turtles. Pond turtles respond best to sounds between 200 and 700 Hz, with slow declines below 100 Hz and rapid declines above 700 Hz, and almost no sensitivity above 3 kHz (Wever and Vernon 1956). Wood turtles are sensitive up to about 500 Hz, followed by a rapid decline above 1 kHz and almost no responses beyond 3 or 4 kHz (Patterson 1966).

Status and trends. Hawksbill sea turtles received protection on June 2, 1970 (35 FR 8495) under the Endangered Species Conservation Act and since 1973 have been listed as endangered under the ESA. Although no historical records of abundance are known, hawksbill sea turtles are considered to be severely depleted due to the fragmentation and low use of current nesting beaches (NMFS and USFWS 2007d). Consideration of the status of populations outside of the action area is important under the present analysis to determine the how risk the risk to the affected population(s) bears on the status of the species as a whole. Worldwide, an estimated 21,212-28,138 hawksbills nest each year among 83 sites. Among the 58 sites for with historic trends, all show a decline during the past 20 to 100 years. Among 42 sites for which recent trend data are available, 10 (24%) are increasing, three (7%) are stable and 29 (69%) are decreasing. Encouragingly, nesting range along Mexico and Central America appears not to have contracted and estimates continue to increase as additional dedicated study is conducted in the eastern Pacific (Gaos et al. 2010a). Genetics supports roughly 6,000-9,000 adult females within the Caribbean (Leroux et al. 2012).

Atlantic Ocean. Atlantic nesting sites include: Antigua (Jumby Bay), the Turks and Caicos, Barbados, the Bahamas, Puerto Rico (Mona Island), the U. S. Virgin Islands, the Dominican Republic, Sao Tome, Guadeloupe, Trinidad and Tobago, Jamaica, Martinique, Cuba (Doce Leguas Cays), Mexico (Yucatan Peninsula), Costa Rica (Tortuguero National Park), Guatemala, Venezuela, Bijagos Archipelago, Guinea-Bissau, and Brazil.

Population increase has been greater in the Insular Caribbean than along the Western Caribbean Mainland or the eastern Atlantic (including Sao Tomé and Equatorial Guinea). Nesting populations of Puerto Rico appeared to be in decline until the early 1990s, but have universally increased during the survey period. Mona Island now hosts 199-332 nesting females annually, and the other sites combined host 51-85 nesting females annually (R.P. van Dam and C.E. Diez, unpublished data in NMFS and USFWS 2007d)(C.E. Diez, Chelonia, Inc., in litt. to J. Mortimer 2006). At Buck Island Reef National Monument, protection has been in force since 1988, and during that time, hawksbill nesting has increased by 143% to 56 nesting females annually, with apparent spill over to beaches on adjacent St. Croix (Z. Hillis-Starr, National Park Service, in litt. to J. Mortimer 2006). However, St. John populations did not increase, perhaps due to the proximity of the legal turtle harvest in the British Virgin Islands (Z. Hillis-Starr, National Park Service, in litt. to J. Mortimer 2006). Populations have also been identified in Belize and Brazil as genetically unique (Hutchinson and Dutton 2007). An estimated 50-200 nests are laid per year in the Guinea-Bissau (Catry et al. 2009).

Pacific Ocean. American Samoa and Western Samoa host fewer than 30 females annually (Grant et al. 1997; Tuato'o-Bartley et al. 1993). In Guam, only 5-10 females are estimated to nest annually (G. Balazs, NMFS, in litt. to J. Mortimer 2007; G. Davis, NMFS, in litt. to J. Mortimer 2007) and the same is true for Hawaii, but there are indications that this population is increasing (G. Balazs, pers. comm. in NMFS and USFWS 2007d). Additional populations are known from the eastern Pacific (potentially extending from Mexico through Panama), northeastern Australia, and Malaysia (Hutchinson and Dutton 2007). El Salvador is now known to host the majority of hawksbill turtle nesting activity in the eastern Pacific, with

79.6% (n= 5430) of all nesting observation records, and Mexico hosting the majority of records of hawksbill turtles at sea, with 60.3% (n= 544) of all in-water observation records (Gaos et al. 2010b). Total number of nesting females for the Central Pacific hawksbill population was estimated at 940–1,200 females annually for the last few years, with an overall downward trend (NMFS and USFWS 2007b).

Indian Ocean. The Indian Ocean hosts several populations of hawksbill sea turtles (Hutchinson and Dutton 2007; Spotila 2004a). These include western Australian, Andaman and Nicobar islands, Maldives, Seychelles, Burma, East Africa, Egypt, Oman, Saudi Arabia, Sudan, and Yemen.

Natural threats. Sea turtles face predation primarily by sharks and to a lesser extent by killer whales. All sea turtles except leatherbacks can undergo "cold stunning" if water temperatures drop below a threshold level, which can be lethal. The only other significant natural threat to hawksbill sea turtles is from hybridization of hawksbills with other species of sea turtles. This is especially problematic at certain sites where hawksbill numbers are particularly low (Mortimer and Donnelly in review). Predators (primarily of eggs and hatchlings) include dogs, pigs, rats, crabs, sea birds, reef fishes, groupers, feral cats, and foxes (Bell et al. 1994; Ficetola 2008). In some areas, nesting beaches can be almost completely destroyed and all nests can sustain some level of depredation (Ficetola 2008). The fungal pathogens *Fusarium falciforme* and *F. keratoplasticum* an kill in excess of 90% of sea turtle embryos they infect and may constitute a major threat to nesting productivity under some conditions (Sarmiento-Ramırez et al. 2014).

Anthropogenic threats. Threats to hawksbill sea turtles are largely anthropogenic, both historically and currently. Impacts to nesting beaches include the construction of buildings and pilings, beach armoring and renourishment, and sand extraction (Bouchard et al. 1998; Lutcavage et al. 1997b). Because hawksbills prefer to nest under vegetation (Horrocks and Scott 1991; Mortimer 1982), they are particularly impacted by beachfront development and clearing of dune vegetation (Mortimer and Donnelly in review). The presence of lights on or adjacent to nesting beaches alters the behavior of nesting adults (Witherington 1992) and is often fatal to emerging hatchlings as they are attracted to light sources and drawn away from the water (Witherington and Bjorndal 1991). One of the most detrimental human threats to hawksbill sea turtles is the intensive harvest of eggs from nesting beaches. Between 1950 and 1992, approximately 1.3 million hawksbill shells were collected to supply tortoiseshell to the Japanese market, the world's largest. Japan stopped importing tortoiseshell in 1993 in order to comply with CITES (Limpus and Miller 2008). The U. S. Virgin Islands have a long history of tortoiseshell trade (Schmidt 1916).

In addition to impacting the terrestrial zone, anthropogenic disturbances also threaten coastal marine habitats. These impacts include contamination from herbicides, pesticides, oil spills, and other chemicals, as well as structural degradation from excessive boat anchoring and dredging (Francour et al. 1999; Lee Long et al. 2000; Waycott et al. 2005). Hawksbills are typically associated with coral reefs, which are among the world's most endangered marine ecosystems (Wilkinson 2000). Although primarily spongivorous, bycatch of hawksbill sea turtles in the swordfish fishery off South Africa occurs (Petersen et al. 2009). Finkbeiner et al. (2011) estimated that annual bycatch interactions total at least 20 individuals annually for U. S. Atlantic fisheries (resulting in less than ten mortalities) and no or very few interactions in U. S. Pacific fisheries.

Future impacts from climate change and global warming may result in significant changes in hatchling sex ratios. The fact that hawksbill turtles exhibit temperature-dependent sex determination (Wibbels 2003) suggests that there may be a skewing of future hawksbill cohorts toward strong female bias (since warmer temperatures produce more female embryos).

Critical habitat. On September 2, 1998, the NMFS established critical habitat for hawksbill sea turtles around Mona and Monito Islands, Puerto Rico (63 FR 46693). Aspects of these areas that are important for hawksbill sea turtle survival and recovery include important natal development habitat, refuge from predation, shelter between foraging periods, and food for hawksbill sea turtle prey. No critical habitat occurs within the action area.

6.9 Kemp's ridley sea turtle

Population. Kemp's ridley sea turtles are considered to consist of a single population, although expansion of nesting may indicate differentiation.

Distribution. The Kemp's ridley was formerly known only from the Gulf of Mexico and along the Atlantic coast of the U.S. (TEWG 2000b). However, recent records support Kemp's ridley sea turtles distribution extending into the Mediterranean Sea on occasion (Tomas and Raga 2008). The vast majority of individuals stem from breeding beaches at Rancho Nuevo on the Gulf of Mexico coast of Mexico. Dozens of sightings have been made along New Jersey during the approximate time frame of the proposed seismic survey (NSF 2014).

Movement and migration. Tracking of post-nesting females from Rancho Nuevo and Texas beaches indicates that turtles move along coastal migratory corridors either to the north or south from the nesting beach (Byles 1989b; Byles and Plotkin 1994; Renaud 1995a; Renaud et al. 1996; Seney and Landry 2011; Shaver 1999; Shaver 2002) after remaining in the nesting area during the nesting period (Seney and Landry 2011). These migratory corridors appear to extend throughout the coastal areas of the Gulf of Mexico and most turtles appear to travel in waters less than roughly 50 m in depth. Turtles that headed north and east traveled as far as southwest Florida, whereas those that headed south and east traveled as far as the Yucatan Peninsula, Mexico (Morreale et al. 2007).

Kemp's ridleys in south Florida begin to migrate northward during spring. With each passing month, the waters to the north become warmer and turtles migrate further to Long Island Sound and even Nova Scotia in late summer (Bleakney 1955). During winter, individuals return south in response to local water temperatures; the turtles in the northernmost areas begin their southward movement first. By early November, turtles from New York and New Jersey merge with turtles from the Chesapeake Bay (Byles 1988; Keinath 1993; Lutcavage and Musick 1985; Renaud 1995a) and North Carolina inshore waters (Epperly et al. 1995a; Epperly et al. 1995b; Musick et al. 1994).

Following migration, Kemp's ridley sea turtles settle into resident feeding areas for several months (Byles and Plotkin 1994; Morreale et al. 2007). Females may begin returning along relatively shallow migratory corridors toward the nesting beach in the winter in order to arrive at the nesting beach by early spring.

During spring and summer, juvenile Kemp's ridleys occur in the shallow coastal waters of the northern Gulf of Mexico from south Texas to north Florida. In the fall, most Kemp's ridleys migrate to deeper or more southern, warmer waters and remain there through the winter (Schmid 1998a). As adults, many turtles remain in the Gulf of Mexico, with only occasional occurrence in the Atlantic Ocean (NMFS et al. 2010). Satellite telemetry of males caught near Padre Island, Texas, indicates no migration, but year-round occurrence in nearshore waters less than 50 m deep (Shaver et al. 2005b). Many postnesting females from Rancho Nuevo migrate north to areas offshore of Texas and Louisiana (Marquez-M. 1994a). Farther south, some post-nesting females migrate from Rancho Nuevo to the northern and western Yucatán Peninsula in the southern Gulf of Mexico, which contains important seasonal foraging sites for adult females, such as the Bay of Campeche (Marquez-M. 1994a; Márquez 1990b; Pritchard and Marquez 1973).

Reproduction. Mating is believed to occur about three to four weeks prior to the first nesting (Rostal 2007), or late-March through early- to mid-April. It is presumed that most mating takes place near the nesting beach (Morreale et al. 2007; Rostal 2007). Females initially ovulate within a few days after successful mating and lay the first clutch approximately two to four weeks later; if a turtle nests more than once per season, subsequent ovulations occur within approximately 48 hours after each nesting (Rostal 2007).

Approximately 60% of Kemp's ridley nesting occurs along an 40 km stretch of beach near Rancho Nuevo, Tamaulipas, Mexico from April to July, with limited nesting to the north (100 nests along Texas in 2006) and south (several hundred nests near Tampico, Mexico in 2006 USFWS 2006). Nesting at this location may be particularly important because hatchlings can more easily migrate to foraging grounds (Putman et al. 2010). The Kemp's ridley sea turtle tends to nest in large aggregations or arribadas (Bernardo and Plotkin 2007). The period between Kemp's ridley arribadas averages approximately 25 days, but the precise timing of the arribadas is unpredictable (Bernardo and Plotkin 2007; Rostal et al. 1997). Like all sea turtles, Kemp's ridley sea turtles nest multiple times in a single nesting season. The most recent analysis suggests approximately 3.075 nests per nesting season per female (Rostal 2007). The annual average number of eggs per nest (clutch size) is 94 to 100 and eggs typically take 45 to 58 days to hatch, depending on temperatures (Marquez-M. 1994b; Rostal 2007; USFWS 2000; USFWS 2001; USFWS 2002; USFWS 2003; USFWS 2004; USFWS 2005; USFWS 2006). The period between nesting seasons for each female is approximately 1.8 to 2.0 years (Marquez et al. 1989; Rostal 2007; TEWG 2000b). The nesting beach at Rancho Nuevo may produce a "natural" hatchling sex ratio that is female-biased, which can potentially increase egg production as those turtles reach sexual maturity (Coyne and Landry Jr. 2007; Wibbels 2007).

Growth. Kemp's ridleys require approximately 1.5 to two (range 1-4) years to grow from a hatchling to a size of approximately 20 cm long, at which size they are capable of making a transition to a benthic coastal immature stage (Caillouet et al. 1995; Ogren 1989; Schmid 1998b; Schmid and Witzell 1997b; Snover et al. 2007b; TEWG 2000b; Zug et al. 1997). Based on the size of nesting females, it is assumed that turtles must attain a size of approximately 60 cm long prior to maturing (Marquez-M. 1994b). Growth models based on mark-recapture data suggest that a time period of seven to nine years would be required for this growth from benthic immature to mature size (Schmid and Witzell 1997b; Snover et al. 2007b). Currently, age to sexual maturity is believed to range from approximately 10 to 17 years for Kemp's ridleys (Caillouet Jr. et al. 1995; Schmid and Witzell 1997a; Snover et al. 2007a; Snover et al. 2007b). However, estimates of 10 to 13 years predominate in previous studies (Caillouet et al. 1995; Schmid and Witzell 1997b; TEWG 2000b).

Habitat. Stranding data indicate that immature turtles in this benthic stage are found in coastal habitats of the entire Gulf of Mexico and U. S. Atlantic coast (Morreale et al. 2007; TEWG

2000b). Developmental habitats for juveniles occur throughout the entire coastal Gulf of Mexico and U. S. Atlantic coast northward to New England (Morreale et al. 2007; Schmid 1998b; Wibbels et al. 2005). Key foraging areas in the Gulf of Mexico include Sabine Pass, Texas; Caillou Bay and Calcasieu Pass, Louisiana; Big Gulley, Alabama; Cedar Keys, Florida; and Ten Thousand Islands, Florida (Carr and Caldwell 1956; Coyne et al. 1995; Ogren 1989; Schmid 1998b; Schmid et al. 2002; Witzell et al. 2005a). Foraging areas studied along the Atlantic coast include Pamlico Sound, Chesapeake Bay, Long Island Sound, Charleston Harbor, and Delaware Bay. Near-shore waters of 35 m or less provide the primary marine habitat for adults, although it is not uncommon for adults to venture into deeper waters (Byles 1989a; Mysing and Vanselous 1989; Renaud et al. 1996; Shaver et al. 2005a; Shaver and Wibbels 2007a).

Benthic coastal waters of Louisiana and Texas seem to be preferred foraging areas for Kemp's ridley sea turtles (particularly passes and beachfronts), although individuals may travel along the entire coastal margin of the Gulf of Mexico (Landry and Costa 1999; Landry et al. 1996; Renaud 1995b). Sightings are less frequent during winter and spring, but this is likely due to lesser sighting effort during these times (Keinath et al. 1996; Shoop and Kenney 1992b).

Feeding. Kemp's ridley diet consists mainly of swimming crabs, but may also include fish, jellyfish, and an array of mollusks. Immature Kemp's ridleys off southwest Florida predate on benthic tunicates, a previously undocumented food source (Witzell and Schmid 2005).

Diving. Kemp's ridley sea turtles can dive for well over 2.5 hours, although most dives are from 16 to 34 minutes (Mendonca and Pritchard 1986; Renaud 1995a). Individuals spend the vast majority of their time underwater; over 12-hour periods, 89% to 96% of their time is spent below the surface (Byles 1989b; Gitschlag 1996).

Vocalization and hearing. Sea turtles are low-frequency hearing specialists, typically hearing frequencies from 30 to 2,000 Hz, with a range of maximum sensitivity between 100 and 800 Hz (Bartol et al. 1999; Lenhardt 2002; Lenhardt 1994b; Moein Bartol and Ketten 2006; Ridgway et al. 1969). Hearing below 80 Hz is less sensitive but still possible (Lenhardt 1994b). Juvenile Kemp's ridleys can hear from 100 to 500 Hz, with a maximum sensitivity between 100 and 200 Hz at thresholds of 110 dB re 1 μPa (Moein Bartol and Ketten 2006).

These hearing sensitivities are similar to those reported for two terrestrial species: pond and wood turtles. Pond turtles respond best to sounds between 200 and 700 Hz, with slow declines below 100 Hz and rapid declines above 700 Hz, and almost no sensitivity above 3 kHz (Wever and Vernon 1956). Wood turtles are sensitive up to about 500 Hz, followed by a rapid decline above 1 kHz and almost no responses beyond 3 or 4 kHz (Patterson 1966).

Status and trends. The Kemp's ridley sea turtle was listed as endangered on December 2, 1970 (35 FR 18319). Internationally, the Kemp's ridley is considered the most endangered sea turtle (NRC 1990a; USFWS 1999).

During the mid-20th century, the Kemp's ridley was abundant in the Gulf of Mexico. Historic information indicates that tens of thousands of Kemp's ridleys nested near Rancho Nuevo, Mexico, during the late 1940s (Hildebrand 1963). From 1978 through the 1980s, arribadas were 200 turtles or less, and by 1985, the total number of nests at Rancho Nuevo had dropped to approximately 740 for the entire nesting season, or a projection of roughly 234 turtles (TEWG 2000b; USFWS and NMFS 1992). Beginning in the 1990s, an increasing number of beaches in Mexico were being monitored for nesting, and the total number of nests on all beaches in

Tamaulipas and Veracruz in 2002 was over 6,000; the rate of increase from 1985 ranged from 14-16% (Heppell et al. 2005; TEWG 2000b; USFWS 2002). In 2006, approximately 7,866 nests were laid at Rancho Nuevo with the total number of nests for all the beaches in Mexico estimated at about 12,000 nests, which amounted to about 4,000 nesting females based upon three nests per female per season (Rostal 2007; Rostal et al. 1997; USFWS 2006). Considering remigration rates, the population included approximately 7,000 to 8,000 adult female turtles at that time (Marquez et al. 1989; Rostal 2007; TEWG 2000b). The 2007 nesting season included an arribada of over 4,000 turtles over a three-day period at Rancho Nuevo (P. Burchfield, pers. comm. in NMFS and USFWS 2007c). The increased recruitment of new adults is illustrated in the proportion of first time nesters, which has increased from 6% in 1981 to 41% in 1994. Average population growth was estimated at 13% per year between 1991 and 1995 (TEWG 1998a). In 2008, there were 17,882 nests in Mexico (Gladys Porter Zoo 2008), and nesting in 2009 reached 21,144 (Burchfield 2010). In 2010, nesting declined significantly, to 13,302 but it is too early to determine if this is a one-time decline or if is indicative of a change in the trend. Preliminary estimates of 2011 and 2012 nesting supports 19,368 and 20,197 nests, respectively (back to 2009 levels)(Gallaway et al. 2013). Population modeling used by the TEWG (2000a) projected that Kemp's ridleys could reach the recovery plan's intermediate recovery goal of 10,000 nesters by the year 2015. Over one million hatchlings were released in 2011 and 2012 (Gallaway et al. 2013).

Nesting has also expanded geographically, with a Headstart program reestablishing nesting on South Padre Island starting in 1978. Growth remained slow until 1988, when rates of return started to grow slowly (Shaver and Wibbels 2007b). Nesting rose from 6 in 1996 to 128 in 2007, 195 in 2008, and 197 in 2009. Texas nesting then experienced a decline similar to that seen in Mexico for 2010, with 140 nests (National Park Service data, http://www.nps.gov/pais/naturescience/strp.htm), but nesting rebounded in 2011 with a record 199 nests (National Park Service data, http://www.nps.gov/pais/naturescience/current-season.htm).

Gallaway et al. (2013) estimated that nearly 189,000 female Kemp's ridley sea turtles over the age of two years were alive in 2012. Extrapolating based upon sex bias, the authors estimated that nearly a quarter million age two or older Kemp's ridleys were alive at this time.

Natural threats. Sea turtles face predation primarily by sharks and to a lesser extent by killer whales. All sea turtles except leatherbacks can undergo "cold stunning" if water temperatures drop below a threshold level, which can pose lethal effects. Kemp's ridley sea turtles are particularly prone to this phenomenon along Cape Cod (Innis et al. 2009). From 2006-201), the number of cold-stunned turtles on Cape Cod beaches averaged 115 Kemp's ridleys. The fungal pathogens *Fusarium falciforme* and *F. keratoplasticum* an kill in excess of 90% of sea turtle embryos they infect and may constitute a major threat to nesting productivity under some conditions (Sarmiento-Ramırez et al. 2014).

Anthropogenic threats. Population decline has been curtailed due to the virtual elimination of sea turtle and egg harvesting, as well as assistance in hatching and raising hatchlings (Headstart). However, habitat destruction remains a concern in the form of bottom trawling and shoreline development. Trawling destroys habitat utilized by Kemp's ridley sea turtles for feeding and construction activities can produce hazardous runoff. Bycatch is also a source of mortality for Kemp's ridley sea turtles (McClellan et al. 2009), with roughly three-quarters of annual mortality attributed to shrimp trawling prior to turtle excluder device (TED) regulations (Gallaway et al.

2013). However, this has dropped to an estimated one-quarter of total mortality nearly 20 years after TEDS were implemented in 1990 (Gallaway et al. 2013). In 2010, due to reductions in shrimping effort and TED use, shrimp-trawl related mortality appears to have dropped to 4% (1,884) of total mortality (65,505 individuals)(Gallaway et al. 2013). This increased to 3,300 individuals in 2012 (20% of total mortality)(Gallaway et al. 2013). Finkbeiner et al. (2011) estimated that annual bycatch interactions total at least 98,300 individuals annually for U. S. Atlantic fisheries (resulting in 2,700 mortalities or more). The vast majority of fisheries interactions with sea turtles in the U. S. are either Kemp's ridley's or loggerhead sea turtles (Finkbeiner et al. 2011).

Toxin burdens in Kemp's ridley sea turtles include DDT, DDE, PCBs, perfluorooctanoic acid (PFOA), perfluorooctanesulfonic acid (PFOS), chlordane, and other organochlorines (Keller et al. 2005; Keller et al. 2004a; Lake et al. 1994; Rybitski et al. 1995). These contaminants have the potential to cause deficiencies in endocrine, developmental and reproductive health, and are known to depress immune function in loggerhead sea turtles (Keller et al. 2006; Storelli et al. 2007b). Along with loggerheads, Kemp's ridley sea turtles have higher levels of PCB and DDT than leatherback and green sea turtles (Pugh and Becker 2001b). Organochlorines, including DDT, DDE, DDD, and PCBs have been identified as bioaccumulative agents and in greatest concentration in subcutaneous lipid tissue (Rybitski et al. 1995). Concentrations ranged from 7.46 mu g/kg to 607 mu g/kg, with a mean of 252 mu g/kg in lipid tissue. Five PCB congeners composed most of the contaminants: 153/132, 138/158, 180, 118, and 187 in order of concentration. PCBs have also been identified in the liver, ranging in concentration from 272 ng/g to 655 ng/g of wet weight, values that are several fold higher than in other sea turtle species (Lake et al. 1994). However, concentrations are reportedly 5% of that which causes reproductive failure in snapping turtles. DDE was identified to range from 137 ng/g to 386 ng/g wet weight. Trans-nonachlor was found at levels between 129 ng/g and 275 ng/g wet weight. Blood samples may be appropriate proxies for organochlorines in other body tissues (Keller et al. 2004a). Perfluorinated compounds in the forms of PFOA and PFOS have been identified in the blood of Kemp's ridley turtles at concentrations of 39.4 ng/mL and 3.57 ng/mL, respectively (Keller et al. 2005). Perfluorinated carboxylic acids (PFCAs) have also been detected. It is likely that age and habitat are linked to perflourinated chemical (PFC) bioaccumulation.

Oil can also be hazardous to Kemp's ridley turtles, with fresh oil causing significant mortality and morphological changes in hatchlings, but aged oil having no detectable effects (Fritts and McGehee 1981). Blood levels of metals are lower in Kemp's ridley sea turtles than in other sea turtles species or similar to them, with copper (215 ng/g to 1,300 ng/g), lead (0 to 34.3 ng/g), mercury (0.5 ng/g to 67.3 ng/g), silver (0.042 ng/g to 2.74 ng/g), and zinc (3,280 ng/g to 18,900 ng/g) having been identified (Innis et al. 2008; Orvik 1997). It is likely that blood samples can be used as an indicator of metal concentration. Mercury has been identified in all turtle species studied, but are generally an order of magnitude lower than toothed whales. The higher level of contaminants found in Kemp's ridley sea turtles are likely due to this species tendency to feed higher on the food chain than other sea turtles. Females from sexual maturity through reproductive life should have lower levels of contaminants than males because contaminants are shared with progeny through egg formation.

Critical habitat. NMFS has not designated critical habitat for Kemp's ridley sea turtle.

6.10 Leatherback sea turtle

Populations. Leatherbacks break into four nesting aggregations: Pacific, Atlantic, and Indian oceans, and the Caribbean Sea. Detailed population structure is unknown, but is likely dependent upon nesting beach location.

Atlantic Ocean. Previous genetic analyses of leatherbacks using only mitochondrial DNA (mtDNA) resulted in an earlier determination that within the Atlantic basin there are at least three genetically different nesting populations: the St. Croix nesting population (U. S. Virgin Islands), the mainland nesting Caribbean population (Florida, Costa Rica, Suriname/French Guiana), and the Trinidad nesting population (Dutton et al. 1999). Further genetic analyses using microsatellite markers in nuclear DNA along with the mtDNA data and tagging data has resulted in Atlantic Ocean leatherbacks now being divided into seven groups or breeding populations: Florida, Northern Caribbean, Western Caribbean, Southern Caribbean/Guianas, West Africa, South Africa, and Brazil (TEWG 2007a).

Caribbean Sea. Nesting occurs in Puerto Rico, St. Croix, Costa Rica, Panama, Colombia, Trinidad and Tobago, Guyana, Suriname, and French Guiana (Bräutigam and Eckert 2006; Márquez 1990a; Spotila et al. 1996).

Indian Ocean. In the Indian Ocean, a significant gap in knowledge remains concerning the genetic population structure of leatherback rookeries. Published genotypes only exist for Malaysia, Indonesia, and South Africa (Dutton et al. 1999; Dutton 2007). It has been hypothesized that the nesting beaches in Sri Lanka and the Nicobar Islands might be part of a distinct Indian Ocean population (Dutton 2005-2006). Nesting is reported in South Africa, India, Sri Lanka, and the Andaman and Nicobar islands (Hamann et al. 2006c).

Pacific Ocean. Leatherbacks are found from tropical waters north to Alaska within the North Pacific and is the most common sea turtle in the eastern Pacific north of Mexico (Eckert 1993a; Stinson 1984b; Wing and Hodge 2002). The west coast of Central America and Mexico hosts nesting from September-March, although Costa Rican nesting peaks during April-May (Chacón-Chaverri and Eckert 2007; LGL Ltd. 2007). Leatherback sea turtles disappeared from India before 1930, have been virtually extinct in Sri Lanka since 1994, and appear to be approaching extinction in Malaysia (Spotila et al. 2000). In Fiji, Thailand, and Australia, leatherback sea turtles have only been known to nest in low densities and scattered sites. Leatherback nesting aggregations occur widely in the Pacific, including China, Malaysia, Papua New Guinea, Indonesia, Thailand, Australia, Fiji, the Solomon Islands, and Central America (Dutton et al. 2007; Limpus 2002). Significant nesting also occurs along the Central American coast (Márquez 1990a). Although not generally known to nest on Japanese shores, two nests were identified in the central Ryukyu Islands in 2002 (Kamezaki et al. 2002).

Nesting beaches also occur in Mexico and Costa Rica (nesting occurs October through March) and represent a separate population from the western Pacific beaches (Benson et al. 2007a; summary in NMFS and USFWS 2007d; Spotila 2004a). In Costa Rica, leatherbacks nest at Playa Naranjo in Santa Rosa National Park, the second-most important nesting beach on the Pacific coast (Yañez et al. 2010), Rio Oro on the Osa Peninsula, and at various beaches in Las Baulas National Park, which includes Playa Langosta and Playa Grande and contains the largest colony of leatherbacks in the Pacific (Spotila 2004a). Females typically lay six clutches per season (average nine days between nests), which incubate for 58–65 days (Lux et al. 2003). Limited nesting also occurs along Nicaragua, Panama, El Salvador, Vanuatu, and Guatemala.

In the Pacific Ocean, genetic studies have identified three distinct populations (referred to also as genetic stocks or Management Units; see Wallace et al. (2010a)) of leatherback turtles: (1) Mexico and Costa Rica, which are genetically homogenous but distinct from the western populations; (2) Papua Barat in Indonesia, Papua New Guinea, Solomon Islands, and Vanuatu, which comprise a metapopulation representing a single genetic stock; and (3) Malaysia (Barragan and Dutton 2000; Barragan et al. 1998; Dutton et al. 1999; Dutton 2005-2006; Dutton et al. 2000; Dutton et al. 2006; Dutton 2007). The genetically distinct Malaysia nesting population likely is extirpated (Chan and Liew 1996b; Dutton et al. 1999; Dutton 2005-2006).

Distribution. Leatherbacks range farther than any other sea turtle species, having evolved physiological and anatomical adaptations that allow them to exploit cold waters (Frair et al. 1972; Greer et al. 1973; USFWS 1995). High-latitude leatherback range includes in the Atlantic includes the North and Barents Seas, Newfoundland and Labrador, Argentina, and South Africa (Goff and Lien 1988; Hughes et al. 1998; Luschi et al. 2003; Luschi et al. 2006; Márquez 1990a; Threlfall 1978). Pacific ranges extend to Alaska, Chile, and New Zealand (Brito 1998; Gill 1997; Hodge and Wing 2000). Several sightings have been made along New Jersey during the approximate time frame of the proposed seismic survey (NSF 2014).

Leatherbacks also occur in Mediterranean and Indian Oceans (Casale et al. 2003; Hamann et al. 2006c). Associations exist with continental shelf and pelagic environments and sightings occur in offshore waters of 7-27˚ C (CETAP 1982a). Juvenile leatherbacks usually stay in warmer, tropical waters >21˚ C (Eckert 2002). Males and females show some degree of natal homing to annual breeding sites (James et al. 2005).

Growth and reproduction. It has been thought that leatherbacks reach sexual maturity somewhat faster than other sea turtles (except Kemp's ridley), with an estimated range of 3-6 (Rhodin 1985) or 13-14 years (Zug and Parham 1996). However, recent research suggests otherwise, with western North Atlantic leatherbacks possibly not maturing until as late as 29 years of age (Avens and Goshe 2007; Avens and Goshe 2008; Avens et al. 2009). Female leatherbacks nest frequently (up to 13, average of 5-7 nests per year and about every 2-3 years)(Eckert et al. 2012). The average number of eggs per clutch varies by region: Atlantic Ocean (85 eggs), western Pacific Ocean (85 eggs), eastern Pacific Ocean (65 eggs) and Indian Ocean (>100 eggs (Eckert et al. 2012)). However, up to ~30% of the eggs can be infertile. Thus, the actual proportion of eggs that can result in hatchlings is less than this seasonal estimate. The eggs incubate for 55-75 days before hatching.

Habitat. Leatherbacks occur throughout marine waters, from nearshore habitats to oceanic environments (Grant and Ferrell 1993; Schroeder and Thompson 1987; Shoop and Kenney 1992a; Starbird et al. 1993). Movements are largely dependent upon reproductive and feeding cycles and the oceanographic features that concentrate prey, such as frontal systems, eddy features, current boundaries, and coastal retention areas (Benson et al. 2011b; Collard 1990; Davenport and Balazs 1991; Frazier 2001; HDLNR 2002). Aerial surveys off the western U. S. support continental slope waters as having greater leatherback occurrence than shelf waters (Bowlby et al. 1994; Carretta and Forney 1993; Green et al. 1992; Green et al. 1993). Nesting sites appear to be related to beaches with relatively high exposure to wind or wind-generated waves (Santana Garcon et al. 2010).

Areas above 30º N in the Atlantic appear to be popular foraging locations (Fossette et al. 2009b). Northern foraging areas were proposed for waters between 35º and 50º N along North American, Nova Scotia, the Gulf of Saint-Laurent, in the western and northern Gulf Stream, the Northeast Atlantic, the Azores front and northeast of the Azores Islands, north of the Canary Islands. Southern foraging was proposed to occur between 5º and 15º N in the Mauritania upwelling, south of the Cape Verde islands, over the Guinea Dome area, and off Venezuela, Guyana and Suriname.

Migration and movement. Leatherback sea turtles migrate throughout open ocean convergence zones and upwelling areas, along continental margins, and in archipelagic waters (Eckert 1998; Eckert 1999; Morreale et al. 1994). In a single year, a leatherback may swim more than 11,000 km to nesting and foraging areas throughout ocean basins (Benson et al. 2007a; Benson et al. 2011b; Benson et al. 2007b; Eckert 1998; Eckert 2006; Eckert et al. 2006; Ferraroli et al. 2004; Hays et al. 2004; Sale et al. 2006). Much of this travel may be due to movements within current and eddy features, moving individuals along (Sale and Luschi 2009). Return to nesting beaches may be accomplished by a form of geomagnetic navigation and use of local cues (Sale and Luschi 2009). Leatherback females will either remain in nearshore waters between nesting events (generally within 100-300 km)(Benson et al. 2011a; Eckert et al. 2012), or range widely, presumably to feed on available prey (Byrne et al. 2009; Fossette et al. 2009a).

Fossette et al. (2009b) identified three main migratory strategies in leatherbacks in the North Atlantic (almost all of studied individuals were female). One involved 12 individuals traveling to northern latitudes during summer/fall and returning to waters during winter and spring. Another strategy used by six individuals was similar to this, but instead of a southward movement in fall, individuals overwintered in northern latitudes (30-40º N, 25-30º W) and moved into the Irish Sea or Bay of Biscay during spring before moving south to between 5 and 10º in winter, where they remained or returned to the northwest Atlantic. A third strategy, which was followed by three females remaining in tropical waters for the first year subsequent to nesting and moving to northern latitudes during summer/fall and spending winter and spring in latitudes of 40-50º N. Individuals nesting in Caribbean Islands migrate to foraging areas off Canada (Richardson et al. 2012).

Genetic studies support the satellite telemetry data indicating a strong difference in migration and foraging fidelity between the breeding populations in the northern and southern hemispheres of the Atlantic Ocean (Dutton et al. 2013; Stewart et al. 2013). Genetic analysis of rookeries in Gabon and Ghana confirm that leatherbacks from West African rookeries migrate to foraging areas off South America (Dutton et al. 2013). Foraging adults off Nova Scotia, Canada, mainly originate from Trinidad and none are from Brazil, Gabon, Ghana, or South Africa (Stewart et al. 2013).

Leatherbacks occur along the southeastern U. S. year-round, with peak abundance in summer (TEWG 2007b). In spring, leatherback sea turtles appear to be concentrated near the coast, while other times of the year they are spread out at least to the Gulf Stream. From August 2009 through August 2010 off Jacksonville, Florida, surveys sighted 48 leatherback sea turtles, while simultaneous vessel surveys sighted four leatherback sea turtles (U.S. Department of the Navy 2010).

Sex ratio. A significant female bias exists in all leatherback populations thus far studied. An examination of strandings and in-water sighting data from the U. S. Atlantic and Gulf of Mexico coasts indicates that 60% of individuals were female. Studies of Suriname nesting beach temperatures suggest a female bias in hatchlings, with estimated percentages of females hatched over the course of each season at 75.4, 65.8, and 92.2% in 1985, 1986, and 1987, respectively (Plotkin 1995). Binckley et al. (1998) found a heavy female bias upon examining hatchling gonad histology on the Pacific coast of Costa Rica, and estimated male to female ratios over three seasons of 0:100, 6.5:93.5, and 25.7:74.3. James et al. (2007) also found a heavy female bias (1.86:1) as well as a primarily large sub-adult and adult size distribution. Leatherback sex determination is affected by nest temperature, with higher temperatures producing a greater proportion of females (Mrosovsky 1994; Witzell et al. 2005b).

Feeding. Leatherbacks may forage in high-invertebrate prey density areas formed by favorable oceanographic features (Eckert 2006; Ferraroli et al. 2004). Although leatherbacks forage in coastal waters, they appear to remain primarily pelagic through all life stages (Heppell et al. 2003). The location and abundance of prey, including medusae, siphonophores, and salpae, in temperate and boreal latitudes likely has a strong influence on leatherback distribution in these areas (Plotkin 1995).

Diving. Leatherbacks are champion deep divers among sea turtles with a maximum-recorded dive of over 4,000 m (Eckert et al. 1989; López-Mendilaharsu et al. 2009). Dives are typically 50-84 m and 75-90% of time duration is above 80 m (Standora et al. 1984). Leatherbacks off South Africa were found to spend <1% of their dive time at depths greater than 200 m (Hays et al. 2009). Dive durations are impressive, topping 86 min, but routinely 1-14 min (Eckert et al. 1989; Eckert et al. 1996; Harvey et al. 2006; López-Mendilaharsu et al. 2009). Most of this time is spent traveling to and from maximum depths (Eckert et al. 1989). Dives are continual, with only short stays at the surface (Eckert et al. 1989; Eckert et al. 1986; Southwood et al. 1999). Off Playa Grande, Costa Rica, adult females spent 57–68% of their time underwater, diving to a mean depth of 19 m for 7.4 min (Southwood et al. 1999). Off St. Croix, adult females dove to a mean depth of 61.6 m for an average of 9.9 min, and spent an average of 4.9 min at the surface (Eckert et al. 1989). During shallow dives in the South China Sea, dives averaged 6.9–14.5 min, with a maximum of 42 min (Eckert et al. 1996). Off central California, leatherbacks dove to 20–30 m with a maximum of 92 m (Harvey et al. 2006). This corresponded to the vertical distribution if their prey (Harvey et al. 2006). Leatherback prey in the Gulf of Alaska are frequently concentrated in the deep-scattering layer (Hodge and Wing 2000). Mean dive and surface durations were 2.9 and 2.2 min, respectively (Harvey et al. 2006). In a study comparing diving patterns during foraging versus travelling, leatherbacks dove shallower (mean of 53.6 m) and moved more slowly (17.2 km/day) while in foraging areas while travelling to or from these areas (81.8 m and 51.0 km/day)(Fossette et al. 2009b).

Vocalization and hearing. Sea turtles are low-frequency hearing specialists, typically hearing frequencies from 30 to 2,000 Hz, with a range of maximum sensitivity between 100 and 800 Hz (Bartol et al. 1999; Lenhardt 2002; Lenhardt 1994b; Moein Bartol and Ketten 2006; Ridgway et al. 1969). Piniak et al. (2012) found leatherback hatchlings capable of hearing underwater sounds at frequencies of 50-1,200 Hz (maximum sensitivity at 100-400 Hz). Hearing below 80 Hz is less sensitive but still possible (Lenhardt 1994b).

These hearing sensitivities are similar to those reported for two terrestrial species: pond and wood turtles. Pond turtles respond best to sounds between 200 and 700 Hz, with slow declines below 100 Hz and rapid declines above 700 Hz, and almost no sensitivity above 3 kHz (Wever and Vernon 1956). Wood turtles are sensitive up to about 500 Hz, followed by a rapid decline above 1 kHz and almost no responses beyond 3 or 4 kHz (Patterson 1966).

Status and trends. Leatherback sea turtles received protection on June 2, 1970 (35 FR 8491) under the Endangered Species Conservation Act and, since 1973, have been listed as endangered under the ESA, but declines in nesting have continued worldwide. Consideration of the status of populations outside of the action area is important under the present analysis to determine the how risk the risk to the affected population(s) bears on the status of the species as a whole. Breeding females were initially estimated at 29,000-40,000, but were later refined to ~115,000 (Pritchard 1971; Pritchard 1982). Spotila et al. (1996) estimated 34,500 females, but later issued an update of 35,860 (Spotila 2004b). The species as a whole is declining and local populations are in danger of extinction (NMFS 2001b; NMFS 2001a)(Table 9).

Table 9. Leatherback nesting population site location information where multiple-year surveys were conducted or trends are known (data type, years surveyed, annual number (nests, females, trend). Nesting population trend symbols: ▲ = increasing; ▼ = decreasing; ▬ = stable; ? = unknown.

Location	Data: Nests, Females	Years	Annual number	Trend	Reference
Atlantic					
United States (Florida)	Nests	1979 - 2008	63-754	▲	Stewart et al. (2011)
Puerto Rico (Culebra)	Nests	1993 - 2012	395-32	▼	{C. Diez, Department of Natural and Environmental Resources of Puerto Rico, unpublished data in NMFS and USFWS, 2013 #36241} Diez et al. (2010; Ramírez-Gallego et al. 2013)
Puerto Rico (other)	Nests	1993 - 2012	131-1,291	▲	C. Diez, Department of Natural and Environmental Resources of Puerto Rico, unpublished data in NMFS and USFWS (2013)
United States Virgin Islands (Sandy Point National Wildlife Refuge, St. Croix)	Nests	1986 - 2004	143-1,008	▲[1]	Dutton et. al. (2005); Turtle Expert Working Group (2007c)
British Virgin Islands	Nests	1986 - 2006	0-65	▲	McGowan et al. (2008) ;Turtle Expert Working Group (2007c)
Nicaragua	Nests	2008 - 2013	42-132	?[2]	{C. Laguex and C. Campbell, Wildlife Conservation Society, unpublished data in NMFS and USFWS, 2013 #36241}
Costa Rica (Tortuguero)	Nests	2007 - 2011	~281	▼	Gordon and Harrison (2012)
Costa Rica (Gandoca)	Nests	1990 - 2004	~583	▼	Chacón and Eckert (2007); Turtle Expert Working Group (2007c)
Panama (Chiriqui Beach)	Nests	2004 - 2011	1,000-4,999	?	Meylan et al. (2013)
Colombia	Nests	2006 - 2007	1,653-2,871	?	Patino-Martinez et al. (2008)

Trinidad	Females	1994 - 2005	2,096	▲	Turtle Expert Working Group (2007c)
Guyana	Nests	2007 - 2010	377-1,722	▲	De Freitas and Pritchard (2008; 2009; 2010); Turtle Expert Working Group (2007c); Kalamandeen et al. (2007)
French Guiana	Nests		5,029-63,294	▬	Fossette et al. (2008)
Suriname	Nests		2,732-31,000	▬	Fossette et al. (2008)
Brazil	Nests	1988 - 2004	6-527	▲	Thomé et al. (Thomé et al. 2007); Turtle Expert Working Group (2007c)
Equatorial Guinea (Bioko)	Nests	2000 - 2005	2,127-5,071	?	Rader et al. (2006)
Congo	Nests	2003 - 2006	70-148	?	Rentaura (2004; 2006)
Gabon	Nests	2002 - 2007	36,185-126,480	?	Witt et al. (2009)
Indian					
South Africa	Nests	1965 - 2010	~296	▬[3]	Nel et al. (2013)
Mozambique	Females	1994 - 2004	~10	?	Hamann et al. (2006a)
Pacific					
Indonesia (Papua-Jamursba-Medi)	Nests	1984 - 2011	14,522-1,596	▼	Tapilatu et al. (2013)
Indonesia (Papua-Wermon)	Nests	2002 - 2011	2,994-1,096	▼	Tapilatu et al. (2013)
Papua New Guinea (Labu Tali)	Nests	1989 - 2011	76–59	▼[4]	Hirth et al. (1993); Pilcher (2011)
Vanuatu	Nests	2002 - 2010	~50	▼	Petro (2011); Petro et al. (2007)
Malaysia (Terengganu)	Nests	1956 - 2009	10,000-10	▼	reviewed by Eckert et al. (2012)
Costa Rica (Las Baulas National Marine Park: Playa Grande, Langosta, and Ventanas)	Females	1988 - 2004	1,504-188	▼	Santidrián Tomillo et al. (2007)
Mexico (Mexiquillo, Tierra Colorada, Cahuitán, Barra de la Cruz)	Nests	1982 - 2004	>10,000 - 120	▼	Sarti Martinez et al. (2007)

Nicaragua (Veracruz, Juan Venado, and Salamina)	Nests	2002 - 2010	~53	?	Urteaga et al. (2012)

[1] A more recent trend analysis was not found in the literature. However, trends since 2001 suggest the population may be declining, possibly due to a decrease in the number of new nesters, lowered productivity (number of clutches per season and lower hatch success), and an increase in remigration intervals (Garner 2012; Garner et al. 2012).

[2] The number of nests likely underrepresents the area because 22% of nesting activity was not surveyed from 2011-2013 due to military presence { Laguex and Campbell, Wildlife Conservation Society, unpublished data in NMFS and USFWS, 2013 #36241}.

[3] Based on 12.8 km index area in Maputaland and St. Lucia Marine Reserves, South Africa.

[4] Survey distance and time differed between the two surveys at Labu Tali, but the weight of evidence from the area indicates a declining population.

Nesting aggregations occur along Gabon, Sao Tome and Principe, French Guiana, Suriname, and Florida (Bräutigam and Eckert 2006; Márquez 1990a; Spotila et al. 1996). Widely dispersed but fairly regular African nesting also occurs between Mauritania and Angola (Fretey et al. 2007). Many sizeable populations (perhaps up to 20,000 females annually) of leatherbacks are known to nest in West Africa (Fretey 2001a). The population of leatherbacks nesting on Gabon beaches has been suggested as being the world's largest, with 36,185-126,480 clutches being laid by 5,865-20,499 females annually from 2002-2007 (Witt et al. 2009). The total number of females utilizing Gabon nesting beaches is estimated to be 15,730- 41,373 (Witt et al. 2009). North Atlantic leatherbacks likely number 34,000-94,000 individuals, with females numbering 18,800 and the eastern Atlantic segment numbering 4,700 (TEWG 2007a). Trends and numbers include only nesting females and are not a complete demographic or geographic cross-section. In 1996, the entire Western Atlantic population was characterized as stable at best (Spotila et al. 1996), with roughly 18,800 nesting females. A subsequent analysis indicated that by 2000, the western Atlantic nesting population had decreased to about 15,000 nesting females (NMFS 2011). Spotila et al. (1996) estimated that the entire Atlantic basin, including all nesting beaches in the Americas, the Caribbean, and West Africa, totaled approximately 27,600 nesting females, with an estimated range of 20,082-35,133. This is consistent with other estimates of 34,000-95,000 total adults (20,000-56,000 adult females; 10,000-21,000 nesting females)(TEWG 2007b). Nesting in Culebra, Puerto Rico has declined since 2004, has slowed in the U.S. Virgin Islands from 2001-2010, and increased by 10% annually in Florida from 1979-2008 (NMFS USFWS 2013).

The largest nesting aggregation in the western North Atlantic occurs in French Guiana and Suriname and likely belongs to a metapopulation whose limits remain unknown (Rivalan et al. 2006). For Suriname and French Guiana, historical estimates of the number of females nesting each year range from approximately 5,000 to 20,000 (Fossette et al. 2008). Suriname and French Guiana may represent over 40% of the world's leatherback population, although the magnitude of the West African rookery needs to be verified (Spotila et al. 1996). Heppell et al. (2003a) concluded that leatherbacks generally show less genetic structuring than green and hawksbill sea turtles. The French Guiana nesting aggregation has declined ~15% annually since 1987 (NMFS 2001a). However, from 1979-1986, the number of nests increased ~15% annually, possibly indicating the current decline may be linked with the erosion cycle of Guiana beaches (NMFS 2006e). Girondot et al. (2007a) analyzed nesting data collected between 1967 and 2002 from French Guiana and Suriname and found that the population can be classified as stable or slightly increasing. The Turtle Expert Working Group (2007c) analyzed nest numbers from 1967-2005 and found a positive population growth rate over the 39-year period for French Guiana and Suriname. Guiana nesting may have increased again in the early 2000s (NMFS 2006e). Suriname nesting numbers have recently increased from more than 10,000 nests annually since 1999 and a peak of 30,000 nests in 2001. Overall, Suriname and French Guiana nesting trends towards an increase (Girondot et al. 2007b; Hilterman and Goverse 2003). Florida (March-July) and U. S. Caribbean nesting since the early 1980s has increased ~0.3% and 7.5% per year, respectively, but lags behind the French Guiana coast and elsewhere in magnitude (NMFS/SEFSC 2001). This positive growth was seen within major nesting areas for the stock, including Trinidad, Guyana, and the combined beaches of Suriname and French Guiana (TEWG 2007b). Trinidad supports an estimated 7,000 to 12,000 leatherbacks nesting annually (Stewart et al. 2013), which represents more than 80% of the nesting in the insular Caribbean Sea (Fournillier and Eckert 1999). Using both Bayesian modeling and regression analyses, the TEWG (2007b) determined that the Southern Caribbean/Guianas stock had demonstrated a long-term, positive population growth rate (using nesting females as a proxy for population).

The Caribbean coast of Costa Rica and extending through Chiriquí Beach, Panama, represents the fourth largest known leatherback rookery in the world (Troeng et al. 2004). Examination of data from three index nesting beaches in the region (Tortuguero, Gandoca, and Pacuare in Costa Rica) using various Bayesian and regression analyses indicated that the nesting population likely was not growing during 1995-2005 (TEWG 2007b). Other modeling of the nesting data for Tortuguero indicates a 67.8% decline between 1995 and 2006 (Troëng et al. 2007).

In Puerto Rico, the primary nesting beaches are at Fajardo and on the island of Culebra. Nesting between 1978 and 2005 ranged between 469-882 nests, and the population has been growing since 1978, with an overall annual growth rate of 1.1% (TEWG 2007b). At the primary nesting beach on St. Croix, the Sandy Point National Wildlife Refuge, nesting has fluctuated from a few hundred nests to a high of 1,008 in 2001, and the average annual growth rate has been approximately 1.1% from 1986-2004 (TEWG 2007b). Overall increases are recorded for mainland Puerto Rico and St. Croix, as well as the U. S. Virgin Islands (Ramírez-Gallego et al. 2013). Trends since 2001 suggest the population may be declining, possibly due to a decrease in the number of new nesters, lowered productivity (number of clutches per season and lower hatch success), and an increase in remigration intervals (Garner 2012; Garner et al. 2012).

The Florida nesting stock comes ashore primarily along the east coast of Florida. This stock is of growing importance, with total nests between 800-900 per year in the 2000s following nesting totals fewer than 100 nests per year in the 1980s (NMFS 2011). Using data from the index nesting beach surveys, the TEWG (2007b) estimated a significant annual nesting growth rate of 1% between 1989 and 2005. Stewart et al. (2011) evaluated nest counts from 68 Florida beaches over 30 years (1979-2008) and found that nesting increased at all beaches with trends ranging from 3.1%-16.3% per year, with an overall increase of 10.2% per year. In 2007, a record 517 leatherback nests were observed on the index beaches in Florida, with 265 in 2008, and then an increase to a new record of 615 nests in 2009, and a slight decline in 2010 back to 552 nests (FWC Index Nesting Beach database). This up-and-down pattern is thought to be a result of the cyclical nature of leatherback nesting, similar to the biennial cycle of green turtle nesting.

The most recent population estimate for leatherback sea turtles from the North Atlantic as a whole is between 34,000-90,000 adult individuals (20,000-56,000 adult females)(TEWG 2007b).

Heavy declines have occurred at all major Pacific basin rookeries, as well as Mexico, Costa Rica, Malaysia, India, Sri Lanka, Thailand, Trinidad, Tobago, and Papua New Guinea. This includes a nesting decline of 23% between 1984-1996 at Mexiquillo, Michoacán, Mexico (Sarti et al. 1996). According to reports from the late 1970s and early 1980s, three beaches on the Pacific coast of Mexico supported as many as half of all leatherback turtle nests for the eastern Pacific. Since the early 1980s, the eastern Pacific Mexican population of adult female leatherback turtles has declined to slightly more than 200 individuals during 1998-1999 and 1999-2000 (Sarti et al. 2000). Spotila et al. (2000) reported the decline of the leatherback turtle population at Playa Grande, Costa Rica, which had been the fourth largest nesting colony in the world. Between 1988 and 1999, the nesting colony declined from 1,367 to 117 female leatherback turtles. Based on their models, Spotila et al. (2000) estimated that the colony could fall to less than 50 females by 2003-2004. Fewer than 1,000 females nested on the Pacific coast of Mexico from 1995-1996 and fewer than 700 females are estimated for Central America (Spotila et al. 2000). The number of leatherback turtles nesting in Las Baulas National Park declined rapidly during the 1990s, from about 1,500 females during the 1988–89 nesting season, to about 800 in 1990–91 and 1991–92 to 193 in 1993–94 (Williams et al. 1996) and 117 in 1998–99 (Spotila et al. 2000). Spotila (2004a) reported that between 59 and 435 leatherbacks nest at Las Baulas each year depending on the El Niño–La Niña cycle.

Declines in the western Pacific are equally severe. Only an Indonesian nesting assemblage has remained relatively abundant in the Pacific basin. The largest extant leatherback nesting assemblage in the Indo-Pacific lies on the northern Vogelkop coast of Irian Jaya (West Papua), Indonesia, with roughly 3,000 nests recorded annually (Dutton et al. 2007; Putrawidjaja 2000; Suárez et al. 2000). The Western Pacific leatherback metapopulation harbors the last remaining nesting aggregation of significant size in the Pacific with approximately 2,700–4,500 breeding females (Dutton et al. 2007; Hitipeuw et al. 2007). The total number of nests per year for the Jamursba-Medi leatherback nesting population ranged between a high of 6,373 nests in 1996 and a low of 1,537 nests in 2010 (Hitipeuw et al. 2007) and 1,596 in 2011 (Tapilatu et al. 2013). Nesting at Terengganu, Malaysia is 1% of that in 1950s (Chan and Liew 1996a). The South China Sea and East Pacific nesting colonies have undergone catastrophic collapse. Overall, Pacific populations have declined from an estimated 81,000 individuals to <3,000 total adults and subadults (Spotila et al. 2000). The number of nesting leatherbacks has declined by an estimated 95% over the past 20 years in the Pacific (Gilman 2009). Drastic overharvesting of eggs and mortality from fishing activities is likely responsible for this tremendous decline (Eckert 1997; Sarti et al. 1996). The current overall estimate for Papua Barat, Indonesia, Papua New Guinea, and Solomon Islands is 5,000 to 10,000 nests per year (Nel 2012).

Based on the survey and tagging work, it was estimated that 400-500 female leatherbacks nest annually on Great Nicobar Island (Andrews et al. 2002). The number of nesting females using the Andaman and Nicobar Islands combined was estimated around 1,000 (Andrews and Shanker 2002).

Reliable estimates of survival or mortality at different life history stages are not easily obtained. The annual survival rate for leatherbacks that nested at Playa Grande, Costa Rica, was estimated to be 0.654 for 1993-1994 and 0.65 for those that nested in 1994-1995 (Spotila et al. 2000). Rivalan et al. (2005) estimated the mean annual survival rate of adult leatherbacks in French Guiana to be 0.91. Pilcher and Chaloupka (2013) used capture-mark-recapture data for 178 nesting leatherbacks tagged at Lababia beach, Kamiali, on the Huon Coast of Papua New Guinea over a 10-year austral summer nesting period (2000-2009). Annual survival probability (ca. 0.85) was constant over the 10-year period. Annual survival was lower than those estimated for Atlantic rookeries (Dutton et al. 2005; Rivalan et al. 2005). For the St. Croix, U. S. Virgin Islands population, the annual survival rate was approximately 0.893 (confidence interval = 0.87-0.92) for adult female leatherbacks at St. Croix (Dutton et al. 2005). Annual juvenile survival rate for St. Croix was estimated to be approximately 0.63, and the total survival rate from hatchling to first year of reproduction for a female hatchling was estimated to be between 0.004 and 0.02, given assumed age at first reproduction between 9 and 13 (Eguchi et al. 2006). In Florida, annual survival for nesting females was estimated to be 0.956 (Stewart 2007). Spotila et al. (1996) estimated the first year (from hatching) of survival for the global population to be 0.0625.

Natural threats. Sea turtles face predation primarily by sharks and to a lesser extent by killer whales (Pitman and Dutton 2004). Hatchlings are preyed upon by herons, gulls, dogfish, and sharks. Leatherback hatching success is particularly sensitive to nesting site selection, as nests that are overwashed have significantly lower hatching success and leatherbacks nest closer to the high-tide line than other sea turtle species (Caut et al. 2009b). The fungal pathogens *Fusarium falciforme* and *F. keratoplasticum* an kill in excess of 90% of sea turtle embryos they infect and may constitute a major threat to nesting productivity under some conditions (Sarmiento-Ramırez et al. 2014).

Anthropogenic threats. Leatherback nesting and marine environments are facing increasing impacts through widespread development and tourism along nesting beaches (Hamann et al. 2006c; Hernandez et al. 2007; Maison 2006; Santidrián Tomillo et al. 2007). Structural impacts to beaches include building and piling construction, beach armoring and renourishment, and sand extraction (Bouchard et al. 1998; Lutcavage et al. 1997b). In some areas, timber and marine debris accumulation as well as sand mining reduce available nesting habitat (Bourgeois et al. 2009; Chacón Chaverri 1999; Formia et al. 2003; Laurance et al. 2008). Lights on or adjacent to nesting beaches alter nesting adult behavior and are often fatal to emerging hatchlings as they are drawn to light sources and away from the sea (Bourgeois et al. 2009; Cowan et al. 2002; Deem et al. 2007; Witherington 1992; Witherington and Bjorndal 1991). Leatherbacks are much more likely to emerge and not nest on developed beaches and much more likely to emerge and nest on undeveloped stretches (Roe et al. 2013). Plastic ingestion is very common in leatherbacks and can block gastrointestinal tracts leading to death (Mrosovsky et al. 2009). Along the coast of Peru, 13% of 140 leatherback carcasses were found to contain plastic bags and film (Fritts 1982). A leatherback found stranded along the northern Adriatic had been weakened by plastic ingestion, likely leading to an infection that ultimately killed the individual (Poppi et al. 2012). Although global warming may expand foraging habitats into higher latitude waters, increasing temperatures may increase feminization of nests (Hawkes et al. 2007b; James et al. 2006; McMahon and Hays 2006; Mrosovsky et al. 1984). Rising sea levels may also inundate nests on some beaches. Egg collection is widespread and attributed to catastrophic declines, such as in Malaysia. Harvest of females along nesting beaches is of concern worldwide.

Bycatch, particularly by longline fisheries, is a major source of mortality for leatherback sea turtles (Crognale et al. 2008; Fossette et al. 2009a; Gless et al. 2008; Petersen et al. 2009). Wallace et al. (2010) estimated that between 1990 and 2008, at least 85,000 sea turtles were captured as bycatch in fisheries worldwide. This estimate is likely at least two orders of magnitude low, resulting in a likely bycatch of nearly half a million sea turtles annually (Wallace et al. 2010b); many of these turtles are expected to be leatherbacks. Donoso and Dutton (2010) found that 284 leatherbacks were bycaught between 2001 and 2005 as part of the Chilean longline fishery, with two individuals observed dead; leatherbacks were the most frequently bycaught sea turtle species. Between 8-17 leatherback turtles likely died annually between 1990 and 2000 in interactions with the California/Oregon drift gillnet fishery; 500 leatherback turtles are estimated to die annually in Chilean and Peruvian fisheries; 200 leatherback turtles are estimated to die in direct harvests in Indonesia; and, before 1992, the North Pacific driftnet fisheries for squid, tuna, and billfish captured an estimated 1,000 leatherback turtles each year, killing about 111 of them each year. Currently, the U.S. tuna and swordfish longline fisheries managed under the HMS FMP are estimated to capture 1,764 leatherbacks (no more than 252 mortalities) for each 3-year period starting in 2007 (NMFS 2004). While 2010 total estimates are not yet available, in 2009, 285.8 (95% CI: 209.6-389.7) leatherback sea turtles are estimated to have been taken in the longline fisheries managed under the HMS FMP based on the observed takes (Garrison and Stokes 2010). Observer coverage for this period ranged from 54 to 92%. Trinidad and Tobago's Institute for Marine Affairs estimated that more than 3,000 leatherbacks were captured incidental to gillnet fishing in the coastal waters of Trinidad in 2000. Half or more of the gravid turtles in Trinidad and Tobago waters may be killed (Lee Lum 2003), though many of the turtles do not die as a result of drowning, but rather because the fishermen butcher them in order to get them out of their nets (NMFS 2001b).

Leatherback sea turtles are known to drown in fish nets set in coastal waters of Sao Tome, West Africa (Castroviejo et al. 1994; Graff 1995). Gillnets are one of the suspected causes for the decline in the leatherback turtle population in French Guiana (Chevalier et al. 1999), and gillnets targeting green and hawksbill turtles in the waters of coastal Nicaragua also incidentally catch leatherback turtles (Lagueux 1998). Observers on shrimp trawlers operating in the northeastern region of Venezuela documented the capture of six leatherbacks from 13,600 trawls (Marcano and Alió-M 2000). An estimated 1,000 mature female leatherback turtles are caught annually off of Trinidad and Tobago with mortality estimated to be between 50-95% (Eckert and Lien 1999). There are known to be many sizeable populations of leatherbacks nesting in West Africa, possibly as many as 20,000 females nesting annually (Fretey 2001b). In Ghana, nearly two thirds of the leatherback turtles that come up to nest on the beach are killed by local fishermen.

We know little about the effects of contaminants on leatherback sea turtles. The metals arsenic, cadmium, copper, mercury, selenium, and zinc bioaccumulate, with cadmium in highest concentration in leatherbacks versus any other marine vertebrate (Caurant et al. 1999; Gordon et al. 1998). Along with these, lead has also been reported in high concentrations, potentially to the detriment of the individual (Perrault et al. 2013; Poppi et al. 2012). A diet of primarily jellyfish, which have high cadmium concentrations, is likely the cause (Caurant et al. 1999). Organochlorine pesticides have also been found (McKenzie et al. 1999). PCB concentrations are reportedly equivalent to those in some marine mammals, with liver and adipose levels of at least one congener being exceptionally high (PCB 209: 500-530 ng/g wet weight Davenport et al. 1990; Oros et al. 2009).

Critical habitat. On March 23, 1979, leatherback critical habitat was identified adjacent to Sandy Point, St. Croix, U. S. Virgin Islands from the 183 m isobath to mean high tide level between 17° 42’12” N and 65°50’00” W (44 FR 17710). This habitat is essential for nesting, which has been increasingly threatened since 1979, when tourism increased significantly, bringing nesting habitat and people into close and frequent proximity. However, studies do not currently support significant critical habitat deterioration. This critical habitat does not co-occur with the action area.

6.11 Loggerhead sea turtle- Northeast Atlantic DPS

Populations. Five groupings represent loggerhead sea turtles by major sea or ocean basin: Atlantic, Pacific, and Indian oceans, as well as Caribbean and Mediterranean seas. As with other sea turtles, populations are frequently divided by nesting aggregation (Hutchinson and Dutton 2007). On September 22, 2011, the NMFS designated nine distinct population segments (DPSs) of loggerhead sea turtles: South Atlantic Ocean and southwest Indian Ocean as threatened as well as Mediterranean Sea, North Indian Ocean, North Pacific Ocean, northeast Atlantic Ocean, northwest Atlantic Ocean, South Pacific Ocean, and southeast Indo-Pacific Ocean as endangered (75 FR 12598). Recent ocean-basin scale genetic analysis supports this conclusion, with additional differentiation apparent based upon nesting beaches (Shamblin et al. 2014).

Western Atlantic nesting locations include The Bahamas, Brazil, and numerous locations from the Yucatán Peninsula to North Carolina (Addison 1997; Addison and Morford 1996; Marcovaldi and Chaloupka 2007). This group comprises five nesting subpopulations: Northern, Southern, Dry Tortugas, Florida Panhandle, and Yucatán. Additional nesting occurs on Cay Sal Bank (Bahamas), Cuba, the Bahamian Archipelago, Quintana Roo (Yucatan Peninsula), Colombia, Brazil, Caribbean Central America, Venezuela, and the eastern Caribbean Islands. Genetic studies indicate that, although females routinely return to natal beaches, males may breed with females from multiple populations and facilitate gene flow Bowen et al. (2005). In the eastern Atlantic, we know of five rookeries from Cape Verde, Greece, Libya, Turkey, and the western Africa coast.

Distribution. Loggerheads are circumglobal, occurring throughout the temperate and tropical regions of the Atlantic Ocean. Loggerheads are the most abundant species of sea turtle found in U.S. coastal waters. Hundreds of sightings have been made along New Jersey during the approximate time frame of the proposed seismic survey (NSF 2014).

Reproduction and growth. Loggerhead nesting is confined to lower latitude temperate and subtropic zones but absent from tropical areas (NMFS and USFWS 1991b; NRC 1990c; Witherington et al. 2006b). The life cycle of loggerhead sea turtles can be divided into seven stages: eggs and hatchlings, small juveniles, large juveniles, subadults, novice breeders, first-year emigrants, and mature breeders (Crouse et al. 1987). Hatchling loggerheads migrate to the ocean (to which they are drawn by near ultraviolet light Kawamura et al. 2009), where they are generally believed to lead a pelagic existence for as long as 7-12 years (Avens et al. 2013; NMFS 2005a). Loggerheads in the Mediterranean, similar to those in the Atlantic, grow at roughly 11.8 cm/yr for the first six months and slow to roughly 3.6 cm/yr at age 2.5-3.5. As adults, individuals may experience a secondary growth pulse associated with shifting into neritic habitats, although growth is generally monotypic (declines with age Casale et al. 2009a; Casale et al. 2009b). Individually-based variables likely have a high impact on individual growth rates (Casale et al. 2009b). At 15-38 years, loggerhead sea turtles become sexually mature, although the age at which they reach maturity varies widely among populations (Casale et al. 2009b; Frazer and Ehrhart 1985b; Frazer et al. 1994; NMFS 2001b; Witherington et al. 2006). However, based on data from tag returns, strandings, and nesting surveys, NMFS (2001b) estimated ages of maturity ranging from 20-38 years and benthic immature stage lasting from 14-32 years. Notably, data from several studies showed decreased growth rates of loggerheads in U.

S. Atlantic waters from 1997-2007, corresponding to a period of 43% decline in Florida nest counts (Bjorndal et al. 2013).

Loggerhead mating likely occurs along migration routes to nesting beaches, as well as in offshore from nesting beaches several weeks prior to the onset of nesting (Dodd 1988a; NMFS and USFWS 1998d). Females usually breed every 2-3 years, but can vary from 1-7 years (Dodd 1988a; Richardson et al. 1978). Females lay an average of 4.1 nests per season (Murphy and Hopkins 1984), although recent satellite telemetry from nesting females along southwest Florida support 5.4 nests per female per season, with increasing numbers of eggs per nest during the course of the season (Tucker 2009). The authors suggest that this finding warrants revision of the number of females nesting in the region. The western Atlantic breeding season is March-August. Nesting sites appear to be related to beaches with relatively high exposure to wind or wind-generated waves (Santana Garcon et al. 2010).

Nesting in the Gulf of Mexico does occur, although primarily in Florida, with rare nests along North and South Padre Island in Texas (Dodd 1988b; Hildebrand 1983).

Migration and movement. Loggerhead hatchlings migrate offshore and become associated with *Sargassum* spp. habitats, driftlines, and other convergence zones (Carr 1986). After 14-32 years of age, they shift to a benthic habitat, where immature individuals forage in the open ocean and coastal areas along continental shelves, bays, lagoons, and estuaries (Bowen et al. 2004; NMFS 2001b). Adult loggerheads make lengthy migrations from nesting beaches to foraging grounds (TEWG 1998c). In the Gulf of Mexico, larger females tend to disperse more broadly after nesting than smaller individuals, which tend to stay closer to their nesting locations (Girard et al. 2009). In the North Atlantic, loggerheads travel north during spring and summer as water temperatures warm and return south in fall and winter, but occur offshore year-round assuming adequate temperature. As water temperatures drop from October to December, most loggerheads emigrate from their summer developmental habitats to warmer waters south of Cape Hatteras, where they winter (Morreale and Standora 1998). For immature individuals, this movement occurs in two patterns: a north-south movement over the continental shelf with migration south of Cape Hatteras in winter and movement north along Virginia for summer foraging, and a not-so-seasonal oceanic dispersal into the Gulf Stream as far north as the 10-15° C isotherm (Mansfield et al. 2009). Wallace et al. (2009) suggested differences in growth rate based upon these foraging strategies. Long Island Sound, Core Sound, Pamlico Sound, Cape Cod Bay, and Chesapeake Bay are the most frequently used juvenile developmental habitats along the Northeast United States Continental Shelf Large Marine Ecosystem (Burke et al. 1991; Epperly et al. 1995a; Epperly et al. 1995b; Epperly et al. 1995c; Mansfield 2006; Prescott 2000; University of Delaware Sea Grant 2000). There is conflicting evidence that immature loggerheads roam the oceans in currents and eddies and mix from different natal origins or distribute on a latitudinal basis that corresponds with their natal beaches (Monzon-Arguello et al. 2009; Wallace et al. 2009). McCarthy et al. (2010) found that movement patterns of loggerhead sea turtles were more convoluted when sea surface temperatures were higher, ocean depths shallower, ocean currents stronger, and chlorophyll α levels lower. Satellite tracking of loggerheads from southeastern U. S. nesting beaches supports three dispersal modes to foraging areas: one northward along the continental shelf to the northeastern U. S., broad movement through the southeastern and mid-Atlantic U. S., and residency near breeding areas (Reina et al. 2012).

Sighting and stranding records support loggerhead sea turtles to be common, year-round residents of the Gulf of Mexico, although their abundance is much greater in the northeastern region versus the northwestern (Davis et al. 2000b; Fritts et al. 1983; Landry and Costa 1999). An estimated 12% of all western North Atlantic loggerhead sea turtles reside in the eastern Gulf of Mexico, with the vast majority in western Florida waters (Davis et al. 2000a; TEWG 1998b). Loggerheads may occur in both offshore habitats (particularly around oil platforms and reefs, where prey and shelter are available; (Davis et al. 2000b; Fritts et al. 1983; Gitschlag and Herczeg 1994; Lohoefener et al. 1990; Rosman et al. 1987), as well as shallow bays and sounds (which may be important developmental habitat for late juveniles in the eastern Gulf of Mexico; (Davis et al. 2000b; Lohoefener et al. 1990; USAF 1996). Offshore abundance in continental slope waters increases during the winter in the eastern Gulf of Mexico, as cooler inshore waters force individuals into warmer offshore areas (Davis et al. 2000b).

Gender, age, and survivorship. Although information on males is limited, several studies identified a female bias, although a single study has found a strong male bias (Dodd 1988a; NMFS 2001b; Rees and Margaritoulis 2004). Nest temperature seems to drive sex determination. Along Florida, males primarily derive from earlier-season nests (LeBlanc et al. 2012). Here, nests ranged from an average sex ratio of 55% female to 85% (LeBlanc et al. 2012).

Additionally, little is known about longevity, although Dodd (1988a) estimated the maximum female life span at 47-62 years. Heppell et al. (2003a) estimated annual survivorship to be 0.81 (southeast U.S. adult females), 0.78-0.91 (Australia adult females), 0.68-0.89 (southeast U. S. benthic juveniles, and 0.92 (Australia benthic juveniles). Another recent estimate suggested a survival rate of 0.41 or 0.60 (CIs 0.20-0.65 and 0.40-0.78, respectively), depending upon assumptions within the study (Sasso et al. 2011). Survival rates for hatchlings during their first year are likely very low (Heppell et al. 2003a; Heppell et al. 2003).

Feeding. Loggerhead sea turtles are omnivorous and opportunistic feeders through their lifetimes (Parker et al. 2005). Hatchling loggerheads feed on macroplankton associated with *Sargassum* spp. communities (NMFS and USFWS 1991b). Pelagic and benthic juveniles forage on crabs, mollusks, jellyfish, and vegetation at or near the surface (Dodd 1988a; Wallace et al. 2009). Loggerheads in the deep, offshore waters of the western North Pacific feed on jellyfish, salps, and other gelatinous animals (Dodd Jr. 1988; Hatase et al. 2002). Sub-adult and adult loggerheads prey on benthic invertebrates such as gastropods, mollusks, and decapod crustaceans in hard-bottom habitats, although fish and plants are also occasionally eaten (NMFS and USFWS 1998d). Stable isotope analysis and study of organisms on turtle shells has recently shown that although a loggerhead population may feed on a variety of prey, individuals composing the population have specialized diets (Reich et al. 2010; Vander Zanden et al. 2010).

Diving. Loggerhead diving behavior varies based upon habitat, with longer surface stays in deeper habitats than in coastal ones. Off Japan, dives were shallower than 30 m (Sakamoto et al. 1993). Routine dives can last 4–172 min (Byles 1988; Renaud and Carpenter 1994; Sakamoto et al. 1990). The maximum-recorded dive depth for a post-nesting female was over 230 m, although most dives are far shallower (9-21 m (Sakamoto et al. 1990)). Loggerheads tagged in the Pacific over the course of five months showed that about 70% of dives are very shallow (<5 m) and 40% of their time was spent within 1 m of the surface (Polovina et al. 2003; Spotila 2004a). During these dives, there were also several strong surface temperature fronts that individuals were associated with, one of 20° C at 28° N latitude and another of 17° C at 32° N latitude. In the Mediterranean, dives of over 300 min have been recorded in association with depressed water temperatures and are proposed as an overwintering strategy (Luschi et al. 2013).

Vocalization and hearing. Sea turtles are low-frequency hearing specialists, typically hearing frequencies from 30 to 2,000 Hz, with a range of maximum sensitivity between 100 and 800 Hz (Bartol et al. 1999; Lenhardt 2002; Lenhardt 1994b; Moein Bartol and Ketten 2006; Ridgway et al. 1969). Hearing below 80 Hz is less sensitive but still possible (Lenhardt 1994b). Bartol et al. (1999) reported effective hearing range for juvenile loggerhead turtles is from at least 250-750 Hz. Both yearling and two-year old loggerheads had the lowest hearing threshold at 500 Hz (yearling: about 81 dB re 1 μPa and two-year-olds: about 86 dB re 1 μPa), with thresholds increasing rapidly above and below that frequency (Moein Bartol and Ketten 2006).

These hearing sensitivities are similar to those reported for two terrestrial species: pond and wood turtles. Pond turtles respond best to sounds between 200 and 700 Hz, with slow declines below 100 Hz and rapid declines above 700 Hz, and almost no sensitivity above 3 kHz (Wever and Vernon 1956). Wood turtles are sensitive up to about 500 Hz, followed by a rapid decline above 1 kHz and almost no responses beyond 3 or 4 kHz (Patterson 1966).

Status and trends. Loggerhead sea turtles were listed as threatened under the ESA of 1973 on July 28, 1978 (43 FR 32800). On September 22, 2011, the NMFS designated nine distinct population segments (DPSs) of loggerhead sea turtles (75 FR 12598).

There is general agreement that the number of nesting females provides a useful index of the species' population size and stability at this life stage, even though there are doubts about the ability to estimate the overall population size (Bjorndal et al. 2005). An important caveat for population trends analysis based on nesting beach data is that this may reflect trends in adult nesting females, but it may not reflect overall population growth rates well. Adult nesting females often account for less than 1% of total population numbers. The global abundance of nesting female loggerhead turtles is estimated at 43,320–44,560 (Spotila 2004b).

The greatest concentration of loggerheads occurs in the Atlantic Ocean and the adjacent Caribbean Sea, primarily on the Atlantic coast of Florida, with other major nesting areas located on the Yucatán Peninsula of Mexico, Columbia, Cuba, and South Africa (EuroTurtle 2006 as cited in LGL Ltd. 2007; Márquez 1990a).

Among the five subpopulations, loggerhead females lay 53,000-92,000 nests per year in the southeastern U. S. and the Gulf of Mexico, and the total number of nesting females are 32,000-56,000. All of these are currently in decline or data are insufficient to assess trends (NMFS 2001b; TEWG 1998a). Loggerheads from western North Atlantic nesting aggregations may or may not feed in the same regions from which they hatch. Loggerhead sea turtles from the northern nesting aggregation, which represents about 9% of the loggerhead nests in the western North Atlantic, comprise 25-59% of individuals foraging from Georgia up to the northeast U. S. (Bass et al. 1998; Norrgard 1995; Rankin-Baransky 1997; Sears 1994; Sears et al. 1995). Loggerheads associated with the South Florida nesting aggregation occur in higher frequencies in the Gulf of Mexico (where they represent ~10% of the loggerhead captures) and the Mediterranean Sea (where they represent ~45% of loggerhead sea turtles captured). About 4,000 nests per year are laid along the Brazilian coast (Ehrhart et al. 2003).

The northern recovery unit along Georgia, South Carolina, and North Carolina has a forty-year time-series trend showing an overall decline in nesting, but the shorter comprehensive survey data (20 years) indicate a stable population (GDNR, NCWRC, and SCDNR nesting data located at www.seaturtle.org). NMFS scientists have estimated that the northern subpopulation produces 65% males (NMFS 2001b).

The peninsular Florida recovery unit is the largest loggerhead nesting assemblage in the northwest Atlantic. A near-complete nest census (all beaches including index nesting beaches) undertaken from 1989 to 2007 showed a mean of 64,513 loggerhead nests per year, representing approximately 15,735 nesting females annually (NMFS and USFWS 2008). The statewide estimated total for 2010 was 73,702 (FWRI nesting database). An analysis of index nesting beach data shows a 26% nesting decline between 1989 and 2008, and a mean annual rate of decline of 1.6% despite a large increase in nesting for 2008, to 38,643 nests (FWRI nesting database)(NMFS and USFWS 2008; Witherington et al. 2009). In 2009, nesting levels, while still higher than the lows of 2004, 2006, and 2007, dropped below 2008 levels to approximately 32,717 nests, but in 2010, a large increase was seen, with 47,880 nests on the index nesting beaches (FWRI nesting database). The 2010 index nesting number is the largest since 2000. With the addition of data through 2010, the nesting trend for the northwestern Atlantic DPS is slightly negative and not statistically different from zero (no trend)(NMFS and USFWS 2010).

Because of its size, the South Florida subpopulation of loggerheads may be critical to the survival of the species in the Atlantic, and in the past it was considered second in size only to the Oman nesting aggregation (NMFS 2006e; NMFS and USFWS 1991b). The South Florida population increased at ~5.3% per year from 1978-1990, and was initially increasing at 3.9-4.2% after 1990. An analysis of nesting data from 1989-2005, a period of more consistent and accurate surveys than in previous years, showed a detectable trend and, more recently (1998-2005), has shown evidence of a declining trend of approximately 22.3% (FFWCC 2007a; FFWCC 2007b; Witherington et al. 2009). This is likely due to a decline in the number of nesting females within the population (Witherington et al. 2009). Nesting data from the Archie Carr Refuge (one of the most important nesting locations in Southeast Florida) over the last 6 years shows nests declined from approximately 17,629 in 1998 to 7,599 in 2004, also suggesting a decrease in population size[3]. Loggerhead nesting is thought to consist of just 60 nesting females in the Caribbean and Gulf of Mexico (NMFS 2006d). Based upon the small sizes of almost all nesting aggregations in the Atlantic, the large numbers of individuals killed in fisheries, and the decline of the only large nesting aggregation, we suspect that the extinction probabilities of loggerhead sea turtle populations in the Atlantic are only slightly lower than those of populations in the Pacific.

Zurita et al. (2003) found a statistically significant increase in the number of nests on seven of the beaches on Quintana Roo, Mexico, from 1987-2001, where survey effort was consistent during the period. However, nesting has declined since 2001, and the previously reported increasing trend appears to have been temporary (NMFS and USFWS 2008).

Natural threats. Sea turtles face predation primarily by sharks and to a lesser extent by killer whales. All sea turtles except leatherbacks can undergo "cold stunning" if water temperatures drop below a threshold level, which can pose lethal effects. In January 2010, an unusually large cold-stunning event occurred throughout the southeast U. S., with well over 3,000 sea turtles

3 While this is a long period of decline relative to the past observed nesting pattern at this location, aberrant ocean surface temperatures complicate the analysis and interpretation of these data. Although caution is warranted in interpreting the decreasing nesting trend given inherent annual fluctuations in nesting and the short time period over which the decline has been noted, the recent nesting decline at this nesting beach is reason for concern.

(mostly greens but also hundreds of loggerheads) found cold-stunned. Most survived, but several hundred were found dead or died after being discovered in a cold-stunned state. Eggs are commonly eaten by raccoons and ghost crabs along the eastern U. S. (Barton and Roth 2008). In the water, hatchlings are hunted by herons, gulls, dogfish, and sharks. Heavy loads of barnacles are associated with unhealthy or dead stranded loggerheads (Deem et al. 2009). Brevetoxin-producing algal blooms can result in loggerhead sea turtle death and pathology, with nearly all stranded loggerheads in affected areas showing signs of illness or death resulting from exposure (Fauquier et al. 2013). The fungal pathogens *Fusarium falciforme* and *F. keratoplasticum* an kill in excess of 90% of sea turtle embryos they infect and may constitute a major threat to nesting productivity under some conditions (Sarmiento-Ramırez et al. 2014).

Anthropogenic threats. Anthropogenic threats impacting loggerhead nesting habitat are numerous: coastal development and construction, placement of erosion control structures, beachfront lighting, vehicular and pedestrian traffic, sand extraction, beach erosion, beach nourishment, beach pollution, removal of native vegetation, and planting of non-native vegetation (Baldwin 1992; Margaritoulis et al. 2003; Mazaris et al. 2009b; USFWS 1998). Surprisingly, beach nourishment also hampers nesting success, but only in the first year post-nourishment before hatching success increases (Brock et al. 2009). Loggerhead sea turtles face numerous threats in the marine environment as well, including oil and gas exploration, marine pollution, trawl, purse seine, hook and line, gill net, pound net, longline, and trap fisheries, underwater explosions, dredging, offshore artificial lighting, power plant entrapment, entanglement in debris, ingestion of marine debris, marina and dock construction and operation, boat collisions, and poaching. At least in the Mediterranean Sea, anthropogenic threats appear to disproportionally impact larger (more fecund) loggerheads (Bellido et al. 2010).

Wallace et al. (2010) estimated that between 1990 and 2008, at least 85,000 sea turtles were captured as bycatch in fisheries worldwide. This estimate is likely at least two orders of magnitude low, resulting in a likely bycatch of nearly half a million sea turtles annually (Wallace et al. 2010b); many of these are expected to be loggerhead sea turtles. Shrimp trawl fisheries account for the highest number of captured and killed loggerhead sea turtles. Pacific bycatch is about 400 individuals annually in U. S. fisheries resulting in at least 20 mortalities (Finkbeiner et al. 2011). Each year, various fisheries capture about 2,000 loggerhead sea turtles in Pamlico Sound, of which almost 700 die. As a result of the 2006 and 2007 tri-national fishermen's exchanges in 2007 a prominent Baja California Sur fleet retired its bottom-set longlines (Peckham and Maldonado-Diaz 2012; Peckham et al. 2008). Prior to this closure, the longline fleet interacted with an estimated 1,160-2,174 loggerheads annually, with nearly all (89%) of the takes resulting in mortalities (Peckham et al. 2008). Offshore longline tuna and swordfish longline fisheries are also a serious concern for the survival and recovery of loggerhead sea turtles and appear to affect the largest individuals more than younger age classes (Aguilar et al. 1995; Bolten et al. 1994; Carruthers et al. 2009; Howell et al. 2008; Marshall et al. 2009; Petersen et al. 2009; Tomás et al. 2008).

Marine debris ingestion is a widespread issue for loggerhead sea turtles. More than one-third of loggerheads found stranded or bycaught had injected marine debris in a Mediterranean study, with possible mortality resulting in some cases (Lazar and Gračan 2010). Another study in the Tyrrhenian Sea found 71% of stranded and bycaught sea turtles had plastic debris in their guts (Campani et al. 2013). Another threat marine debris poses is to hatchlings on beaches escaping to the sea. Two thirds of loggerheads contacted marine debris on their way to the ocean and many became severely entangled or entrapped by it (Triessnig et al. 2012).

Climate change may also have significant implications on loggerhead populations worldwide. In addition to potential loss of nesting habitat due to sea level rise, loggerhead sea turtles are very sensitive to temperature as a determinant of sex while incubating. Ambient temperature increase by just 1º-2º C can potentially change hatchling sex ratios to all or nearly all female in tropical and subtropical areas (Hawkes et al. 2007a). Over time, this can reduce genetic diversity, or even population viability, if males become a small proportion of populations (Hulin et al. 2009). Sea surface temperatures on loggerhead foraging grounds correlate to the timing of nesting, with higher temperatures leading to earlier nesting (Mazaris et al. 2009a; Schofield et al. 2009). Increasing ocean temperatures may also lead to reduced primary productivity and eventual food availability. This has been proposed as partial support for reduced nesting abundance for loggerhead sea turtles in Japan; a finding that could have broader implications for other populations in the future if individuals do not shift feeding habitat (Chaloupka et al. 2008b). Warmer temperatures may also decrease the energy needs of a developing embryo (Reid et al. 2009). Pike (2014) estimated that loggerhead populations in tropical areas produce about 30% fewer hatchlings than do populations in temperate areas. Historical climactic patterns have been attributed to the decline in loggerhead nesting in Florida, but evidence for this is tenuous (Reina et al. 2013).

Tissues taken from loggerheads sometimes contain very high levels of organochlorines chlorobiphenyl, chlordanes, lindane, endrin, endosulfan, dieldrin, PFOS, PFOA, DDT, and PCB (Alava et al. 2006; Corsolini et al. 2000; Gardner et al. 2003; Guerranti et al. 2013; Keller et al. 2005; Keller et al. 2004a; Keller et al. 2004b; McKenzie et al. 1999; Monagas et al. 2008; Oros et al. 2009; Perugini et al. 2006; Rybitski et al. 1995; Storelli et al. 2007a). It appears that levels of organochlorines have the potential to suppress the immune system of loggerhead sea turtles and may affect metabolic regulation (Keller et al. 2004c; Keller et al. 2006; Oros et al. 2009). These contaminants could cause deficiencies in endocrine, developmental, and reproductive health (Storelli et al. 2007a). It is likely that the omnivorous nature of loggerheads makes them more prone to bioaccumulating toxins than other sea turtle species (Godley et al. 1999; McKenzie et al. 1999). PAH pollution from petroleum origins has been found in Cape Verde loggerheads, where marine oil and gas extraction is not undertaken (Camacho et al. 2012).

Heavy metals, including arsenic, barium, cadmium, chromium, iron, lead, nickel, selenium, silver, copper, zinc, and manganese, have also been found in a variety of tissues in levels that increase with turtle size (Anan et al. 2001; Fujihara et al. 2003; Garcia-Fernandez et al. 2009; Gardner et al. 2006; Godley et al. 1999; Saeki et al. 2000; Storelli et al. 2008). These metals likely pass to turtles from plants and seem to have high transfer coefficients (Anan et al. 2001; Celik et al. 2006; Talavera-Saenz et al. 2007). Loggerhead sea turtles have higher mercury levels than any other sea turtle studied, but concentrations are an order of magnitude less than many toothed whales (Godley et al. 1999; Pugh and Becker 2001a). Arsenic occurs at levels several fold more concentrated in loggerhead sea turtles than marine mammals or seabirds.

Also of concern is the spread of antimicrobial agents from human society into the marine environment. Loggerhead sea turtles may harbor antibiotic-resistant bacteria, which may have developed and thrived as a result of high use and discharge of antimicrobial agents into freshwater and marine ecosystems (Foti et al. 2009).

Critical habitat. The NMFS has not designated critical habitat for loggerhead sea turtles.

However, on July 18, 2013, NMFS proposed critical habitat for loggerhead sea turtles along the U.S. Atlantic and Gulf of Mexico coasts from North Carolina to Mississippi (78 FR 43005). This area does not co-occur with the proposed action area.

7 ENVIRONMENTAL BASELINE

By regulation, the environmental baseline for ESA section 7 consultation includes the past and present impacts of all state, federal, or private actions and other human activities in the action area, the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions that are contemporaneous with the consultation in process (50 CFR §402.02). The *Environmental Baseline* for this Opinion includes the effects of several activities affecting the survival and recovery of ESA-listed species in the action area.

7.1 Climate change

We primarily discuss climate change as a threat common to all species addressed in this Opinion, rather than in each of the species-specific narratives. As we better understand responses to climate change, we will address these effects in the relevant species-specific section.

In general, based on forecasts made by the Intergovernmental Panel on Climate Change, climate change is projected to have substantial direct and indirect effects on individuals, populations, species, and the structure and function of marine, coastal, and terrestrial ecosystems in the near future(IPCC 2002). From 1906 to 2006, global surface temperatures have risen 0.74º C and continue at an accelerating pace; 11 of the 12 warmest years on record since 1850 have occurred since 1995 (Poloczanska et al. 2009). Furthermore, the Northern Hemisphere (where a greater proportion of ESA-listed species occur) is warming faster than the Southern Hemisphere, although land temperatures are rising more rapidly than over the oceans (Poloczanska et al. 2009). The direct effects of climate change will result in increases in atmospheric temperatures, changes in sea surface temperatures, patterns of precipitation, and sea level. Oceanographic models project a weakening of the thermohaline circulation resulting in a reduction of heat transport into high latitudes of Europe as well as an increase in the mass of the Antarctic and Greenland ice sheets, although the magnitude of these changes remain unknown. Species that are shorter-lived, larger body size, or generalist in nature are liable to be better able to adapt to climate change over the long term versus those that are longer-lived, smaller-sized, or rely upon specialized habitats (Brashares 2003; Cardillo 2003; Cardillo et al. 2005; Issac 2009; Purvis et al. 2000). Climate change is most likely to have its most pronounced effects on species whose populations are already in tenuous positions (Isaac 2008). As such, we expect the risk of extinction to listed species to rise with the degree of climate shift associated with global warming.

Indirect effects of climate change would result from changes in the distribution of temperatures suitable for whale calving and rearing, the distribution and abundance of prey, and abundance of competitors or predators. For species that undergo long migrations, individual movements are usually associated with prey availability or habitat suitability. If either is disrupted by changing ocean temperature regimes, the timing of migration can change or negatively impact population sustainability (Simmonds and Eliott. 2009). With warming temperatures and decreasing sea ice, humpback and fin whales have been found in increasing numbers at the northern extreme of their Pacific range and are regularly found now in the southern Chukchi Sea (Clarke et al. 2013). We do not know if this is due to range expansion owing to species recovery, or due to altered habitat associated with climate change (Clarke et al. 2013). Climate change can influence reproductive success by altering prey availability, as evidenced by high success of northern elephant seals during El Niño periods, when cooler, more productive waters are associated with higher first year pup survival (McMahon and Burton. 2005). Reduced prey availability resulting from increased sea temperatures has also been suggested to explain reductions in Antarctic fur seal pup and harbor porpoise survival (Forcada et al. 2005; Macleod et al. 2007). Polygamous marine mammal mating systems can also be perturbed by rainfall levels, with the most competitive grey seal males being more successful in wetter years than in drier ones (Twiss et al. 2007). Sperm whale females were observed to have lower rates of conception following unusually warm sea surface temperature periods (Whitehead 1997). Marine mammals with restricted distributions linked to water temperature may be particularly exposed to range restriction (Issac 2009; Learmonth et al. 2006). MacLeod (2009) estimated that, based upon expected shifts in water temperature, 88% of cetaceans would be affected by climate change, 47% would be negatively affected, and 21% would be put at risk of extinction. Of greatest concern are cetaceans with ranges limited to non-tropical waters and preferences for shelf habitats (Macleod 2009). Modeling of North Atlantic cetacean species found that three of four odontocete species would likely undergo range contraction while one would expand its range (Lambert et al. 2014). Kaschner et al. (2011) modeled marine mammal species richness, overlaid with projections of climate change and found that species in lower-latitude areas would likely be more affected than those in higher-latitude regions. Variations in the recruitment of krill and the reproductive success of krill predators correlate to variations in sea-surface temperatures and the extent of sea-ice cover during winter months. Although the IPCC (2001) did not detect significant changes in the extent of Antarctic sea-ice using satellite measurements, Curran et al. (2003) analyzed ice-core samples from 1841 to 1995 and concluded Antarctic sea ice cover had declined by about 20% since the 1950s.

Roughly 50% of the Earth's marine mammal biomass occurs in the Southern Ocean, with all baleen whales feeding largely on a single krill species, *Euphausia superba*, here and feeding virtually nowhere else (Boyd 2002). However, Atkinson et al. (2004) found severe decreases in krill populations over the past several decades in some areas of the Antarctic, linked to sea ice loss. Reid and Croxall (2001) analyzed a 23-year time series of the reproductive performance of predators (Antarctic fur seals, gentoo penguins, macaroni penguins, and black-browed albatrosses) that depend on krill for prey and concluded that these populations experienced increases in the 1980s followed by significant declines in the 1990s accompanied by an increase in the frequency of years with reduced reproductive success. The authors concluded that macaroni penguins and black-browed albatrosses had declined by as much as 50% in the 1990s, although incidental mortalities from longline fisheries probably contributed to the decline of the albatross. However, these declines resulted, at least in part, from changes in the structure of the krill population, particularly reduced recruitment into older krill age classes, which lowered the number of predators krill could sustain. The authors concluded that the biomass of krill within the largest size class was sufficient to support predator demand in the 1980s but not in the 1990s. By 2055, severe reductions in fisheries catch due to climate change have been suggested to occur in the Indo-Pacific, Red Sea, Mediterranean Sea, Antarctic, and tropical areas worldwide while increased catches are expected in the Arctic, North Pacific, North Atlantic, and northern portions of the Southern Ocean (Cheung et al. 2010).

Climate-mediated changes in the distribution and abundance of keystone prey species like krill and climate-mediated changes in the distribution of cephalopod populations worldwide is likely to affect marine mammal populations as they re-distribute throughout the world's oceans in search of prey. If sea ice extent decreases, then larval krill may not be able to survive without access to underice algae to feed on. This may be a cause of decreased krill abundance in the northwestern Antarctic Peninsula during the last decade (Fraser and Hofmann 2003). Meltwaters have also reduced surface water salinities, shifting primary production along the Antarctic Peninsula (Moline et al. 2004). Blue whales, as predators that specialize in eating krill, are likely to change their distribution in response to changes in the distribution of krill (Clapham et al. 1999; Payne et al. 1986; Payne et al. 1990b). If they did not change their distribution or could not find the biomass of krill necessary to sustain their population numbers, their populations would likely experience declines similar to those observed in other krill predators, including dramatic declines in population size and increased year-to year variation in population size and demographics. These outcomes would dramatically increase the extinction probability of baleen whales. Edwards et al. (2007) found a 70% decrease in one zooplankton species in the North Sea and an overall reduction in plankton biomass as warm-water species invade formerly cold-water areas. However, in other areas, productivity may increase, providing more resources for local species (Brown et al. 2009). This has been proposed to be the case in the eastern North Pacific, where a poleward shift in the North Pacific Current that would likely continue under global warming conditions would enhance nutrient and planktonic species availability, providing more prey for many higher trophic level species (Sydeman et al. 2011). Species such as gray whales may experience benefits from such a situation (Salvadeo et al. 2013). In addition, reductions in sea ice may alleviate "choke points" that allow some marine mammals to exploit additional habitats (Higdon and Ferguson 2009).

Foraging is not the only potential aspect that climate change could influence. Acevedo-Whitehouse and Duffus (2009) proposed that the rapidity of environmental changes, such as those resulting from global warming, can harm immunocompetence and reproductive parameters in wildlife to the detriment of population viability and persistence. An example of this is the altered sex ratios observed in sea turtle populations worldwide (Fuentes et al. 2009a; Mazaris et al. 2008; Reina et al. 2008; Robinson et al. 2008). This does not appear to have yet affected population viabilities through reduced reproductive success, although nesting and emergence dates of days to weeks in some locations have changed over the past several decades (Poloczanska et al. 2009). Altered ranges can also result in the spread of novel diseases to new areas via shifts in host ranges (Schumann et al. 2013; Simmonds and Eliott. 2009). It has also been suggested that increases in harmful algal blooms could be a result from increases in sea surface temperature (Simmonds and Eliott. 2009).

Sims et al. (2001) found the timing of squid peak abundance in the English Channel advanced by 120-150 days in the warmest years compared with the coldest. Bottom water temperatures correlated with the extent of squid movement, and temperature increases over the five months before and during the month of peak squid movement did not differ between early and late years. These authors concluded that the temporal variation in peak abundance of squid seen off Plymouth represents temperature-dependent movement, which climatic changes association with the North Atlantic Oscillation mediate. Cephalopods dominate the diet of sperm whales, who would likely re-distribute following changes in the distribution and abundance of their prey. If, however, cephalopod populations collapse or decline dramatically, sperm whales would likely decline as well. Long-term shifts of sperm whale prey in the California Current have also been attributed to the re-distribution of their prey resulting from climate-based shifts in oceanographic variables (Salvadeo et al. 2011). Similar changes have also been suggested for sardines and anchovy in the California Current (Salvadeo et al. 2011), which are important prey for humpback and fin whales, among others.

Climate change has been linked to changing ocean currents as well. Rising carbon dioxide levels have been identified as a reason for a poleward shift in the Eastern Australian Current, shifting warm waters into the Tasman Sea and altering biotic features of the area (Johnson et al. 2011; Poloczanska et al. 2009). Similarly, the Kuroshio Current in the western North Pacific (an important foraging area for juvenile sea turtles) has shifted southward as a result of altered long-term wind patterns over the Pacific Ocean (Poloczanska et al. 2009). Ocean temperatures around Iceland are linked with alterations in the continental shelf ecosystem there, including shifts in minke whale diet (Víkingsson et al. 2014).

Changes in global climatic patterns will likely have profound effects on the coastlines of every continent by increasing sea levels and the intensity, if not the frequency, of hurricanes and tropical storms (Wilkinson and Souter 2008). A half degree Celsius increase in temperatures during hurricane season from 1965-2005 correlated with a 40% increase in cyclone activity in the Atlantic. Sea levels have risen an average of 1.7 mm/year over the 20th century due to glacial melting and thermal expansion of ocean water; this rate will likely increase. Based on computer models, these phenomena would inundate nesting beaches of sea turtles, change patterns of coastal erosion and sand accretion that are necessary to maintain those beaches, and would increase the number of turtle nests destroyed by tropical storms and hurricanes (Wilkinson and Souter 2008). The loss of nesting beaches, by itself, would have catastrophic effects on sea turtle populations globally if they are unable to colonize new beaches that form or if the beaches do not provide the habitat attributes (sand depth, temperature regimes, refuge) necessary for egg survival. In some areas, increases in sea level alone may be sufficient to inundate sea turtle nests and reduce hatching success (Caut et al. 2009a). Storms may also cause direct harm to sea turtles, causing “mass” strandings and mortality (Poloczanska et al. 2009). Increasing temperatures in sea turtle nests alters sex ratios, reduces incubation times (producing smaller hatchling), and reduces nesting success due to exceeded thermal tolerances (Fuentes et al. 2009b; Fuentes et al. 2010; Fuentes et al. 2009c). Smaller individuals likely experience increased predation (Fuentes et al. 2009b).

Climactic shifts also occur due to natural phenomena. In the North Atlantic, this primarily concerns fluctuations in the NAO, which results from changes in atmospheric pressure between a semi-permanent high pressure feature over the Azores and a subpolar low pressure area over Iceland (Curry and McCartney 2001; Hurrell 1995; Stenseth et al. 2002a). This interaction affects sea surface temperatures, wind patterns, and oceanic circulation in the North Atlantic (Stenseth et al. 2002a). The NAO shifts between positive and negative phases, with a positive phase having persisted since 1970 (Hurrell 1995). North Atlantic conditions experienced during positive NAO phases include warmer than average winter weather in central and eastern North America and Europe and colder than average temperatures in Greenland and the Mediterranean Sea (Visbeck 2002). Effects are most pronounced during winter (Taylor et al. 1998). The NAO is significant for North Atlantic right whales due to its influence on the species primary prey, zooplankton of the genus *Calanus*, which are more abundant in the Gulf of Maine during positive NAO years (Conversi et al. 2001b; Greene and Pershing 2004; Greene et al. 2003a). This subsequently impacts the nutritional state of North Atlantic right whales and the rate at which sexually mature females can produce calves (Greene et al. 2003a).

7.2 Habitat degradation

A number of factors may be directly or indirectly affecting listed species in the action area by degrading habitat. These include ocean noise and fisheries impacts.

Natural sources of ambient noise include: wind, waves, surf noise, precipitation, thunder, and biological noise from marine mammals, fishes, and crustaceans. Anthropogenic sources of ambient noise include: transportation and shipping traffic, dredging, construction activities, geophysical surveys, and sonars. In general, it has been asserted that ocean background noise levels have doubled every decade for the last six decades in some areas, primarily due to shipping traffic (IWC 2004). The acoustic noise that commercial traffic contributes to the marine environment is a concern for listed species because it may impair communication between individuals (Hatch et al. 2008), among other effects (Eriksen and Pakkenberg 2013; Francis and Barber 2013). For species inhabiting Arctic waters, vessel and industrial noise may become much more problematic as oil and gas development and commercial shipping lanes through ice-free areas expand and intensify (Reeves et al. 2014). Vessels pose not only a risk of ship strike, but also impede the ability of whales to communicate. Hatch et al. (2012) estimated that roughly two-thirds of a right whales' communication space may be lost due to current ocean noise levels, which have greatly increased due to shipping noise. Shipping noise is also linked with increased stress levels in right whales (Rolland et al. 2012b).

Marine debris is another significant concern for listed species and their habitats. Marine debris has been discovered to be accumulating in gyres throughout the oceans. Law et al. (2010) presented a time series of plastic content at the surface of the western North Atlantic Ocean and Caribbean Sea from 1986 to 2008. More than 60% of 6,136 surface plankton net tows collected small, buoyant plastic pieces. The data identified an accumulation zone east of Bermuda that is similar in size to the accumulation zone in the Pacific Ocean. Over half of cetacean species (including humpback, fin, sei, and sperm whales) are known to ingest marine debris (mostly plastic), with up to 31% of individuals in some populations containing marine debris in their guts and being the cause of death for up to 22% of individuals found stranded on shorelines (Baulch and Perry 2014).

Ingestion of marine debris can have fatal consequences even for large whales as well as sea turtles. In 1989, a stranded sperm whale along the Mediterranean was found to have died from ingesting plastic that blocked its' digestive tract. A sperm whale examined in Iceland had a lethal disease thought to have been caused by the complete obstruction of the gut with plastic marine debris (Lambertsen 1990). Further incidents may occur but remain undocumented when carcasses do not strand.

For sea turtles, marine debris is a problem due primarily to individuals ingesting debris and blocking the digestive tract, causing death or serious injury (Laist et al. 1999; Lutcavage et al. 1997a). Gulko and Eckert (2003) estimated that between one-third and one-half of all sea turtles ingest plastic at some point in their lives; this figure is supported by data from Lazar and Gracan (Lazar and Gračan 2010), who found 35% of loggerheads had plastic in their gut. One study found 37% of dead leatherback turtles had ingested various types of plastic (Mrosovsky et al. 2009). A Brazilian study found that 60% of stranded green sea turtles had ingested marine debris (primarily plastic and oil; (Bugoni et al. 2001)). Loggerhead sea turtles had a lesser frequency of marine debris ingestion. Plastic is possibly ingested out of curiosity or due to confusion with prey items; for example, plastic bags can resemble jellyfish (Milton and Lutz 2003). Marine debris consumption has been shown to depress growth rates in post-hatchling loggerhead sea turtles, elongating the time required to reach sexual maturity and increasing predation risk (McCauley and Bjorndal 1999). Sea turtles can also become entangled and die in marine debris, such as discarded nets and monofilament line (Laist et al. 1999; Lutcavage et al. 1997a; NRC 1990b; O'Hara et al. 1988). This fundamentally reduces the reproductive potential of affected populations, many of which are already declining (such as loggerhead and leatherback sea turtle populations in the action area).

7.3 Dredging

Marine dredging vessels are common within U.S. coastal waters. Although the underwater noises from dredge vessels are typically continuous in duration (for periods of days or weeks at a time) and strongest at low frequencies, they are not believed to have any long-term effect on sea turtles. However, the construction and maintenance of federal navigation channels and dredging in sand mining sites have been identified as sources of sea turtle mortality and are currently being undertaken along the U.S. east coast, such as in Port Everglades, Florida. Hopper dredges in the dredging mode are capable of moving relatively quickly compared to sea turtle swimming speed and can thus overtake, entrain, and kill sea turtles as the suction draghead(s) of the advancing dredge overtakes the resting or swimming turtle. Entrained sea turtles rarely survive. Relocation trawling frequently occurs in association with dredging projects to reduce the potential for dredging to injure or kill sea turtles (Dickerson et al. 2007).

7.4 Seismic surveys

During October and November 2003, the NSF undertook a seismic survey over the mid-Atlantic Ridge. No marine mammals or sea turtles were observed during the cruise, which had airgun operations for six days (Holst 2004). The airgun array discharge size was 8,760 in^3.

There have also been numerous prior seismic surveys from 1979 to 2002. These include surveys with a 6-airgun, 1,350-in^3 array in 1990; a single, 45-in^3 GI gun in 1996 and 1998; and two 45-in^3 GI guns in 2002 (NSF 2014). Impacts to listed species were not identified.

There is little information available to us as to what response individuals would have to future exposures to seismic sources compared to prior experience. Based upon the little information available to us for marine mammals, if prior exposure produces a learned response, then this response would likely be similar to or less than prior responses to other stressors where the individual experienced a stress response associated with the novel stimuli and responded behaviorally as a consequence (such as moving away and reduced time budget for activities otherwise undertaken) (Andre and Jurado 1997; André et al. 1997; Gordon et al. 2006). We do not believe sensitization would occur based upon the lack of severe responses previously observed in marine mammals and sea turtles exposed to seismic sounds that would be expected to produce a more intense, frequent, and/or earlier response to subsequent exposures (see *Response Analysis*).

7.5 Vessel traffic

Vessel noise could affect marine animals in the study area. Shipping and seismic noise generally dominates ambient noise at frequencies from 20 to 300 Hz (Andrew et al. 2002; Hildebrand 2009; Richardson et al. 1995c). Background noise has increased significantly in the past 50 years as a result of increasing vessel traffic, and particularly shipping, with increases of as much as 12 dB in low frequency ranges; background noise may be 20 dB higher now versus preindustrial periods (Hildebrand 2009; Jasny et al. 2005; McDonald et al. 2006; NRC 1994; NRC 2003; NRC 2005; Richardson et al. 1995a). Over the past 50 years, the number of commercial vessels has tripled, carrying an estimated six times as much cargo (requiring larger, more powerful vessels)(Hildebrand 2009). Seismic signals also contribute significantly to the low frequency ambient sound field (Hildebrand 2009). Baleen whales may be more sensitive to sound at those low frequencies than are toothed whales. Masking of acoustic information can result (Simard et al. 2013); an important issue for marine mammals that rely primarily on sound as a sense. Dunlop et al. (2010) found that humpback whales shifted from using vocal communication (which carries relatively large amounts of information) to surface-active communication (splashes; carry relatively little information) when low-frequency background noise increased due to increased sea state. Other coping mechanisms include shifting the frequency or amplitude of calls, increasing the redundancy or length of calls, or waiting for a quieter period in which to vocalize (Parks et al. 2013) (Boness et al. 2013; Holt et al. 2013). Increases in vessel traffic and marine industrial construction is associated with decreases in the presence of minke whales and gray seals, presumably due to increased noise in the area (Anderwald et al. 2013). Sonars and small vessels also contribute significantly to mid-frequency ranges (Hildebrand 2009).

7.6 U.S. Navy training and testing activities

Table 10 indicates the number of different listed species likely to be "taken" annually as a result of their exposure to U.S. Navy training activities (excluding active sonar) on East Coast Training Ranges from June 2012 through June 2014.

Table 10. Anticipated incidental take of ESA species within U.S. Navy East Coast Training Range Complexes.

Whale or sea turtle species	Operating area: Northeast		Virginia Capes		Cherry Point		Jacksonville	
	Harass	Harm	Harass	Harm	Harass	Harm	Harass	Harm
Blue	0	0	0	0	0	0	0	0
Fin	0	0	2	0	0	0	0	0
Humpback	0	0	2	0	0	0	0	0
North Atlantic right	0	0	0	0	0	0	0	0
Sei	0	0	0	0	0	0	0	0
Sperm	0	0	2	0	0	0	0	0
Hardshell sea turtles	0	0	300	2	0	0	11	1
Kemp's ridley	0	0	555	5	0	0	2	0
Leatherback	0	0	9	0	0	0	11	1
Northwest Atlantic loggerhead	0	0	466	8	0	0	19	1

Anticipated impacts from harassment include changes from foraging, resting, milling, and other behavioral states that require lower energy expenditures to traveling, avoidance, and behavioral states that require higher energy expenditures and, therefore, would represent significant disruptions of the normal behavioral patterns of the animals that have been exposed. Behavioral responses that result from stressors associated with these training activities are expected to be temporary and would not affect the reproduction, survival, or recovery of these species. Instances of harm identified generally represent animals that would have been exposed to underwater detonations at 205 dB re μPa^2-s or 13 psi, which corresponds to an exposure in which 50% of exposed individuals would be expected to experience rupture of their tympanic membrane, an injury that correlates with measures of permanent hearing impairment (Ketten 1998c).

U.S. Navy aerial bombing training in the ocean off the southeast U. S. involving live ordnance (500 and 1,000-lb bombs) has been estimated to have injured or killed 84 loggerhead, 12 leatherback, and 12 green or Kemp's ridley sea turtles (NMFS 1997). From 2009- 2012, NMFS issued a series of biological opinions to the U. S. Navy for training activities occurring within their Northeast, Virginia Capes, Cherry Point and Jacksonville Range Complexes that anticipated annual levels of take of listed species incidental to those training activities through 2014. During the proposed activities 2 fin whales, 2 humpback whales, 2 sperm whales, 344 hardshell sea turtles (any combination of green hawksbill, Kemp's ridley or Northwest Atlantic loggerhead sea turtles), 644 Kemp's ridley sea turtles, 21 leatherback sea turtles and 530 Northwestern Atlantic loggerhead sea turtles per year are expected to be harassed as a result of their behavioral responses to mid- and high frequency active sonar transmissions Another six Kemp's ridley and five Northwestern Atlantic loggerhead turtles per year are expected to be injured during exposure to underwater detonations.

7.7 U.S. Marine Corps training in the Cherry Point Range Complex

Table 11 identifies the likely take associated with Marine Corps activities in the Cherry Point Range Complex.

Table 11. Incidental take associated with U.S. Marine Corps training in the Cherry Point Range Complex that is currently authorized.

<table>
<tr><th rowspan="4">Species</th><th colspan="7">MCAS Cherry Point water ranges</th></tr>
<tr><th colspan="2">Boat maneuvers (BT-9 & BT-11)</th><th colspan="2">Ordnance/munitions delivery (BT-9 & BT-11)</th><th colspan="3">Underwater explosions (BT-9 only)</th></tr>
<tr><th rowspan="2">Harass</th><th rowspan="2">Harm (injury, mortality) from vessel strike</th><th rowspan="2">Harass</th><th rowspan="2">Harm (injury, mortality) from direct strike</th><th rowspan="2">Harass (TTS and other behavioral impacts)</th><th colspan="2">Harm</th></tr>
<tr><th>Injury</th><th>Mortality</th></tr>
<tr><td>Green sea turtle</td><td rowspan="4">10 of any species per year</td><td rowspan="4">1 of any species over a 10-year period</td><td rowspan="4">10 of any species per year</td><td rowspan="4">2 of any species over a 10-year period</td><td rowspan="4">23 per year</td><td rowspan="4">1 per year (PTS)</td><td rowspan="4">1 over a 10-year period</td></tr>
<tr><td>Kemp's ridley sea turtle</td></tr>
<tr><td>Leatherback sea turtle</td></tr>
<tr><td>Northwest Atlantic DPS Loggerhead sea turtle</td></tr>
</table>

7.8 Entrapment and entanglement in fishing gear

Fisheries interactions are a significant problem for several marine mammal species and particularly so for humpback whales, as well as sea turtles. Between 1970 and 2009, two-thirds of mortalities of large whales in the northwestern Atlantic were attributed to human causes, primarily ship strike and entanglement (Van der Hoop et al. 2013). In excess of 97% of entanglement is caused by derelict fishing gear (Baulch and Perry 2014). Aside from the potential of entrapment and entanglement, there is also concern that many marine mammals that die from entanglement in commercial fishing gear tend to sink rather than strand ashore, thus making it difficult to accurately determine the frequency of mortalities. Entanglement may also make whales more vulnerable to additional dangers, such as predation and ship strikes, by restricting agility and swimming speed. Like fin whales, humpback whales have been entangled by fishing gear off Newfoundland and Labrador, Canada. A total of 595 humpback whales were reported captured in coastal fisheries in those two provinces between 1969 and 1990, of which 94 died (Lien 1994; Perkins and Beamish 1979). Along the Atlantic coast of the U.S. and the Maritime Provinces of Canada, there were 160 reports of humpback whales being entangled in fishing gear between 1999 and 2005 (Cole et al. 2005c; Nelson et al. 2007c). Of these, 95 entangled humpback whales were confirmed, with 11 whales sustaining injuries and nine dying of their wounds. Waring et al. (2007) reported four fin whales in the western North Atlantic having died or were seriously injured in fishing gear

Of the current threats to North Atlantic right whales, entanglement in commercial fishing gear poses one of the greatest threats (Figure 10). Along the Atlantic coast of the U. S. and the Maritime Provinces of Canada, there were 46 confirmed reports of North Atlantic right whales entangled in fishing gear between 1990 and 2007 (Cole et al. 2005a; Nelson et al. 2007b; Waring et al. 2009). Of the 39 reports that NMFS could confirm, North Atlantic right whales were injured in five of the entanglements and killed in four entanglements. Three of the 24 entangled whales between 2004 and 2008 died and one other resulted in serious injury (Glass et al. 2009). Recent efforts to disentangle right whales have met with success (Anonmyous. 2009b).

Figure 10. A North Atlantic right whale entangled in fisheries gear off Florida, with Georgia Department of Natural Resources and Coastwise Consulting staff attempting to cut rope off (Credit: EcoHealth Alliance and Georgia Department of Natural Resources, ESA permit number 932-1905).

Nine instances of entanglement were recorded between 2006 and 2010, two of which were disentangled (Waring et al. 2013). From 1970-2010, 74 instances of entanglement have been documented (Waring et al. 2013). Scars examined between 1980 and 2002 revealed that 75% of 447 individuals examined showed scarring from fishing gear (Waring et al. 2013). It is also estimated that 14 and 51% of right whales are entangled on an annual basis (Knowlton et al. 2005). Another study assessing photographs of right whales from 1980-2009 found 626 individuals having 1,032 entanglement scars (Knowlton et al. 2012). This included 83% having at least one scar and 59% having multiple scars, with juveniles being entangled at higher rates than adults and the sexes entangling equally (Knowlton et al. 2012). Scars also became more abundant over the study period, suggesting entanglement rates are increasing (Knowlton et al. 2012). In August 1993, a dead sperm whale, with longline gear wound tightly around the jaw, was found floating about 32 km off Maine.

Fishery interaction remains a major factor in sea turtle recovery and, frequently, the lack thereof. Wallace et al. (2010b) estimated that worldwide, 447,000 turtles are killed each year from bycatch in commercial fisheries. NMFS (2002a) estimated that 62,000 loggerhead sea turtles have been killed as a result of incidental capture and drowning in shrimp trawl gear. Although TEDs and other bycatch reduction devices have significantly reduced the level of bycatch to sea turtles and other marine species in U. S. waters, mortality still occurs. The fisheries that have the most significant demographic effect on sea turtles are the Gulf of Mexico shrimp trawl fisheries. The estimated annual number of interactions and mortalities between sea turtles and shrimp trawls in the Gulf shrimp fisheries (state and federal) are believed to have declined versus prior regulations (Epperly et al. 2002; Nance et al. 2008) (Table 12). Although participants in this and other fisheries are required to use Turtle Exclusion Devices, which are estimated to reduce the number of sea turtles trawlers capture by as much as 97%, each year these fisheries are expected to capture about 185,000 sea turtles annually and kill about 5,000 of them. Loggerhead sea turtles account for most of this these: capturing about 163,000 loggerhead sea turtles, killing almost 4,000 of them. However, more recent estimates suggest interactions and mortality has decreased from pre-regulatory periods, with a conservative estimate of 26,500 loggerheads captured annually in U.S. Atlantic fisheries causing mortality to 1,400 individuals per year (Finkbeiner et al. 2011). These are followed by green sea turtles: about 18,700 green sea turtles are expected to be captured each year with more than 500 of them dying as a result of their capture (NMFS 2002b). Each year, various fisheries capture about 2,000 loggerhead sea turtles in Pamlico Sound, of which almost 700 die (Finkbeiner et al. 2011). The action area and its surrounding region appears to be a location of moderate sea turtle longline bycatch relative to long-term global levels (Lewison et al. 2014).

Table 12. Estimated annual interactions between sea turtles and shrimp trawls in the Gulf of Mexico shrimp fisheries associated estimated mortalities based on 2007 Gulf effort data taken from Nance et al. (2008).

Species	Estimated interactions	Estimated mortalities
Leatherback	520	15
Loggerhead	23,336	647
Kemp's ridley	98,184	2,716
Green	11,311	319

Mortality of leatherbacks in the U. S. shrimp fishery is now estimated at 54 turtles per year. Data collected by the Northeast Fisheries Science Center (NEFSC) Fisheries Observer Program from 1994 through 1998 (excluding 1997) indicate that a total of 37 leatherbacks were incidentally captured (16 lethally) in drift gillnets set in offshore waters from Maine to Florida during this period. Observer coverage for this period ranged from 54 to 92%. Trinidad and Tobago's Institute for Marine Affairs estimated that more than 3,000 leatherbacks were captured incidental to gillnet fishing in the coastal waters of Trinidad in 2000.

Portions of the Atlantic pelagic fisheries for swordfish, tuna, shark, and billfish also operate in the action area and capture and kill the second highest number of sea turtles along the Atlantic coast. These fisheries include purse seine fisheries for tuna, harpoon fisheries for tuna and swordfish, commercial and recreational rod and reel fisheries, gillnet fisheries for shark, driftnet fisheries, pelagic longline fisheries, and bottom longline fisheries. Lewison et al. (2004) estimated that 30,000-60,000 leatherbacks were taken in all Atlantic longline fisheries in 2000 (including the U.S. Atlantic tuna and swordfish longline fisheries, as well as others). Between

1986 and 1995, this fishery captured and killed one North Atlantic right whale, two humpback whales, and two sperm whales. Between 1992 and 1998, the longline components of these fisheries are estimated to have captured more than 10,000 sea turtles (4,585 leatherback sea turtles and 5,280 loggerhead sea turtles), killing 168 of these, disincluding sea turtles that might have died after being released (Johnson et al. 1999; Yeung 1999). Since then, all components of these fisheries are estimated to capture about 1,350 sea turtles each year, killing 345. Finkbeiner et al. (2011) estimated that annual bycatch interactions total 1,400 leatherbacks annually for U. S. Atlantic fisheries (resulting in roughly 40 mortalities).

On 4 July 2004, NMFS published a final rule to implement management measures to reduce bycatch and bycatch mortality of Atlantic sea turtles in the Atlantic pelagic longline fishery (6979 FR 40734). The management measures include mandatory circle hook and bait requirements and mandatory possession and use of sea turtle release equipment to reduce bycatch mortality. This is expected to have significantly reducing sea turtle mortality from pelagic longlines.

In 2008, SEFSC observer programs and subsequent analyses indicated that the overall amount and extent of incidental take for sea turtles specified in the incidental take statement of the 2005 opinion on the reef fish fishery had been severely exceeded by the bottom longline component of the fishery (approximately 974 captures and at least 325 mortalities estimated for the period July 2006-2007). The Gulf of Mexico Fishery Management Council developed a long-term management strategy via a new amendment (Amendment 31 to the Reef Fish FMP). The amendment included a prohibition on the use of bottom longline gear in the Gulf of Mexico reef fish fishery, shoreward of a line approximating the 35-fathom contour east of Cape San Blas, Florida, from June through August; a reduction in the number of bottom longline vessels operating in the fishery via an endorsement program and a restriction on the total number of hooks that may be possessed onboard each Gulf of Mexico reef fish bottom longline vessel to 1,000, only 750 of which may be rigged for fishing. These changes are expected to greatly reduce the mortality of loggerhead sea turtles resulting from the operation of this fishery.

Observation of the directed highly migratory shark fisheries has been ongoing since 1994, but a mandatory program was not implemented until 2002. Neritic juvenile and adult loggerhead sea turtles are the primary species taken, but leatherback sea turtles have also been observed caught. From 1994-2002, observers covered 1.6% of all hooks, observing bycatch of 31 loggerhead, 4 leatherback, and 8 unidentified sea turtles with estimated annual average take levels of 30, 222, and 56, respectively (NMFS 2003).

In addition to commercial bycatch, recreational hook-and-line interaction also occurs. Cannon and Flanagan (1996) reported that from 1993 to 1995, at least 170 Kemp's ridley sea turtles were hooked or tangled by recreational hook-and-line gear in the northern Gulf of Mexico. Of these, 18 were dead stranded turtles, 51 were rehabilitated turtles, five died during rehabilitation, and 96 were reported as released by fishermen.

7.9 Invasive species

Invasive species have been referred to as one of the top four threats to the world's oceans consistently ranked behind habitat degradation and alteration (Pughiuc 2010; Raaymakers 2003; Raaymakers and Hilliard 2002; Terdalkar et al. 2005; Wambiji et al. 2007). In most cases, habitat is directly affected by human alterations, such as hydromodification, mining, dredging, drilling, and construction. However, invasive species, facilitated by human commerce, have the ability to directly alter ecosystems upon which listed species rely.

Invasive species are a major threat to many ESA-listed species. For species listed by the United States Fish and Wildlife Service (USFWS), 26% were listed partially because of the impacts of invasive species and 7% were listed because invasive species were the major cause of listing (Anttila et al. 1998). Pimentel et al. (2004) found that roughly 40% of listed species are at risk of becoming endangered or extinct completely or in part due to invasive species, while Wilcove et al. (1998) found this to be 49%, with 27% of invertebrates, 37% of reptiles, 53% of fishes, and 57% of plants imperiled partly or wholly due to non-native invasions. In some regions of the world, up to 80% of species facing extinction are threatened by invasive species (Pimentel et al. 2004; Yan et al. 2002). Clavero and Garcia-Bertro (2005) found that invasive species were a contributing cause to over half of the extinct species in the International Union for the Conservation of Nature (IUCN) database; invasive species were the only cited cause in 20% of those cases. Richter et al. (1997) identified invasive species as one of three top threats to threatened and endangered freshwater species in the U.S. as a whole.

7.10 Diseases

The impacts of introduced pathogens in the aquatic environment has been poorly explored and we likely know very little about the true frequency and significance of pathogen invasions (Drake et al. 2001). Pathogens are known to have adverse effects to invertebrate communities. Molluscs such as black and white abalone seem to be particularly sensitive to pathogens. Various species of the genus *Vibrio*, known to cause cholera in humans, white pox and white plague type II diseases in corals, and mortality in abalone of the same genus as black and white abalone, have been identified in ports and ballast water of vessels (Aguirremacedo et al. 2008; Anguiano-Beltrán et al. 1998; Ben-Haim and Rosenberg 2002). Oyster species have sustained several outbreaks from invasive pathogens, including *Haplosporidium nelsoni* (the cause of MSX disease, which Chesapeake Bay eastern oysters have shown 75-92% mortality to) and *Perkinsus marinus* (the cause of Dermo disease) in California, eastern North America, and Europe (Andrews 1984; Burreson and Ford 2004; Burreson et al. 2000; Ford and Haskin 1982; Renault et al. 2000), Bonamia ostreae in Europe (Ciguarria and Elston 1997; Van Banning 1987), and in the northeastern U.S., respectively (Ford 1996). Although specific instances of sea turtle pathogen transference via invasive species are not documented, their spread into new areas are easily possible, particularly given environmental perturbations and naïve individuals in receiving habitats.

7.11 Habitat impacts

In general, species located higher within a food web (including most ESA-listed species under NMFS' jurisdiction) are more likely to become extinct as a result of an invasion; conversely, species that are more centrally or bottom-oriented within a food web are more likely to establish (Byrnes et al. 2007; Harvey and May 1997). This can have major implications for higher-trophic level listed species, particularly those that rely upon benthic habitats in their development, such as green, Kemp's ridley, hawksbill, and loggerhead sea turtles. These species can experience reductions or benefits in altered forage and prey base, altering survival and reproduction parameters of entire populations.

Propagule pressure is generally the reason for this trend, as individuals lower in the food web tend to have higher fecundity and lower survival rates (r-selection). This unbalancing of food webs makes subsequent introductions more likely as resource utilization shifts, increasing resource availability, and exploitation success by non-native species (Barko and Smart 1981; Byrnes et al. 2007). Such shifts in the base of food webs fundamentally alter predator-prey dynamics up and across food chains (Moncheva and Kamburska 2002). The number of extinction events seems to be roughly correlated with the number of invasive establishments within an area (Harvey and May 1997).

Pathogens and species with toxic effects not only have direct effects to listed species, but also may affect PCEs of critical habitat or indirectly affect the species through ecosystem-mediated impacts. There are a number of non-native species that have the potential to either expel toxins at low levels, only becoming problematic for other members of the ecosystem if their population grows to very large sizes, resulting in very large amounts of toxins being released. In other cases, pathogens are introduced to an environment affecting organisms in the environment that would directly affect critical habitat PCEs or indirectly affect listed species. Pathogens are in some cases very specific to hosts, but when a species similar to a listed species is introduced, eventually that parasite that was specific to the non-native species can shift to also affecting similar native populations. In these cases, the effects may be directly adverse to listed species or indirect to food resources as identified in a species' critical habitat. In other cases, parasites can have direct effects to PCEs of designated critical habitat or indirectly affect listed species.

Introduced red tide dinoflagellates have the potential to undergo extreme seasonal population fluctuations. During bloom conditions, high levels of neurotoxins are released into local and regional surface water and air that can cause illness and death in fishes, sea turtles, marine mammals, and invertebrates (as well as their larvae) (Hallegraeff and Bolch 1992; Hallegraeff 1998; Hamer et al. 2001; Hamer et al. 2000; Lilly et al. 2002; McMinn et al. 1997). The brown alga, *Aureococcus anophagefferens*, causes brown tide when it blooms, causing diebacks of eelgrass habitat due to blooms decreasing light availability and failure of scallops and mussels to recruit (Doblin et al. 2004).

There are a few examples of indirect predatory effects caused by invasive species. European green crabs have invaded both the east and west coasts of the U. S., having trophic scale effects to both environments. In Massachusetts Bay, green crabs prey upon native mussels and oysters, altering community structure (Grosholz 2002; Lafferty and Kuris 1996; Pimentel et al. 2004). The suppression of these native invertebrates led to increases in their natural prey; however, organisms at higher trophic levels did not increase in response to the green crabs.

The most commonly reported impact of non-native species in the freshwater and coastal environment is competition for limited resources (Nyberg 2007). Molluscs, decapods, and aquatic plants as taxonomic groups tend to be especially capable invaders and have proven to be disruptive to food webs. The most common impacts are alteration of habitat and nutrient availability as well as altering species composition and diversity within an ecosystem (Strayer 2010). Crabs, polychaetes, and mussels can increase bioturbation and aerate the sediment (Nyberg 2007). Gastropods can alter the biogeochemical cycle through excretion of biogenic silicate in the faeces and pseudofaeces (Ragueneau et al. 2005). Molluscan invasions can also provide substrate for epibionts, shelter for benthic species, remove nutrients from the water, decrease turbidity and increase light penetration, remove sediments, and promote phytoplankton blooms by releasing nutrients from sediments (Bertness 1984; Gutierrez et al. 2003; Hecky et al. 2004).

There are many examples of invertebrate competition either indirectly affecting similar species to listed species under NMFS jurisdiction or directly affecting the habitat they rely on. The compound tunicate, *Botrylloides sandiegensis*, was released near Woods Hole, Massachusetts and has outcompeted other encrusting organism in the coastal environment of southern New England (Lafferty and Kuris 1996). The invasive green mussel *Perna viridis* may competitively displace the native scorched mussel *Brachidontes exustus* through its greater growth rate and maximum size in Tampa Bay (Ranwell 1964).

Invasive plants can cause widespread habitat alteration, including native plant displacement, changes in benthic and pelagic animal communities, altered sediment deposition, altered sediment characteristics, and shifts in chemical processes such as nutrient cycling (Grout et al. 1997; Ruiz et al. 1999; Wigand et al. 1997). Introduced seaweeds alter habitat by colonizing previously unvegetated areas, while algae form extensive mats that exclude most native taxa, dramatically reducing habitat complexity and the ecosystem services provided by it (Wallentinus and Nyberg 2007). Invasive algae can alter native habitats through a variety of impacts, including trapping sediment, reducing the number of suspended particles that reach the benthos for benthic suspension and deposit feeders, reduce light availability, and adversely impact foraging for a variety of animals (Britton-Simmons 2004; Gribsholt and Kristensen 2002; Levi and Francour 2004; Sanchez et al. 2005). Invasive fishes can compose a large portion of fish taxa in at least some areas, including New Zealand where 53% of fish taxa are exotic, Puerto Rico where invasive fish are 91% of the total species, and Brazil where they are 13% of the total (Lövei 1997).

The spiny water flea causes extensive ecosystem disruption (Grout et al. 1997; Johannsson et al. 1991; Kerfoot et al. 2011). *Bythotrephes* is an important contributor to its native habitat, including as prey to salmon; however, in the Great Lakes, they reduce the fitness of many fish that are prey to salmonids (Hessen et al. 2011). Bythotrephes preys heavily upon plankton species, severely reducing not only their abundance, but has also caused their diversity to decline by roughly 20% (Foster and Sprules 2009; Kerfoot et al. 2011; Rennie et al. 2011). As a result, rotifers decline because of reduced diatom food resources and phytoplankton increase because *Bythotrephes* feeds on their competitors (Beisner et al. 2006; Kerfoot et al. 2011). Further tertiary effects include elevation of contaminant levels in higher-level predators due to extensions in the food web that allow for additional contaminants to accumulate in the underlying prey base (Kerfoot et al. 2011; Rennie et al. 2011). Other macroinvertebrate predators and fishes are also likely adversely impacted by this disruption of their prey base, with less prey available to them (Foster and Sprules 2009; Parker Stetter et al. 2005). These alterations to ecosystem food webs appear to be stable and persistent (Yan et al. 2008). Through these mechanisms, *Bythotrephes* alone represents a significant threat to the biodiversity within temperate North American aquatic environments (Grout et al. 1997).

Other invertebrates can also have major impacts on the ecosystems they invade. The introduced periwinkle, *Littorina littorea*, ranging along the Atlantic Coast from Canada to the mid-Atlantic, is highly-influential in the sedimentation process; because individuals cumulatively engage in so much grazing, some bottom habitats have become dominated by hard-bottom instead of soft bottom as they formerly were (Bertness 1984; Carlton 1999; Wallentinus and Nyberg 2007). Significant declines in soft-sediment habitats and fringing salt marshes are attributed at least partially to the invasion of this species, possibly due to consumption of marsh grasses, such as *S. alterniflora* (Bertness 1984). Species normally adapted to living in soft-bottom systems are gradually replaced by species better adapted for hard-bottom substrates.

A comprehensive review of the impacts of invasive species to the Chesapeake Bay was conducted by Ruiz et al. (1999). With at least 196 established non-native populations in the Chesapeake Bay, it is surprising that most of the impacts of invasive species on the Chesapeake Bay are generally undocumented. The authors found that 20% of the 196 documented invasive species had significant ecological impacts, while most of the other invasive species had not been studied for their impacts. Of the 39 species with significant ecological impacts, 69% did so through competition with native species, 38% altered habitat, 44% served as prey, 15% were predators of native species, 21% engaged in extensive herbivory, 8% produced hybrids with native taxa, and 8% were parasitic (Ruiz et al. 1999). Plants and fish were the largest taxonomic groups represented in the known invasive species of the Chesapeake Bay, representing 23% and 18% of the invasive species by taxa, respectively.

In this case study, while the invasive species have not been well studied, it appears the best documentation of effects may be indirect to sturgeon or sea turtles via alteration of food web dynamics and food availability. Two protistan pathogens, *Haplosporidium nelsoni* and *Perkinsus marinus*, are significant contributors to a 90% reduction in oyster abundance in the Chesapeake Bay over the past century, causing secondary effects such as reduced oyster reef habitat and altered food webs (Ruiz et al. 1999). The rapa whelk is now an abundant predator of native clams and oysters in the Bay (Deacutis and Ribb 2002) with similar ecological impacts to the protist pathogens. Mud crabs have also declined as a result of the invasive parasitic barnacles, *Loxothylacus panopaei*, which causes reproductive failure in the host (Hines et al. 1997; Ruiz et al. 1999; Van Engel et al. 1966). The Asiatic clam is so abundant in the Potomac River that it is estimated this species alone can filter the total phytoplankton biomass in three to four days and can constitute 90% or more of the bivalve biomass in some areas. Such efficient conversion of energy from the pelagic to the benthic environment likely benefits shortnose sturgeon by increasing worms and chironomids, two of their prey items. As a result of this invasion, between 1981 and 1993, water clarity tripled, subsequently increasing aquatic vegetation 50%, and ultimately increasing abundance of fish populations, slowing currents, increasing sedimentation, as well as altering benthic community composition and sediment characteristics through its large production of pseudofeces (Cohen et al. 1984; Phelps 1994; Ruiz et al. 1999). The reed, *Phragmites auatralis*, also outcompetes local plants and has become widespread and dominant within the Chesapeake Bay, altering habitat parameters and animal abundances (Marks et al. 1994; Ruiz et al. 1999). *Typha angustifolia* has similar impacts, outcompeting local species, reducing flow rates, increasing sedimentation, and altering sediment chemistry (Ruiz et al. 1999). Two invasive aquatic plants, *Hydrilla verticillata* and *Myriophyllum spicatum*, have received significant attention in the Chesapeake Bay. They form dense mats, alter aquatic chemical and habitat characteristics, fish and invertebrate communities, compete with native plants, and change the food base available for local waterfowl and fishes (Ruiz et al. 1999). Also noteworthy is that the cover provided by *Hydrilla* spp. provides additional refuge for smaller fishes, which can increase the populations of larger predatory species (Killgore et al. 1989; Ruiz et al. 1999). *Trapa natans*, a floating plant, at one time also outcompeted native plant species to the detriment of fishes and waterfowl, but has not recovered from an eradication program in the 1930s (Ruiz et al. 1999).

7.12 Wind energy

Efforts to develop wind energy facilities offshore of the U. S. east coast have increased over the past several years. The Bureau of Ocean Energy Management assumed that the entire area of each Mid-Atlantic Wind Energy Area would be leased based on the expressions of commercial wind energy interest received. Leases could be issued and site characterization and assessment activities started as early as 2012. Site characterization and assessment activities would occur over a period of about 5.5 years per lease (BOEM 2012). The most advanced in development of these is the Cape Wind Energy project (Cape Cod, Massachusetts) calls for 130 wind turbine generators. The Bureau of Ocean Energy Management approved a construction and operations plan for the project in 2011 (USDOI 2011). Another six-turbine system is proposed off New Jersey, for which state permits were issued in 2011 (Fisherman's Energy of New Jersey LLC 2011). Several leases have been issued that would allow for testing and investigation of wind resources at various sites (BOEM 2012). Significant ocean noise and vessel activity is associated with construction of facilities such as these, which numerous studies have shown to displace marine mammals from the area, but who generally return post-construction. It is not known whether migratory species deflect to avoid facilities such as these once constructed.

7.13 Entrainment in power plants

Sea turtles entering coastal or inshore areas have been affected by entrainment in the cooling-water systems of electrical generating plants. A comprehensive biological opinion that covers all power plant cooling water intakes was issued by the Services in May 2014, but does not identify amount or extent of listed species expected to be taken. This will be undertaken on a case-by-case basis for each power plant.

7.14 Ship-strikes

Ship-strike is a significant concern for the recovery of listed whales and, to a lesser degree, sea turtles. Between 1970 and 2009, two-thirds of mortalities of large whales in the northwestern Atlantic were attributed to human causes, primarily ship strike and entanglement (Van der Hoop et al. 2013). Between 1999 and 2005, there were three reports of sei whales being struck by vessels along the U. S. Atlantic coast and Canada’s Maritime Provinces (Cole et al. 2005c; Nelson et al. 2007c). Two of these ship strikes were reported as having resulted in death. An update (unpublished data 1995–2011) ship strike inventory for the eastern seaboard indicates the following percentage of strikes by species: North Atlantic right whale (19%), humpback whale (28%), sei whale (6%), fin whale (17%), sperm whale (2%), and unknown species (16%). Based on the records available, large whales have been struck by ships off almost every coastal state in the U. S., although ship strikes are most common along the Atlantic Coast. More than half (56%) of the recorded ship strikes from 1975-2002 occurred off the coasts of the northeastern U. S. and Canada, while the mid-Atlantic and southeastern areas each accounted for 22% (Jensen and Silber 2003). According to Waring et al. (2007), five fin whales were killed or injured as a result of ship strikes between January 2000 and December 2004. Between 1999-2005, there were 15 reports of fin whales strikes by vessels along the U. S. and Canadian Atlantic coasts (Cole et al. 2005a; Nelson et al. 2007b). Of these, 13 were confirmed, resulting in the deaths of 11 individuals. Of 123 humpback whales that stranded along the Atlantic coast of the U.S. between 1975 and 1996, 10 (8.1%) showed evidence of collisions with ships (Laist et al. 2001).

In the Bay of Fundy, recommendations for slower vessel speeds to avoid right whale ship strike appear to be largely ignored (Vanderlaan et al. 2008). However, new rules for seasonal (June through December) slowing of vessel traffic to 10 knots and changing shipping lanes by less than one nautical mile to avoid the greatest concentrations of right whales are expected to reduce the chance of humpback whales being hit by ships by 9%, fin whales by 42%, right whales by 62%, and sei whales by 17%; the same rule applies from November through April from Brunswick, Georgia to Jacksonville, Florida, where North Atlantic right whales go for calving and breeding. Speed rules also apply to medium and large ports along the eastern seaboard during this time frame when right whales migrate to and from northern feeding and southern breeding areas. Nearly a dozen shipping lanes transect through coastal waters of the southeastern U. S. from the North-South Carolina to Cape Canaveral, Florida. Modeling efforts suggest voluntary changes in "areas to be avoided" suggested by the International Maritime Organization will reduce right whale strikes over the Scotian Shelf from one lethal strike every 0.78-2.07 years to one every 41 years (Hoop et al. 2012). Part of the susceptibility of North Atlantic right whales to ship strike may be its propensity to remain just below the surface, invisible to vessels, but at significant risk to ship strike (Parks et al. 2011b).

We believe the vast majority of ship-strike mortalities go unnoticed, and that actual mortality is higher than currently documented; Kraus et al. (2005) estimated that 17% of ship strikes are actually detected. The magnitude of the risks commercial ship traffic pose to large whales in the proposed action areas has been difficult to quantify or estimate. We struggle to estimate the number of whales that are killed or seriously injured in ship strikes within the U. S. EEZ and have virtually no information on interactions between ships and commercial vessels outside of U. S. waters. With the information available, we know those interactions occur but we cannot estimate their significance to whale species.

Ship strikes are the largest single contributor to North Atlantic right whale deaths, accounting for approximately 35% of all known mortalities, even though right whales should be able to hear the sound produced by vessels (Ketten 1998a; Knowlton and Kraus 2001a; Laist et al. 2001; Richardson et al. 1995a). Some information suggests right whales respond only within very close proximity to ships (Nowacek et al. 2004a). Various types and sizes of vessels have been involved in ship strikes with large whales, including container/cargo ships/freighters, tankers, steamships, U. S. Coast Guard vessels, Navy vessels, cruise ships, ferries, recreational vessels, fishing vessels, whale-watching vessels, and other vessels (Jensen and Silber 2004b). Injury is generally caused by the rotating propeller blades, but blunt injury from direct impact with the hull also occurs. There have been 18 reports of North Atlantic right whales being struck by vessels between 1999 and 2005 (Cole et al. 2005b; Nelson et al. 2007a). Of the 17 reports that NMFS could confirm, right whales were injured in two of the ship strikes and killed in nine. Recent records show that from 2004-2008, there were 17 confirmed reports of North Atlantic right whales being struck with eight whales dying of their wounds and two additional right whales sustaining serious injuries (Glass et al. 2009). Deaths of females are especially deleterious to the ability of the North Atlantic right whale population to recover. For instance, in 2005, mortalities included six adult females, three of which were carrying near-term fetuses and four of which were just starting to bear calves, thereby representing a lost reproductive potential of as many as 21 individuals over the short term (Kraus et al. 2005). Between 1999 and 2006, ships are confirmed to have struck 22 North Atlantic right whales, killing 13 of these whales (Jensen and Silber 2003; Knowlton and Kraus 2001b; NMFS 2005c). From 1999 to 2003, an average of 2.6 right whales were killed per year from various types of anthropogenic factors, but mostly from ship-strike (Waring et al. 2010). From 2000 to 2004, this increased to 2.8 annually and increased again from 2001 to 2005 to an average of 3.2 right whales (Waring et al. 2010). The most recent estimate of anthropogenic mortality and serious injury available showed a rate of 3.8 right whales per year from 2002 to 2006. Of these, 2.4 were attributed to ship strikes (Glass et al. 2008). Based on records collected between 1970 and 1999, about 60% of the right whales struck by ships along the Atlantic Coast of the U. S., 20% occurred in waters off the northeast states and 20% occurred in waters off the mid-Atlantic or southeast states (Knowlton and Kraus 2001b). Over the same time interval (1970 to 1999), these authors identified 25 (45%) unconfirmed serious injuries and mortalities from ship strikes. Of these, 16 were fatal interactions; two possibly fatal; and seven nonfatal. Based on these confirmed mortalities, ships are responsible for more than one-third (16 out of 45, or 36%) of all confirmed right whale mortalities (a confirmed mortality is one observed under specific conditions defined by NMFS).[4] Part of the susceptibility of this species to ship strike may be its propensity to remain just below the surface, invisible to vessels, but at significant risk to ship strike (Parks et al. 2011b).

Another study conducted over a similar period – 1970 to 2002 – examined 30 (18 adults and juveniles, and 12 calves) out of 54 reported right whale mortalities from Florida to Canada (Moore et al. 2005). Human interaction (ship strike or gear entanglement) was evident in 14 of the 18 adults examined, and trauma, presumably from vessel collision, was apparent in 10 out of the 14 cases. Trauma was also present in four of the 12 calves examined, although the cause of death was more difficult to determine in these cases. In 14 cases, the assumed cause of death was vessel collision; an additional four deaths were attributed to entanglement. In the remaining 12 cases, the cause of death was undetermined (Moore et al. 2005).

Sea turtle ship strikes are a poorly-studied threat to sea turtles, but has the potential to be highly-significant (Work et al. 2010). All sea turtles must surface to breath and several species are known to bask at the surface for long periods, including loggerhead sea turtles. Although sea turtles can move rapidly, sea turtles apparently are not well able to move out of the way of vessels moving at more than 4 km/hr; most vessels move far faster than this in open water (Hazel and Gyuris 2006; Hazel et al. 2007; Work et al. 2010). This, combined with the massive level of vessel traffic in the Gulf of Mexico and coastal Atlantic, has the potential to result in frequent injury and mortality to sea turtles in the region (MMS 2007). Hazel et al. (2007) suggested that green sea turtles may use auditory cues to react to approaching vessels rather than visual cues, making them more susceptible to strike as vessel speed increases. Overall, ship strike is likely highly underestimated as a source of injury or mortality to sea turtles in the action area.

7.15 Commercial whaling

Large whale population numbers in the action areas have historically been impacted by commercial exploitation, mainly in the form of whaling. Between 1969-1990, 14 fin whales were captured in coastal fisheries off Newfoundland and Labrador; of these seven are known to have died because of capture (Lien 1994; Perkins and Beamish 1979).

7.16 Scientific and research activities

Scientific research permits issued by the NMFS currently authorize studies of listed species in the North Atlantic Ocean, some of which extend into portions of the action area for the proposed project. Authorized research on ESA-listed whales includes close vessel and aerial approaches, biopsy sampling, tagging, ultrasound, and exposure to acoustic activities, and breathe sampling. Authorized research on ESA-listed sea turtles includes capture, handling, and restraint, satellite,

4 There are four main criteria used to determine whether serious injury or mortality resulted from ship strikes: (1) propeller cut(s) or gashes that are more than approximately 8 cm in depth; (2) evidence of bone breakage determined to have occurred premortem; (3) evidence of hematoma or hemorrhaging; and (4) the appearance of poor health in the ship-struck animal Knowlton, A. R., and S. D. Kraus. 2001b. Mortality and serious injury of northern right whales (Eubalaena glacialis) in the western North Atlantic Ocean. Journal of Cetacean Research and Management Special Issue 2:193-208..

sonic, and passive integrated transponder (PIT) tagging, blood and tissue collection, lavage, ultrasound, captive experiments, laparoscopy, and imaging. Research activities involve "takes" by harassment, with some resulting mortality. Additional "take" is likely to be authorized in the future as additional permits are issued. It is noteworthy that although the numbers tabulated below represent the maximum number of "takes" authorized in a given year, monitoring and reporting indicate that the actual number of "takes" rarely approach the number authorized. Therefore, it is unlikely that the level of exposure indicated below has or will occur in the near term. However, our analysis assumes that these "takes" will occur since they have been authorized. It is also noteworthy that these "takes" are distributed across the Atlantic Ocean, mostly from Florida to Maine, and in the eastern Gulf of Mexico. Although whales and sea turtles are generally wide-ranging, we do not expect many of the authorized "takes" to involve individuals who would also be "taken" under the proposed research.

Tables 13-22 describe the cumulative number of takes for each listed species in the action area authorized in scientific research permits.

Table 13. Blue whale takes in the North Atlantic.

Year	Approach	Biopsy	Suction cup tagging	Implantable tagging	Exhalation sampling	Acoustic playback
2009	655	25	90	45	0	2
2010	720	25	90	45	0	0
2011	620	25	90	45	0	0
2012	730	25	90	45	0	0
2013	6,300	630	1,255	540	80	0
2014	5,715	630	1,165	495	80	0
2015	5,715	630	1,165	495	80	0
Total	20,455	1,990	3,645	1,710	240	2

Permit numbers: 633-1778, 775-1875, 1036-1744, 1058-1733, 10014, 14451, 14856, 15575, 16109, 16239, 16325, 16388, and 17355.

Table 14. Fin whale takes in the North Atlantic.

Year	Approach	Biopsy	Suction cup tagging	Implantable tagging	Exhalation sampling	Acoustic playback
2009	1,671	170	75	0	0	2
2010	1,876	170	45	0	0	0
2011	1,776	170	45	0	0	0
2012	2,846	170	45	0	0	0
2013	9,551	1,215	1,315	495	340	0
2014	8,727	1,165	1,290	495	340	0
2015	8,727	1,165	1,290	495	340	0
Total	32,174	4,225	4,105	1,485	1,020	2

Permit numbers: 10014, 605-1904, 775-1875, 948-1692, 981-1707, 1036-1744, 1058-1733, 14
14451, 14586, 14856, 15575, 16109, 16239, 16325, 16388, 16473, and 17355.

Table 15. Humpback whale takes in the North Atlantic and Mediterranean.

Year	Approach	Biopsy	Suction cup tagging	Implantable tagging	Belt tag	Exhalation sampling	Acoustic playback
2009	5,260	415	173	45	0	0	624
2010	5,568	415	173	45	0	0	600
2011	8,653	1,040	723	95	0	0	600
2012	8,419	1,040	723	95	125	0	600
2013	17,925	1,980	1,465	395	125	2,410	600
2014	16,800	1,880	1,440	395	125	2,410	600
2015	16,155	1,880	1,440	395	125	2,410	0
Total	78,780	8,650	6,137	1,465	500	7,230	3,624

Permit numbers: 605-1904, 633-1778, 775-1875, 948-1692, 981-1707, 1036-1744, 1058-1733, 1121-1900, 1128-1922, 10014, 13927, 14118, 14245, 14451, 14586, 14856, 15575, 15682, 16109, 16325, 16388, 16473, and 17355.

Table 16. Sei whale takes in the North Atlantic.

Year	Approach	Biopsy	Suction cup tagging	Implantable tagging	Exhalation sampling	Acoustic playback
2009	1,604	50	158	45	0	2
2010	1,604	50	158	45	0	0
2011	1,504	50	158	45	0	0
2012	1,664	50	158	45	0	0
2013	8,227	1,735	773	390	160	0
2014	6,933	1,735	640	345	160	0
2015	6,933	1,735	640	345	160	0
Total	28,469	5,405	2,685	1,260	480	2

Permit numbers: 605-1904, 633-1778, 775-1875, 1058-1733, 10014, 14118, 14451, 14856, 15575, 16109, 16239, 16325, 16388, 16473, and 17355.

Table 17. Sperm whale takes in the North Atlantic.

Year	Approach	Biopsy	Suction cup tagging	Implantable tagging	Exhalation sampling	Acoustic playback
2009	5,560	375	820	0	0	920
2010	4,110	400	520	0	0	120
2011	4,010	425	520	0	0	120
2012	1,950	125	10	0	0	0
2013	8,789	990	720	450	80	0
2014	7,789	890	710	450	80	0
2015	7,789	890	710	450	80	0
Total	32,086	4,095	4,010	1,350	240	1,160

Permit numbers: 633-1778, 775-1875, 909-1719, 948-1692, 981-1707, 1036-1744, 1121-1900, 10014, 14451, 14586, 14856, 15575, 16109, 16239, 16325, 16473, 17312, and 17355.

Table 18. Green sea turtle takes in the Atlantic Ocean.

Year	Capture/handling /restraint	Satellite,sonic, or pit tagging	Blood/tissue collection	Lavage	Ultrasound	Captive experiment	Laparoscopy	Imaging	Mortality
2009	3,093	3,093	3,009	1,860	555	66	74	72	6
2010	3,753	3,753	3,669	2,480	555	66	74	72	6
2011	4,255	4,255	3,505	2,990	564	66	74	72	20
2012	3,354	3,354	2,622	2,210	704	66	74	72	18.2
2013	5,001	5,001	4,325	3,654	1,903	91	398	396	4.2
2014	4,236	4,236	3,560	3,004	1,408	65	324	324	4.2
2015	4,210	4,210	3,540	3,004	1,408	65	324	324	4.2
Total	27,902	27,902	24,230	19,202	7,097	485	1,046	1,332	62.8

Permit numbers: 1450, 1462, 1501, 1506, 1507, 1518, 1522, 1526, 1527, 1540, 1544, 1551, 1552, 1570, 1571, 1576, 10014, 10022, 13306, 13307, 13543, 13544, 13573, 14506, 14508,14622, 14655, 14726, 14949, 15112, 15135, 15552, 15556, 15575, 15606, 15802, 16134, 16146, 16174, 16194, 16253, 16556, 16598, 16733, 17183, 17304, 17355, 17381, and 17506.

Table 19. Kemp's ridley sea turtle takes in the Atlantic Ocean.

Year	Capture/handling /restraint	Satellite,sonic, or pit tagging	Blood/tissue collection	Lavage	Ultrasound	Captive experiment	Laparoscopy	Imaging	Mortality
2009	1,394	1,394	1,195	425	371	56	53	53	5
2010	1,402	1,402	1,203	426	371	56	53	53	5
2011	2,210	2,210	1,368	976	400	56	53	53	9
2012	2,229	2,219	1,561	972	450	56	53	53	7.2
2013	2,836	2,852	2,190	1,627	990	116	213	218	3.2
2014	2,460	2,476	1,814	1,256	619	60	160	165	3.2
2015	2,283	2,299	1,669	1,256	619	60	160	165	3.2
Total	14,814	14,852	11,000	6,938	3,820	460	745	548	35.8

Permit numbers: 1462, 1501, 1506, 1507, 1526, 1527, 1540, 1544, 1551, 1552, 1570, 1571, 1576, 10014, 10022, 13306, 13543, 13544, 14508, 14726, 14506, 14622, 14655, 14726, 15112, 15135, 15552, 15566, 15575, 15606, 15802, 16134, 16194, 16253, 16556, 16598, 16733, 17183, 17304, 17355, 17381, and 17506.

Table 20. Leatherback sea turtle takes in the North Atlantic Ocean.

Year	Capture/handling/restraint	Satellite, sonic, or pit tagging	Blood/tissue collection	Lavage	Ultrasound	Imaging	Laparoscopy	Mortality
2009	1,357	1,357	1,331	197	188	0	0	2
2010	1,421	1,421	1,394	197	188	0	0	1
2011	1,709	1,709	1,682	197	189	0	0	3.4
2012	736	736	709	187	189	0	0	2.6
2013	842	835	808	312	254	65	65	1.6
2014	653	646	620	135	66	65	65	1.6
2015	647	640	620	135	66	65	65	1.6
Total	7,365	7,344	7,164	1,360	1,140	195	195	13.8

Permit numbers: 1506, 1527, 1540, 1544, 1551, 1552, 1557, 1570, 1571, 1576, 10014, 13543, 14506, 14586, 14655, 14726, 15112, 15552, 15556, 15575, 15672, 15802, 16109, 16194, 16253, 16556, 16733, 17355, and 17506.

Table 21. Loggerhead sea turtle takes in the North Atlantic Ocean.

Year	Capture/handling /restraint	Satellite,sonic, or pit tagging	Blood/tissue collection	Lavage	Ultrasound	Captive experiment	Laparoscopy	Imaging	Mortality
2009	5,462	5,462	5,044	1,165	1,322	200	109	123	111
2010	5,464	5,464	5,046	1,205	1,322	200	109	116	111
2011	7,165	7,165	6,097	1,420	1,667	200	148	114	122.2
2012	4,791	4,791	3,741	1,370	1,429	200	161	114	29.8
2013	5,909	5,909	4,859	2,609	2,519	305	401	354	24.8
2014	4,762	4,762	3,712	1,495	1,543	105	292	240	24.8
2015	4,635	4,635	3,635	1,495	1,543	105	292	240	7.8
Total	38,188	38,188	32,134	10,759	11,345	1,315	1,512	1,301	431.4

Permit numbers: 1450, 1462, 1501, 1506, 1507, 1522, 1526, 1527, 1540, 1544, 1551, 1552, 1570, 1571, 1576, 1599, 10014, 10022, 13306, 13307, 13543, 13544, 14249, 14622, 14506, 14508, 14622, 14655, 14726, 15112, 15552, 15566, 15575, 15606, 15802, 16134, 16146, 16194, 16253, 16556, 16598, 16733, 17183, 17304, 17355, 17381, and 17506.

Table 22. Hawksbill sea turtle takes in the Atlantic Ocean.

Year	Capture/handling /restraint	Satellite,sonic, or pit tagging	Blood/tissue collection	Lavage	Ultrasound	Captive experiment	Laparoscopy	Imaging	Mortality
2009	1,088	1,088	1,081	464	254	0	0	0	3
2010	1,424	1,424	1,417	534	254	0	0	0	3
2011	1,959	1,959	1,955	914	255	0	0	0	4.4
2012	1,462	1,456	1,452	904	255	0	0	0	3.6
2013	1,423	1,417	1,415	844	320	39	0	0	1.6
2014	1,114	1,108	1,106	550	66	39	0	0	1.6
2015	1,032	1,026	1,026	550	66	39	0	0	1.6
Total	9,502	9,484	9,452	4,760	1,470	117	0	0	18.8

Permit numbers: 1462, 1501, 1506, 1507, 1518, 1526, 1527, 1540, 1544, 1551, 1552, 1570, 1571, 1576, 1599, 10014, 10022, 13306, 13307, 13543, 13544, 14272, 14508, 14726, 14506, 14508, 14622, 14655, 14726, 14949, 15112, 15135, 15552, 15566, 15575, 15606, 15802, 16134, 16146, 16194, 16253, 16598, 16733, 17183, 17304, 17355, 17381, and 17506.

7.17 Physical and oceanographic features

The presence of key habitat features, such as shelter or foraging opportunities, are the primary reasons why listed individuals occur where they do. In the marine environment, this is fundamentally built upon local physical and oceanographic features that influence the marine environment. As such, we describe the physical and oceanographic environment here to establish a rationale for why listed species occur in the action area at the levels we observe or expect. This does not represent a stressor, but is instead an underlining principle for establishing why effects are what we expect them to be.

The continental shelf through the action area is a nearly uniform, smooth seafloor with an evenly-carved continental shelf edge (Backus 1987). The continental shelf slopes gently and is relatively shallow. The continental shelf break is marked by an abrupt increase in the seafloor gradient and ranges in water depth from 100 to 150 m. The average width of the continental slope from Georges Bank to Cape Hatteras is approximately 30 km but varies in size from 10 to 50 km (Tucholke 1987). The only submarine canyon in the area is the Hudson Canyon and is the best developed canyon on the U.S. Atlantic continental margin. Submarine canyons are considered to be highly modified areas of the continental slope containing a much richer biodiversity; the abundance of nutrients introduced by the strong down flowing currents are factors leading to the biological richness found in canyons (Cooper et al. 1987). No seamounts exist within the action area.

The Gulf Stream Current is a powerful surface current, carrying warm water into the cooler North Atlantic just south of the action area (Pickard and Emery 1990; Verity et al. 1993). Surface velocities range from 2-5 nautical miles per hour and the temperature is generally 25° to 28° C (Mann and Lazier 1991). The Gulf Stream is usually sharply defined on its west and north side but much less so on its east or south sides (Pickard and Emery 1990).

In general, the Gulf Stream flows parallel to shore from the Florida Straits to Cape Hatteras, where it flows northeastward past the Grand Banks away from land. While stratification of the water column and other factors may play a role, climactic factors such as the North Atlantic Oscillation (NAO) likely cause it's variation in position (Pershing et al. 2001; Schmeits and Dijkstra 2000). Wave-like meandering begins to occur at Cape Hatteras and increases as the current progresses offshore. North of Cape Hatteras, small gyres form that separate from the Gulf Stream as either warm- or cold-core rings (Mann and Lazier 1991). Between three and eleven warm-core rings are formed per year, each about 100 km across (García-Moliner and Yoder 1994), 1,000 m in height (Mann and Lazier 1991), and lasting 11-399 days (García-Moliner and Yoder 1994; Pickard and Emery 1990). Warm-core rings bring warm water and associated plankton to colder inshore areas. Cold-core rings form when a cyclonic loop pinches off from the Gulf Stream, resulting in a counterclockwise rotating ring of cool slope water in the warm Sargasso Sea (Pickard and Emery 1990). Twice as many cold-core rings are formed as warm-core rings every year (Pickard and Emery 1990). They are larger (100-300 km across) and longer lasting (months to years) than warm-core rings (Pickard and Emery 1990).

A persistent front exists from the Mid-Atlantic Bight into New England waters due to the intersection of the continental shelf and slope. This surface manifestation of a thermohaline front extends year round from the surface downward, where it intersects the seafloor just shoreward of the shelf break (Halliwell Jr. and Mooers 1979). Phytoplankton production is enhanced at this frontal boundary, often with twice the concentration of phytoplankton found in adjacent waters

(Ryan et al. 1999b).

An annual phenomenon in the Mid-Atlantic Bight is the formation of the "cold pool". This mass of cooler water occurs over the continental shelf in summer and stretches from the Gulf of Maine to Cape Hatteras and is detectible from spring through fall (Linder et al. 2004). The cold pool usually exists near the seafloor between the 40 m and 100 m isobaths and extends up into the water column for about 35 m. Minimum temperatures for the cold pool occur in early spring and summer and range from 1.1º to 4.7º C.

The NAO affects sea surface temperatures, wind conditions, and ocean circulation throughout the North Atlantic Ocean (Stenseth et al. 2002b). The NAO is an intensity alteration of the atmospheric pressure between the semi-permanent high pressure center over the Azores Islands and the subpolar low-pressure center over Iceland (Curry and McCartney 2001; Stenseth et al. 2002b). Sea-level atmospheric pressure in the two regions tends to vary inversely, creating "positive" and "negative" phases. However, these phases are stable for years to decades. The NAO was generally positive from 1900 to 1950, mainly negative in the 1960s and 1970s, and mainly positive since 1970 (Hurrell et al. 2001).

The NAO also influences the latitude of the Gulf Stream Current and is largely responsible for its variable location. During positive NAO years, the Gulf Stream is farther east (Taylor and Stephens 1998). The flow rate of the Gulf Stream is also affected; during negative NAO years, the Gulf Stream System is not only shifted southward but weakened by up to 25-33% (Curry and McCartney 2001). The upper slope-water system off the U.S. east coast is affected by the NAO (Pershing et al. 2001). During low NAO periods, the Labrador Current intensifies, leading to the advance of cold slope water along the continental shelf as far south as the Mid-Atlantic Bight (Pershing et al. 2001). Intensity variability in another regionally important current, the Labrador Current, is linked to the effects of winter temperatures in Greenland and its surrounding waterways, sea-ice formation, and the relative balance between the formation of deep and intermediate water masses and surface currents. Although the NAO influences the northern North Atlantic most, its effects remain significant south through the Outer Banks (Hurrell et al. 2001).

The NAO strongly affects trophic groups in North Atlantic marine ecosystems (Drinkwater et al. 2003; Fromentin and Planque 1996). *Calanus* copepod temporal and spatial patterns are linked to the phases of the NAO (Fromentin and Planque 1996; Stenseth et al. 2002b); positive NAO indices are associated with increased *Calanus* copepod abundance in the Gulf of Maine and the corollary in negative NAO index years (Conversi et al. 2001a; Greene et al. 2003b). This has secondary effects, such as prey availability for North Atlantic right whales, which feeds principally on *Calanus finmarchicus*. High *Calanus finmarchicus* abundance is linked to increased North Atlantic right whale calving rates (Greene et al. 2003b). Negative NAO indices are associated with abundances of cod, herring, and sardines: species that are important to other listed mysticetes (Drinkwater et al. 2003).

Phytoplankton are single-celled organisms that form the base of marine food chains and whose occurrence and abundance are strongly driven by light, temperature, and nutrient conditions. As nutrients from river outflows near shore generally provide more nutrients than are present offshore, phytoplankton are generally more abundant nearshore. Although the North Atlantic is generally well mixed (nutrients are generally available), light levels tend to be low for phytoplankton, limiting their growth (Ryan et al. 1999a). However, spring time is a period with reduced mixing and increasing light levels, meaning that phytoplankton tend to stay at the surface and are better able to photosynthesize, grow, and reproduce at exponential rates (Mann and Lazier 1991; Parsons et al. 1984; Ryan et al. 1999a). However, nutrients are eventually exhausted in surface waters by May and seasonal progression into winter returns the region to a light-limiting condition. During spring and summer, nectophytoplankton are dominant but are replaced by nanophytoplankton during limiting conditions (Ryan et al. 1999b).

Not only the water conditions, but intersections between water bodies (frontal boundaries) are important factors in biological productivity. This is the case year-round between the shelf and slope waters of the mid-Atlantic, but particularly during winter and spring (Ryan et al. 1999a; Ryan et al. 1999b).

Zooplankton, the next higher level in the marine food chain from phytoplankton and the prey of several listed whales and sea turtles, are generally higher in slope water versus other locations (Wiebe et al. 1987). Spring is a time of higher abundance temporally, particularly within the upper 200 m of the water column (Wiebe et al. 1987). However, zooplankton biomass abundance can increase when shelf water intrudes over slope water, creating a stratified water column. High nutrients and a shallow mixed layer set conditions for enhanced phytoplankton production, which subsequently aids zooplankton biomass increases. Copepods are the primary zooplankters dominate in New England shelf waters, and whose abundance is highest in spring on the outer shelf but highest in summer on the inner shelf (Flagg et al. 1984). *Calanus finmarchicus* and *Pseudocalanus* sp. are the predominant copepods over the outer shelf while the inner shelf has *Centropages typicus* and *Temora longicornis* predominating. The relatively large size of *Calanus* species and its annual cycle in New England waters makes it a major driver of New England marine ecosystem during spring (Flagg et al. 1984).

8 EFFECTS OF THE PROPOSED ACTIONS

Pursuant to Section 7(a)(2) of the ESA, federal agencies must insure, through consultation with the NMFS, that their activities are not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat. The proposed use of the *Langseth* and issuance of the IHA by the NMFS Permits and Conservation Division for “takes” of marine mammals during the seismic studies would expose listed species to seismic airgun pulses, as well as sound emitted from a multi-beam bathymetric echosounder, ADCP, and sub-bottom profiler and other stressors. In this section, we describe the potential physical, chemical, or biotic stressors associated with the proposed actions, the probability of individuals of listed species being exposed to these stressors, and the probable responses of those individuals (given probable exposures) based on the best scientific and commercial evidence available. As described in the *Approach to the Assessment* section, for any responses that would be expected to reduce an individual’s fitness (i.e., growth, survival, annual reproductive success, or lifetime reproductive success), the assessment would consider the risk posed to the viability of the population(s) those individuals comprise and to the listed species those populations represent. The purpose of this assessment and, ultimately, of the Opinion is to determine if it is reasonable to expect the proposed action to have effects on listed species that could appreciably reduce their likelihood of surviving and recovering in the wild.

For this consultation, we are particularly concerned about behavioral and physiological disruptions that may result in animals that fail to feed or breed successfully or fail to complete their life history because these responses are likely to have population-level consequences. The proposed action would authorize non-lethal "takes" by harassment as defined by the MMPA of listed species during seismic survey activities. The ESA does not define harassment nor has the NMFS defined the term pursuant to the ESA through regulation. The MMPA of 1972, as amended, defines harassment as any act of pursuit, torment, or annoyance which has the potential to injure a marine mammal or marine mammal population in the wild or has the potential to disturb a marine mammal or marine mammal population in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering [16 U.S.C. 1362(18)(A)]. The latter portion of this definition (that is, "...causing disruption of behavioral patterns including...migration, breathing, nursing, breeding, feeding, or sheltering") is similar to the USFWS's regulatory definition of "harass"[5] pursuant to the ESA. For this Opinion, we define harassment similarly: an intentional or unintentional human act or omission that creates the probability of injury to an individual animal by disrupting one or more behavioral patterns that are essential to the animal's life history or its contribution to the population the animal represents.

Our analysis considers that behavioral harassment or disturbance is not limited to the 160 dB acoustic "take" definition for marine mammals and may in fact occur in many ways. Fundamentally, if our analysis leads us to conclude that an individual changes its behavioral state (for example, from resting to traveling away from the airgun source or from traveling to evading), we consider the individual to have been harassed or disturbed, regardless of whether it has been exposed to acoustic sources at levels that define "take" as long as it creates the probability of injury. In addition, individuals may respond in a variety of ways, some of which have more significant fitness consequences than others. For example, quick evasion of a seismic source would be more significant than slow travel away from the same stressor due to increased metabolic demands, stress responses, and potential for calf abandonment that this response could or would entail. As described in the *Approach to the Assessment*, the universe of likely responses is considered in evaluating the fitness consequences to the individual and (if appropriate), the affected population and species as a whole to determine the likelihood of jeopardy.

8.1 Potential Stressors

The assessment for this consultation identified several possible stressors associated with the proposed seismic activities, including:

1. pollution by oil or fuel leakage;
2. acoustic interference from engine noise;
3. ship-strikes;
4. entanglement in towed hydrophone;
5. sound fields produced by airguns; and
6. sub-bottom profiler, ADCP, or multibeam echosounder

Based on a review of available information, we determined which of these possible stressors would be likely to occur and which would be discountable or insignificant. The potential for fuel

5 An intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering (50 CFR 17.3)

or oil leakages is extremely unlikely. The former would likely pose a significant risk to the vessel and its crew and actions to correct a leak should occur immediately, to the extent possible. In the event that a leak should occur, the amount of fuel and oil onboard the *Langseth* or its smaller counterparts is unlikely to cause widespread, high dose contamination (excluding the remote possibility of severe damage to the vessel) that would impact listed species directly or pose hazards to their food sources.

The propulsion system of the *Langseth* is designed to be very quiet compared to other vessels to reduce interference with seismic activities. Although noise originating from vessel propulsion will propagate into the marine environment, this amount would be highly improbable. The *Langseth'*s passage past a whale or sea turtle would be brief and not likely to be significant in impacting any individual's ability to feed, reproduce, or avoid predators. Brief interruptions in communication via masking are possible, but unlikely given the habits of whales to move away from vessels, either as a result of engine noise, the physical presence of the vessel, or both (Lusseau 2006). The same can be said for the chase vessel.

The *Langseth* will be traveling at generally slow speeds, reducing the amount of noise produced by the propulsion system and the probability of a ship-strike (Kite-Powell et al. 2007; Vanderlaan and Taggart 2007). Our expectation of ship strike is discountably small due to the hundreds of thousands of kilometers the *Langseth* has traveled without a ship strike, general expected movement of marine mammals away or parallel to the *Langseth*, as well as the generally slow movement of the *Langseth* during most of its travels (Hauser and Holst 2009; Holst 2009; Holst 2010; Holst and Smultea 2008a). The same can be said for the chase vessel to be utilized. All things considered, we have concluded the potential for ship strike or acoustic interference from propulsion and machinery noise is highly improbable.

Listed species could interact directly with the towed hydrophone streamers and these interactions have been documented in the past. For example, a seismic survey in the eastern tropical Pacific during 2011 recovered a dead olive ridley sea turtle in the foil of towed seismic gear; it is unclear whether the sea turtle became lodged in the foil pre- or post mortem (Spring 2011). However, entanglement is highly unlikely due to the streamer design as well as observations of sea turtles investigating the streamer and not becoming entangled or operating in regions of high turtle density and entanglements not occurring (Hauser et al. 2008; Holst and Smultea 2008a; Holst et al. 2005a; Holst et al. 2005b). Although the towed hydrophone streamers could come in direct contact with a listed species, entanglements are highly unlikely and considered highly improbable based upon investigation into the use of these devices during the activities of other oceanographic activities.

Accordingly, this consultation focused on the following stressors likely to occur from the proposed seismic activities and may adversely affect ESA-listed species: 1. acoustic energy introduced into the marine environment by the airgun array and 2. acoustic energy introduced by both the sub-bottom profiler, ADCP, and multibeam echosounder sonars.

8.2 Exposure Analysis

Exposure analyses identify the ESA-listed species that are likely to co-occur with the actions' effects on the environment in space and time and identify the nature of that co-occurrence. The *Exposure analysis* identifies, as possible, the number, age or life stage, and gender of the individuals likely to be exposed to the actions' effects and the population(s) or subpopulation(s) those individuals represent.

NMFS applies certain acoustic thresholds to help determine at what point during exposure to seismic airguns (and other acoustic sources) marine mammals are "harassed," under the MMPA (65 FR 16374). These thresholds help to develop exclusion radii around a source and the necessary power-down or shut-down criteria. Airguns contribute a massive amount of anthropogenic energy to the world's oceans (3.9×10^{13} joules cumulatively), second only to nuclear explosions (Moore and Angliss 2006). Although most energy is in the low-frequency range, airguns emit a substantial amount of energy up to 150 kHz (Goold and Coates 2006). Seismic airgun noise can propagate substantial distances at low frequencies (e.g., Nieukirk et al. 2004).

The exposure analysis for this Opinion relates primarily to the number of blue, sei, fin, humpback, North Atlantic right, and sperm whales, as well as green, hawksbill, leatherback, loggerhead, and Kemp's ridley sea turtles likely to be exposed to received levels greater than 160 dB re 1 μPa_{rms} (166 dB for sea turtles), which constitute the best estimates of adverse response by listed whales and sea turtles. This also constitutes our best estimate of when individual responses would be significant enough to result in "take", which is expected for all individuals receiving these exposure levels or higher. The NSF and NMFS' Permits and Conservation Division estimated the expected number of ESA-listed whales exposed to received levels ≥160 dB re 1 μPa_{rms}. This methodology was based upon a product of animal density and ensonified area that we roughly adopted here. The NSF provided a calculation of the area of overlap that we used to determine a recalculation of area ensonified that reflected this repeated exposure. We utilize these area values, as well as the density values provided by the NSF, to estimate marine mammal exposure.

The NSF and NMFS' Permits and Conservation Division provided density estimates for listed whales in the action area. Review of the local survey data as well as knowledge of listed species life history and local oceanographic conditions supports these estimates as the best available information. The NSF and NMFS' Permits and Conservation Division used data from the Navy OPAREA density estimates detailed in DON (2007) for sperm and fin whales, which are based upon NMFS Northeast regional sighting surveys from 1998-2004 conducted during the same season (summer) as the proposed seismic survey. Fin and sei whale numbers were increased to reflect average group size (Palka 2012). North Atlantic right whale density was based upon NODES model using the spring mean density estimate in survey area (http://seamap.env.duke.edu/serdp/serdp_map.php). Humpback and blue whale density estimates stemmed from the SERDP SDSS Duke Habitat Model using the summer mean density estimates in the survey area (http://seamap.env.duke.edu/serdp/serdp_map.php). In two cases (North Atlantic right and humpback whales) exposure numbers were increased to reflect average group size in the region based upon survey data used.

The L-DEO also estimated the exposure radii around the proposed *Langseth* operations using empirical data gathered in the Gulf of Mexico in 2007-2008 aboard the *Langseth*. The distances to which sound levels (rms) might propagate for single airgun and 4- to 8-airgun arrays used during the proposed study are provided in Table 1 on page 14. The maximum distance from airguns where received levels might reach 160 dB re 1 μPa_{rms} (i.e., from the 8-gun array) at 2,000 m depth (maximum depth at which listed species are expected to occur) is 8.15 km with a 6 m tow depth (6.1 km from the 4-airgun array at 6-m tow depth). A thorough review of available literature (see *Response Analysis*) supports this level as a general point at which baleen whales tend to show some avoidance response to received seismic sound. The NSF's assumption that individuals will move away if they experience sound levels high enough to cause significant stress or functional impairment is also reasonable (see *Response Analysis*). Isopleth modeling tends to overestimate the distance to which various isopleths will propagate because most exposure will likely occur at depths shallower than 2,000 m, where received sound levels should be reduced (see Figures 3-7). As we are unable to know where individuals will be in the water column at the time of exposure, we accept this assumption. In addition, the 160 dB re 1 μPa_{rms} radius will not always reach these distances, as shorter radii will occur during the use of smaller numbers of airguns (e.g., the use of a single airgun during turns or power-down procedures). A received level of 166 dB re 1 μPa_{rms} (2.599 km for the 4-airgun array at 6-m tow depth and 3.471 km for the 8-airgun array at 6-m tow depth) is considered here to be the threshold for harassment for sea turtle response based upon the little information available (McCauley et al. 2000a; McCauley et al. 2000b) (see sea turtle section below).

A major mitigation factor proposed by the NSF (and L-DEO) is visual monitoring, especially for marine mammals, which should reduce exposure of listed whales and sea turtles. However, visual monitoring has several limitations. Although regions ensonified by 160, 166, and 180 dB re 1 μPa_{rms} propagation distances are within the visual range of the *Langseth* and its observers, it is unlikely that all listed species are easily visible at the surface at these distances. On their own, power-down and shut-down procedures are unlikely to be completely effective at eliminating the co-occurrence of listed individuals within the sound field ≥160 dB re 1 μPa_{rms} Other measures such as vessel turns and minimizing airgun source levels, seek to further minimize the exposure protected species will experience. Ramp-up was effective in reducing hearing-related effects in sonar systems (Von Benda-Beckmann et al. 2014) and we also expect reduced or less intense exposure in application to airgun ramp-up. When combined with the other proposed mitigation and monitoring measures, we conclude that the probability of listed individuals being exposed to the sound field ≥ 160dB re 1 μPa_{rms} is reduced significantly by the use of ramp-ups and shut-downs. Vessel platforms are subject to some limitations such as that even under good sighting conditions, observers have limited ability to identify protected species during their brief time at the surface. Vocalizations by protected species will also help in identifying abundance of cetaceans in the action area. PAM will only detect the presence of marine mammals if they vocalize. Further ability to identify bearing, distance, and abundance is limited.

Through consultation, the NSF, Permits and Conservation Division, and ESA Interagency Cooperation Division agreed that the fore-mentioned approach was the best available and worked to identify the necessary information for this analysis.

Marine Mammals

Exposure of Listed Mammals to Airguns. Exposure estimates stem from the best available information on whale densities and a planned ensonified area of approximately 2,502 km^2 along survey track lines, including areas of repeated exposure from adjacent track lines and turning legs.

Our exposure estimates (Table 23) were calculated by using the density per 1,000 km^2 multiplied by the total survey track area (4,900 km track line ensonifying 2,502 km^2 to the 160 dB re 1 μPa_{rms} level) to obtain the total number of exposures (rounded to the next whole number).

Table 23. Estimated exposure of ESA-listed whales to sound levels ≥160 dB re 1 μPa_{rms} during the proposed seismic activities.

Whale density per 1,000 km^2	# of exposures to listed whales	# of whales exposed to proposed activities	Population size	% of population exposed	Population/ location
Blue -6.74	17	Up to17	440	Up to 3.86%	Northwest Atlantic[1]
Fin -0.002	2	Up to 2	3,985	Up to 0.05%	Northwest Atlantic[1]
Sei -0.161	2	Up to 1	386	Up to 0.259%	Nova Scotia stock[1]
Humpback–0.154	2	Up to 2	11,600	Up to 0.017%	Northwestern Atlantic[2]
North Atlantic right-0.283	3	Up to 3	444	Up to 0.676%	North Atlantic[1]
Sperm -7.06	18	Up to 18	13,190	Up to 0.136%	Northeast Atlantic, Faroe Islands, Iceland, and northeastern U.S. coast[3]
Total	43	--	--	--	--

[1] Waring et al. (2013)
[2] IWC (2014)
[3] Whitehead (2002)

The NSF originally estimated the amount of ensonified area with and without overlap to determine the amount of re-exposure that may occur (determined to be a 38.3-fold difference in the Environmental Assessment). Based upon this, the NSF estimated that a given individual may be re-exposed 39 times on average. However, this assumes individuals do not move within their environment. We do not agree with this assumption. We expect listed individuals to naturally move in their environment to feed on available prey, continue migration, or complete other life functions. Unfortunately, there is no known factor with which we can accurately account for the probability and effect of movement (particularly horizontal movement in terms of latitudinal and longitudinal location), and we do not know of a mechanism by which we can accurately calculate the number of exposures per individual in this situation. Therefore, as we cannot articulate a better method, we accept the possibility, but not the realistic expectation that individuals will be re-exposed an average of 39 times. This does not represent the maximum number of occasions that a point in the action area would be ensonified to the 160 dB level, which is equal to the total number of track lines in the survey (78). Therefore, an individual may be ensonified up to 78 times, but likely would be ensonified substantially fewer times than this. Although we cannot determine a mean or expected number of times re-exposure will occur, we can estimate a range of exposures.

It is reasonable to expect, based upon review of observed effects of seismic sound exposure to marine mammals that some individuals will move a distance of several hundred to tens of kilometers away due to individual or situational sensitivity or other rationale for why whales move (ex. feeding or breeding opportunities unrelated to effects of the proposed action). As such, it is reasonable to expect that some individuals will receive a single exposure and vacate the action area. Other individuals may move, but move to locations where re-exposure could occur, either due to the direction or short distance they travel. Thus, it is reasonable that some individuals may be exposed up to the maximum number of transect lines that would be surveyed (78) (this is unlikely unless the stressor does not represent a significant one motivating the individual to vacate the area, the motivation to stay in a specific area is high and/or an individually randomly moves to a location that is repeatedly ensonified and the location of the individual is near the middle of the long axis of the action area). This is particularly significant given that marine mammals tend to return to specific areas for foraging and breeding, or use particular migratory corridors. However, based upon observations from previous seismic surveys and our professional judgment, the likelihood that individuals will be re-exposed is very low, if at all.

Whales of all age classes are likely to be exposed. Listed whales are expected to be feeding, traveling, or migrating in the area and some females would have young-of-the-year accompanying them. We would normally assume that sex distribution is even for whales and sexes are exposed at a relatively equal level. However, sperm whales in the area likely consist of groups of adult females and their offspring and generally consist of more females than males in the group. Therefore, we expect a female bias to sperm whale exposure. Exposure to adult males is expected to be much lower than to other age and sex class combinations.

Exposure of listed whales to multibeam echosounder, ADCP, and sub-bottom profiler.

Three additional acoustic systems will operate during the proposed *Langseth* cruise, as well as from the chase vessel: the multibeam echosounder, ADCP, and the sub-bottom profiler. These systems have the potential to expose listed species to sound above the 160 dB re 1 μPa_{rms} threshold. All systems operate at generally higher frequencies than airgun operations (10.5-13 kHz for the multibeam echosounder, 70 kHz for the ADCP, and 3.5 kHz for the sub-bottom profiler) and this mitigates effects. As such, their frequencies will attenuate more rapidly than those from airgun sources. Listed individuals would experience higher levels of airgun noise well before either multibeam echosounder, ADCP, or sub-bottom profiler noise of equal amplitude would reach them. Thus, as explained below, operational airguns mitigate multibeam echosounder, ADCP, and sub-bottom profiler noise exposure.

As with the *Langseth*, the chase vessel is expected to avoid close whale approaches, which reduces the chance of exposure to sonars as well. While airguns are not operational, marine mammal observers will remain on duty to collect sighting data. If listed whales were to closely approach the vessel, the *Langseth* would take evasive actions to avoid a ship-strike and simultaneously mitigate exposure to very high source levels. Ship strike has already been ruled out as an insignificant effect, and we also rule out high-level ensonification of listed whales (multibeam echosounder source level = 242 dB re 1 μPa_{rms}; ADCP source level <224 dB re 1μPa · m; sub-bottom profiler source level = 204 dB re 1 μPa_{rms}). Boebel et al. (2006) and Lurton and

DeRuiter (2011) concluded that multibeam echosounders and sub-bottom profilers similar to those to be used during the proposed activities presented a low risk for auditory damage or any other injury, and that an individual would require exposure to 250–1,000 pulses from a sub-bottom profiler to be at risk for a temporary threshold shift (TTS). To be susceptible to TTS, a whale would have to pass at very close range and match the vessel's speed; we expect a very small probability of this during the proposed study. An individual would have to be well within 100 m of the vessel to experience a single multibeam echosounder pulse that could result in TTS (LGL Ltd. 2008). The same result could only occur at even closer ranges for sub-bottom profiler signals, because the signals are weaker. Furthermore, we expect both multibeam echosounder and sub-bottom profiler systems to operate continuously with duty cycles of 1-20 s. It is possible, however, that some small number of listed whales (fewer than those exposed to airguns) could experience low-level multibeam echosounder, ADCP, and/or sub-bottom profiler sound. We are unable to quantify the level of exposure, but do not expect any exposure to result to occur at high levels.

Sea Turtles

Exposure of listed turtles to airguns. Exposure estimates stem from the best available information on turtle densities and a planned ensonified area of approximately 1,066 km^2 along survey track lines, including areas of repeated exposure from adjacent track lines and turning legs. Based upon information presented in the *Response analysis*, we expect all exposures at the 166 dB re 1 μPa_{rms} level and above to constitute "take".

Loggerhead, Kemp's ridley, and leatherback sea turtle densities during summer in the action area were taken from the technical report of the Navy marine species density database (USN 2012). Hardshell turtle categories from this report were used for hawksbill and green sea turtle densities, as species-specific estimates were not available and likely overestimate the density of these species in the action area.

Our exposure estimates (Table 24) were calculated by using the density per 1,000 km^2 multiplied by the total survey track area (4,900 km track line ensonifying 1,066 km^2 to the 166 dB re 1 μPa_{rms} level) to obtain the total number of exposures (rounded to the next whole number). The same justification described above for marine mammal exposure and "take" also applies to sea turtles. We also expect that the potential amount of re-exposure (up to 78) applies to sea turtles.

We do not expect sound generated by the proposed action to expose eggs or hatchlings because we do not expect these life stages to be present in the action area. However the *Status of listed resources* section identifies the oceanic environment of the North Atlantic as an important developmental habitat for juveniles and subadults of all sea turtle species and we expect these to occur in the action area. In addition, adult life stages of all species are expected to be exposed to sound. For sea turtle species that have been studied, a skewed sex distribution biased towards females versus males exists. As such, we expect more female sea turtles of all species to be exposed than males.

Table 24. Estimated exposure of ESA-listed sea turtles to sound levels ≥166 dB re 1 μPa_{rms} during the proposed seismic activities.

Sea turtle density per 1,000 km^2	# of exposures to listed turtles	# of turtles exposed to proposed activities	Population size	% of population exposed	Population/ location
Green -121.783	130	Up to 130	Unknown	Unknown	North Atlantic
Hawksbill - 121.783	130	Up to 130	Unknown	Unknown	North Atlantic
Kemp's ridley - 71.88	77	Up to 77	>189,000	<0.04%	North Atlantic[1]
Leatherback–31.475	34	Up to 34	34,000	Up to 0.1%	North Atlantic[2]
Loggerhead - 155.438	166	Up to 166	>32,000	<0.519%	Northwestern Atlantic[3]
Total	537	--	--	--	--

[1]Gallaway et al. (2013)

[2]TEWG (2007c)

[3](NMFS 2001b; TEWG 1998a)

Exposure of listed turtles to multibeam echosounder, ADCP, and sub-bottom profiler. As with baleen whales, sea turtles hear in the low frequency range. The multibeam echosounder operates at 10.5-13 kHz and the ADCP operates at 75 kHz, both of which emit sounds outside the hearing frequency of sea turtles. Thus, there is a low probability that sea turtles could experience exposure to sounds emitted by multibeam echosounder, ADCP, or sub-bottom profiler.

8.3 Response Analysis

As discussed in the *Approach to the assessment* section of this Opinion, response analyses determine how listed resources are likely to respond after exposure to an action's effects on the environment or directly on listed species themselves. For the purposes of consultation, our assessments try to detect potential lethal, sub-lethal (or physiological), or behavioral responses that might result in reducing the fitness of listed individuals. Ideally, response analyses would consider and weigh evidence of adverse consequences as well as evidence suggesting the absence of such consequences. Our primary concerns in this consultation revolve around exposure of listed individuals to anthropogenic sound sources, which can have a variety of effects that can have fitness consequences (Francis and Barber 2013; Nowacek and Tyack 2013)

(Figure 11).

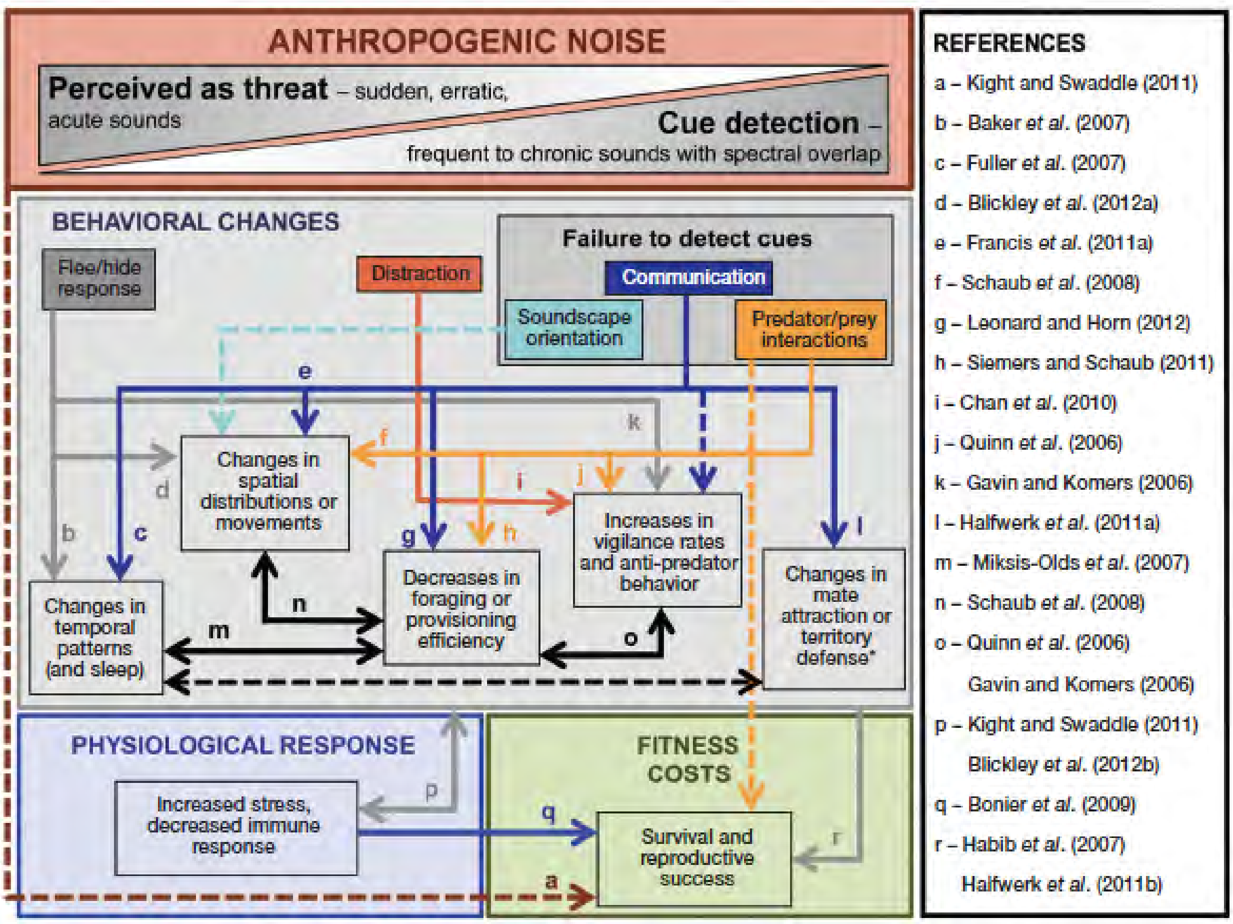

Figure 11. Conceptual framework of how anthropogenic noise impacts individuals and how those impacts can lead to fitness consequences. Figure taken from Francis et al. (2013).Original supporting literature (A. et al. 2007; Baker et al. 2007; Blickley et al. 2012; Blickley and Patricelli 2012; Bonier et al. 2009; Chan et al. 2010; D. et al. 2011; Gavin and Komers 2006; Habib et al. 2007; Halfwerk et al. 2011a; Halfwerk et al. 2011b; Kight and Swaddle 2011b; Leonard and Horn 2012; Miksis-Olds et al. 2007; Quinn et al. 2006; Schaub et al. 2008; Siemers and Schaub 2011).

Marine Mammals

Response of marine mammals to airguns. A pulse of seismic airgun sound displaces water around the airgun and creates a wave of pressure, resulting in physical effects on the marine environment that can then affect marine organisms, such as listed whales and sea turtles considered in this Opinion. Possible responses considered in this analysis consist of:

- threshold shifts,
- auditory interference (masking),
- behavioral responses, and
- non-auditory physical or physiological effects

The *Response analysis* also considers information on the potential for stranding and the potential effects on the prey of ESA-listed whales and sea turtles in the action area.

Marine mammals and threshold shifts. Exposure of marine mammals to very strong sound pulses can result in physical effects, such as changes to sensory hairs in the auditory system, which may temporarily or permanently impair hearing. A TTS results in a temporary hearing change and depends upon the duration, frequency, sound pressure, and rise time of the sound (Finneran and Schlundt 2013). TTSs can last minutes to days. Full recovery is expected and this condition is not considered a physical injury. However, a recent mouse study has shown that although full hearing can be regained from TTS (i.e., the sensory cells actually receiving sound are normal), damage can still occur to nerves of the cochlear nerve leading to delayed but permanent hearing damage (Kujawa and Liberman 2009). At higher received levels, or in frequency ranges where animals are more sensitive, permanent threshold shifts (PTSs) can occur in which auditory sensitivity is unrecoverable. Either of these conditions can result from a single pulse or from the accumulated effects of multiple pulses, in which case each pulse need not be as loud as a single pulse to have the same accumulated effect. TTS and PTS are specific only to the frequencies over which exposure occurs.

Few data are available to precisely define each listed species' hearing range, let alone its sensitivity and levels necessary to induce TTS or PTS. Based upon captive studies of odontocetes, our understanding of terrestrial mammal hearing, and extensive modeling, the best available information supports sound levels at a given frequency would need to be ~186 dB SEL or ~196-201 dB re 1 μPa_{rms} in order to produce a low-level TTS from a single pulse (Southall et al. 2007b). PTS is expected at levels ~6 dB greater than TTS levels on a peak-pressure basis, or 15 dB greater on an SEL basis than TTS (Southall et al. 2007b). In terms of exposure to the *Langseth's* airgun array, an individual would need to be within a few meters of the largest airgun to experience a single pulse >230 dB re 1 μPa peak (Caldwell and Dragoset 2000). If an individual experienced exposure to several airgun pulses of ~190 dB re 1 μPa_{rms}, PTS could occur. A marine mammal would have to be within 100 m of the *Langseth's* airgun array to be within the 190 dB re 1 μPa_{rms} isopleth and risk a TTS. Estimates that are conservative for species protection are 230 dB re 1 μPa (peak) for a single pulse, or multiple exposures to ~198 dB re 1 $\mu Pa^2 s$.

Overall, we do not expect TTS or PTS to occur to any listed whale as a result of airgun exposure for several reasons. We expect that individuals will move away from the airgun array as it approaches. We further believe that as sound intensity increases, individuals will experience conditions (stress, loss of prey, discomfort, etc.) that prompt them to move away from the sound source and thus avoid exposures that would induce TTS. Ramp-ups would also reduce the probability of TTS exposure at the start of seismic surveys. Furthermore, mitigation measures would be in place to initiate a ramp-down if individuals enter or are about to enter the 180 dB isopleth or within 585 m during full airgun operations, which is below the levels believed to be necessary for potential TTS.

Marine mammals and auditory interference (masking). Interference, or masking, generally occurs when the interfering noise is of a similar frequency and similar to or louder than the auditory signal received by an animal processing echolocation signals or listening for acoustic information from other individuals (Francis and Barber 2013). Masking can interfere with an individual's ability to gather acoustic information about its environment, such as predators, prey, conspecifics, and other environmental cues. Generally, noise will only mask a signal if it is sufficiently close to the signal in frequency. This can result in loss of environmental cues of predatory risk, mating opportunity, or foraging options (Francis and Barber 2013). Low frequency sounds are broad and tend to have relatively constant bandwidth, whereas higher frequency bandwidths are narrower (NMFS 2006h).

There is frequency overlap between airgun noise and vocalizations of listed whales, particularly baleen whales. Any masking that might occur would likely be temporary because seismic sources are discontinuous and the seismic vessel would continue to transit. The proposed seismic surveys could mask whale calls at some of the lower frequencies, in particular for baleen whales but also for sperm whales. This could affect communication between individuals, affect their ability to receive information from their environment, or affect sperm whale echolocation (Evans 1998; NMFS 2006h). Most of the energy of sperm whales clicks is concentrated at 2 to 4 kHz and 10 to 16 kHz, and though the findings by Madsen et al. (2006) suggest frequencies of seismic pulses can overlap this range, the strongest spectrum levels of airguns are below 200 Hz (0-188 Hz for the *Langseth* airguns). Given the disparity between sperm whale echolocation and communication-related sounds with the dominant frequencies for seismic surveys, masking is not likely to be significant for sperm whales (NMFS 2006h). Overlap of the dominant low frequencies of airgun pulses with low-frequency baleen whale calls would be expected to pose a greater risk of effects due to masking. The *Langseth's* airguns will emit a 0.1 s pulse when fired every 5 sec. Therefore, pulses will not "cover up" the vocalizations of listed whales to a significant extent (Madsen et al. 2002). We address the response of listed whales stopping vocalizations as a result of airgun sound in the *Marine mammals and behavioral responses* section below.

Although seismic sound pulses begin as short, discrete sounds, they interact with the marine environment and lengthen through processes such as reverberation. This means that in some cases, such as shallow water environments, seismic sound can become part of the acoustic background. Few studies of how impulsive sound in the marine environment deforms from short bursts to lengthened waveforms exist, but can apparently add significantly to acoustic background (Guerra et al. 2011), potentially interfering with the ability of animals to hear otherwise detectible sounds in their environment.

Marine mammals and behavioral responses. We expect the greatest response to airgun sounds by number of responses and overall impact to be in the form of changes in behavior. Listed individuals may briefly respond to underwater sound by slightly changing their behavior or relocating a short distance, in which case the effects are unlikely to be significant at the population level, but can equate to take. Displacement from important feeding or breeding areas over a prolonged period would likely be more significant. This has been suggested for humpback whales along the Brazilian coast as a result of increased seismic activity (Parente et al. 2007). Marine mammal responses to anthropogenic sound vary by species, state of maturity, prior exposure, current activity, reproductive state, time of day, and other factors (Ellison et al. 2012); this is reflected in a variety of aquatic, aerial, and terrestrial animal responses to anthropogenic noise that may ultimately have fitness consequences (Francis and Barber 2013). Although some studies are available which address responses of listed whales considered in this opinion directly, additional studies to other related whales (such as bowhead and gray whales) are relevant in determining the responses expected by species under consideration. Therefore, studies from non-listed or species outside the action area are also considered here. Individual differences in responding to stressful stimuli also appear to exist and appear to have at least a partial genetic basis in trout (Laursen et al. 2011). Animals generally respond to anthropogenic perturbations as they would predators, increasing vigilance and altering habitat selection (Reep et al. 2011). Habitat abandonment due to anthropogenic noise exposure has been found in terrestrial species (Francis and Barber 2013).

Several studies have aided in assessing the various levels at which whales may modify or stop their calls in response to airgun sound. Whales continue calling while seismic surveys are operating locally (Greene Jr et al. 1999; Jochens et al. 2006; Madsen et al. 2002; McDonald et al. 1993; McDonald et al. 1995a; Nieukirk et al. 2004; Richardson et al. 1986; Smultea et al. 2004; Tyack et al. 2003). However, humpback whale males increasingly stopped vocal displays on Angolan breeding grounds as received seismic airgun levels increased (Cerchio et al. 2014). Some blue, fin, and sperm whales stopped calling for short and long periods apparently in response to airguns (Bowles et al. 1994; Clark and Gagnon 2006; McDonald et al. 1995a). Fin whales (presumably adult males) engaged in singing in the Mediterranean Sea moved out of the area of a seismic survey while airguns were operational as well as for at least a week thereafter (Castellote et al. 2012). A blue whale discontinued calls in response to received airgun sound of 143 dB re 1 μPa for one hour before resuming (McDonald et al. 1995a). Blue whales may also attempt to compensate for elevated ambient sound by calling more frequently during seismic surveys (Iorio and Clark 2009). Sperm whales, at least under some conditions, may be particularly sensitive to airgun sounds, as they have been documented to cease calling in association with airguns being fired hundreds of kilometers away (Bowles et al. 1994). Other studies have found no response by sperm whales to received airgun sound levels up to 146 dB re 1 $\mu Pa_{p\text{-}p}$ (Madsen et al. 2002; McCall Howard 1999). Some exposed individuals may cease calling in response to the *Langseth's* airguns. If individuals ceased calling in response to the *Langseth's* airguns during the course of the proposed survey, the effect would likely be temporary.

There are numerous studies of the responses of some baleen whale to airguns. Although responses to lower-amplitude sounds are known, most studies seem to support a threshold of ~160 dB re 1 μPa_{rms} as the received sound level to cause behavioral responses other than vocalization changes (Richardson et al. 1995c). Activity of individuals seems to influence response (Robertson et al. 2013), as feeding individuals respond less than mother/calf pairs and migrating individuals (Harris et al. 2007; Malme and Miles 1985; Malme et al. 1984; Miller et al. 1999; Miller et al. 2005; Richardson et al. 1995c; Richardson et al. 1999b). Surface duration decreased markedly during seismic sound exposure, especially while individuals were engaged in traveling or non-calf social interactions (Robertson et al. 2013). Migrating bowhead whales show strong avoidance reactions to received 120–130 dB re 1 μPa_{rms} exposures at distances of 20-30 km, but only changed dive and respiratory patterns while feeding and showed avoidance at higher received sound levels (152–178 dB re 1 μPa_{rms}) (Harris et al. 2007; Ljungblad et al. 1988; Miller et al. 1999; Miller et al. 2005; Richardson et al. 1995c; Richardson et al. 1999b; Richardson et al. 1986). Responses such as stress may occur and the threshold for displacement may simply be higher while feeding. Bowhead calling rate was found to decrease during migration in the Beaufort Sea as well as temporary displacement from seismic sources (Nations et al. 2009). Calling rates decreased when exposed to seismic airguns at received levels of 116-129 dB re 1 μPa (possibly but not knowingly due to whale movement away from the airguns), but did not change at received levels of 99-108 dB re 1 μPa (Blackwell et al. 2013). Despite the above information and exposure to repeated seismic surveys, bowheads continue to return to summer feeding areas and when displaced, bowheads appear to reoccupy areas within a day

(Richardson et al. 1986). We do not know whether the individuals exposed in these ensonified areas are the same returning or whether individuals that tolerate repeat exposures may still experience a stress response.

Gray whales respond similarly. Gray whales discontinued feeding and/or moved away at received sound levels of 163 dB re 1 μPa_{rms} (Bain and Williams 2006; Gailey et al. 2007; Johnson et al. 2007b; Malme and Miles 1985; Malme et al. 1984; Malme et al. 1986; Malme et al. 1988; Würsig et al. 1999; Yazvenko et al. 2007a; Yazvenko et al. 2007b). Migrating gray whales began to show changes in swimming patterns at ~160 dB re 1 µPa and slight behavioral changes at 140-160 dB re 1 μPa_{rms} (Malme and Miles 1985; Malme et al. 1984). As with bowheads, habitat continues to be used despite frequent seismic survey activity, but long-term effects have not been identified, if they are present at all (Malme et al. 1984). Johnson et al. (2007a) reported that gray whales exposed to seismic airguns off Sakhalin Island, Russia, did not experience any biologically significant or population level effects, based on subsequent research in the area from 2002–2005.

Humpback whales continue a pattern of lower threshold responses when not occupied with feeding. Migrating humpbacks altered their travel path (at least locally) along Western Australia at received levels as low as 140 dB re 1 μPa_{rms} when females with calves were present, or 8-12 km from the seismic source (McCauley et al. 2000a; McCauley et al. 1998). A startle response occurred as low as 112 dB re 1 μPa_{rms}. Closest approaches were generally limited to 3-4 km, although some individuals (mainly males) approached to within 100 m on occasion where sound levels were 179 dB re 1 μPa_{rms}. Changes in course and speed generally occurred at estimated received level of 157–164 dB re 1 μPa_{rms}. Feeding humpbacks appear to be somewhat more tolerant. Humpback whales along Alaska startled at 150–169 dB re 1 µPa and no clear evidence of avoidance was apparent at received levels up to 172 re 1 μPa_{rms} (Malme et al. 1984; Malme et al. 1985). Potter et al. (2007) found that humpbacks on feeding grounds in the Atlantic did exhibit localized avoidance to airguns. Among humpback whales on Angolan breeding grounds, no clear difference was observed in encounter rate or point of closest approach during seismic versus non-seismic periods (Weir 2008).

Observational data are sparse for specific baleen whale life histories (breeding and feeding grounds) in response to airguns. Available data support a general avoidance response. Some fin and sei whale sighting data indicate similar sighting rates during seismic versus non-seismic periods, but sightings tended to be further away and individuals remained underwater longer (Stone 2003; Stone and Tasker 2006). Other studies have found at least small differences in sighting rates (lower during seismic activities) as well as whales being more distant during seismic operations (Moulton et al. 2006a; Moulton et al. 2006b; Moulton and Miller 2005). When spotted at the average sighting distance, individuals would have likely been exposed to ~169 dB re 1 μPa_{rms} (Moulton and Miller 2005).

Sperm whale response to airguns has thus far included mild behavioral disturbance (temporarily disrupted foraging, avoidance, cessation of vocal behavior) or no reaction. Several studies have found Atlantic sperm whales to show little or no response (Davis et al. 2000d; Madsen et al. 2006; Miller et al. 2009; Moulton et al. 2006a; Moulton and Miller 2005; Stone 2003; Stone and Tasker 2006; Weir 2008). Detailed study of Gulf of Mexico sperm whales suggests some alteration in foraging from <130-162 dB re 1 μPa_{p-p}, although other behavioral reactions were not noted by several authors (Gordon et al. 2006; Gordon et al. 2004; Jochens et al. 2006; Madsen et al. 2006; Winsor and Mate 2006). This has been contradicted by other studies, which found avoidance reactions by sperm whales in the Gulf of Mexico in response to seismic ensonification (Jochens and Biggs 2003; Jochens and Biggs 2004; Mate et al. 1994). Johnson and Miller (2002) noted possible avoidance at received sound levels of 137 dB re 1 μPa. Other anthropogenic sounds, such as pingers and sonars, disrupt behavior and vocal patterns (Goold 1999; Watkins et al. 1985; Watkins and Schevill 1975). Miller et al. (2009) found sperm whales to be generally unresponsive to airgun exposure in the Gulf of Mexico, with possible but inconsistent responses that included delayed foraging and altered vocal behavior. Displacement from the area was not observed. Winsor and Mate (2013) did not find a nonrandom distribution of satellite-tagged sperm whales at and beyond five kilometers from seismic airgun arrays, suggesting individuals were not displaced or move away from the array at and beyond these distances in the Gulf of Mexico (Winsor and Mate 2013). However, no tagged whales within five kilometers were available to assess potential displacement within five kilometers (Winsor and Mate 2013). The lack of response by this species may in part be due to its higher range of hearing sensitivity and the low-frequency (generally <188 Hz) pulses produced by seismic airguns (Richardson et al. 1995c). Sperm whales are exposed to considerable energy above 500 Hz (Goold and Fish 1998). Breitzke et al. (2008) found that source levels were ~30 dB re 1 μPa lower at 1 kHz and 60 dB re 1 μPa lower at 80 kHz compared to dominant frequencies during a seismic source calibration. Another odontocete, bottlenose dolphins, progressively reduced their vocalizations as an airgun array came closer and got louder (Woude 2013). Reactions to impulse noise likely vary depending on the activity at time of exposure – e.g., in the presence of abundant food or during sexual encounters toothed whales sometimes are extremely tolerant of noise pulses (NMFS 2006b).

For whales exposed to seismic airguns during the proposed activities, behavioral changes stemming from airgun exposure may result in loss of feeding opportunities. We expect listed whales exposed to seismic airgun sound will exhibit an avoidance reaction, displacing individuals from the area at least temporarily. We also expect secondary foraging areas to be available that would allow whales to continue feeding. Although breeding may be occurring, we are unaware of any habitat features that sperm whales would be displaced from that is essential for breeding if sperm whales depart an area as a consequence of the *Langseth*'s presence. We expect breeding may be temporarily disrupted if avoidance or displacement occurs, but we do not expect the loss of any breeding opportunities. Individuals engaged in travel or migration would continue with these activities, although potentially with a deflection of a few kilometers from the route they would otherwise pursue.

Marine mammals and physical or physiological effects. Individual whales exposed to airguns (as well as other sound sources) could experience effects not readily observable, such as stress, that can significantly affect life history.

Stress is an adaptive response and does not normally place an animal at risk. Distress involves a stress response resulting in a biological consequence to the individual. The mammalian stress response involves the hypothalamic-pituitary-adrenal (HPA) axis being stimulated by a stressor, causing a cascade of physiological responses, such as the release of the stress hormones cortisol, adrenaline (epinephrine), glucocorticosteroids, and others (Busch and Hayward 2009; Gregory and Schmid 2001; Gulland et al. 1999; St. Aubin and Geraci 1988; St. Aubin et al. 1996; Thomson and Geraci 1986). These hormones subsequently can cause short-term weight loss, the liberation of glucose into the blood stream, impairment of the immune and nervous systems, elevated heart rate, body temperature, blood pressure, and alertness, and other responses (Busch and Hayward 2009; Cattet et al. 2003; Dickens et al. 2010; Dierauf and Gulland 2001b; Elftman et al. 2007; Fonfara et al. 2007; Kaufman and Kaufman 1994; Mancia et al. 2008; Noda et al. 2007; Thomson and Geraci 1986). In some species, stress can also increase an individual's susceptibility to gastrointestinal parasitism (Greer et al. 2005). In highly-stressful circumstances, or in species prone to strong "fight-or-flight" responses, more extreme consequences can result, including muscle damage and death (Cowan and Curry 1998; Cowan and Curry 2002; Cowan and Curry 2008; Herraez et al. 2007). The most widely-recognized indicator of vertebrate stress, cortisol, normally takes hours to days to return to baseline levels following a significantly stressful event, but other hormones of the HPA axis may persist for weeks (Dierauf and Gulland 2001a). Mammalian stress levels can vary by age, sex, season, and health status (Gardiner and Hall 1997; Hunt et al. 2006; Keay et al. 2006; Romero et al. 2008; St. Aubin et al. 1996). Stress is lower in immature right whales than adults and mammals with poor diets or undergoing dietary change tend to have higher fecal cortisol levels (Hunt et al. 2006; Keay et al. 2006).

Loud noises generally increase stress indicators in mammals (Kight and Swaddle 2011a). Romano et al. (2004) found beluga whales and bottlenose dolphins exposed to a seismic water gun (up to 228 dB re 1 μPa · m_{p-p}) and single pure tones (up to 201 dB re 1 μPa) had increases in stress chemicals, including catecholamines, which could affect an individual's ability to fight off disease. During the time following September 11, 2001, shipping traffic and associated ocean noise decreased along the northeastern U.S.; this decrease in ocean noise was associated with a significant decline in fecal stress hormones in North Atlantic right whales, providing evidence that chronic exposure to increased noise levels, although not acutely injurious, can produce stress (Rolland et al. 2012a). These levels returned to baseline after 24 hours of traffic resuming. As whales use hearing as a primary way to gather information about their environment and for communication, we assume that limiting these abilities would be stressful. Stress responses may also occur at levels lower than those required for TTS (NMFS 2006g). Therefore, exposure to levels sufficient to trigger onset of PTS or TTS are expected to be accompanied by physiological stress responses (NMFS 2006g; NRC 2003). As we do not expect individuals to experience TTS or PTS, (see *Marine mammals and threshold shifts*), we also do not expect any listed individual to experience a stress response at high levels. We assume that a stress response could be associated with displacement or, if individuals remain in a stressful environment, the stressor (sounds associated with the airgun, multibeam echosounder, or sub-bottom profiler) will dissipate in a short period as the vessel (and stressors) transects away without significant or long-term harm to the individual via the stress response.

Exposure to loud noise can also adversely affect reproductive and metabolic physiology (Kight and Swaddle 2011a). Premature birth and indicators of developmental instability (possibly due to disruptions in calcium regulation) have been found in embryonic and neonatal rats exposed to loud sound. In fish eggs and embryos exposed to sound levels only 15 dB greater than background, increased mortality was found and surviving fry had slower growth rates (a similar effect was observed in shrimp), although the opposite trends have also been found in sea bream. Dogs exposed to loud music took longer to digest food. The small intestine of rats leaks additional cellular fluid during loud sound exposure, potentially exposing individuals to a higher risk of infection (reflected by increases in regional immune response in experimental animals). Exposure to 12 hours of loud noise can alter elements of cardiac tissue. In a variety of factors, including behavioral and physiological responses, females appear to be more sensitive or respond more strongly than males (Kight and Swaddle 2011a). It is noteworthy that although various exposures to loud noise appear to have adverse results, exposure to music largely appears to result in beneficial effects in diverse taxa; the impacts of even loud sound are complex and not universally negative (Kight and Swaddle 2011a).

Marine mammals and strandings. There is some concern regarding the coincidence of marine mammal strandings and proximal seismic surveys. No conclusive evidence exists to causally link stranding events to seismic surveys.

Suggestions that there was a link between seismic surveys and strandings of humpback whales in Brazil (Engel et al., 2004) were not well founded (IAGC, 2004; IWC, 2007). In September 2002, two Cuvier's beaked whales stranded in the Gulf of California, Mexico. The *R/V Ewing* had been operating a 20-airgun, 8,490-in^3 airgun array 22 km offshore the general area at the time that strandings occurred. The link between the stranding and the seismic surveys was inconclusive and not based on any physical evidence (Hogarth, 2002; Yoder, 2002) as some vacationing marine mammal researchers who happened upon the stranding were ill-equipped to perform an adequate necropsy. Furthermore, the small numbers of animals involved and the lack of knowledge regarding the spatial and temporal correlation between the beaked whales and the sound source underlies the uncertainty regarding the linkage between seismic sound sources and beaked whale strandings (Cox et al., 2006). We do not expect listed whales to strand as a result of the proposed seismic survey.

Responses of marine mammal prey. Seismic surveys may also have indirect, adverse effects on prey availability through lethal or sub-lethal damage, stress responses, or alterations in their behavior or distribution. Studies described herein provide extensive support for this, which is the basis for later discussion on implications for listed whales. Unfortunately, species-specific information on the prey of listed whales is not generally available. Until more specific information is available, we expect that teleost, cephalopod, and krill prey of listed whales to react in manners similar to those fish and invertebrates described herein.

Some support has been found for fish or invertebrate mortality resulting from airgun exposure, and this is limited to close-range exposure to high-amplitudes (Bjarti 2002; Falk and Lawrence 1973; Hassel et al. 2003; Holliday et al. 1987; Kostyuchenko 1973; La Bella et al. 1996a; McCauley et al. 2000a; McCauley et al. 2000b; McCauley et al. 2003; Popper et al. 2005; Santulli et al. 1999). Lethal effects, if any, are expected within a few meters of the airgun array (Buchanan et al. 2004; Dalen and Knutsen 1986). We expect fish to be capable of moving away from the airgun array if it causes them discomfort.

More evidence exists for sub-lethal effects. Several species at various life stages have been exposed to high-intensity sound sources (220-242 dB re 1 μPa) at close distances, with some cases of injury (Booman et al. 1996; McCauley et al. 2003). TTS was not found in whitefish at received levels of ~175 dB re 1 $\mu Pa^2 \cdot s$, but pike did show 10-15 dB of hearing loss with recovery within 1 day (Popper et al. 2005). Caged pink snapper have experienced PTS when exposed over 600 times to received seismic sound levels of 165-209 dB re 1 μPa_{p-p}. Exposure to airguns at close range were found to produce balance issues in exposed fry (Dalen and Knutsen 1986). Exposure of monkfish and capelin eggs at close range to airguns did not produce differences in mortality compared to control groups (Payne et al. 2009). Salmonid swim bladders were reportedly damaged by received sound levels of ~230 dB re 1 μPa (Falk and Lawrence 1973).

By far the most common response by fishes is a startle or distributional response, where fish react momentarily by changing orientation or swimming speed, or change their vertical distribution in the water column. Although received sound levels were not reported, caged

Pelates spp., pink snapper, and trevally generally exhibited startle, displacement, and/or grouping responses upon exposure to airguns (McCauley and Fewtrell 2013a). This effect generally persisted for several minutes, although subsequent exposures to the same individuals did not necessarily elicit a response (McCauley and Fewtrell 2013a). Startle responses were observed in rockfish at received airgun levels of 200 dB re 1 $\mu Pa_{0\text{-}p}$ and alarm responses at >177 dB re 1 $\mu Pa_{0\text{-}p}$ (Pearson et al. 1992). Fish also tightened schools and shifted their distribution downward. Normal position and behavior resumed 20-60 minutes after seismic firing ceased. A downward shift was also noted by Skalski et al. (1992) at received seismic sounds of 186–191 re 1 $\mu Pa_{0\text{-}p}$. Caged European sea bass showed elevated stress levels when exposed to airguns, but levels returned to normal after 3 days (Skalski et al. 1992). These fish also showed a startle response when the survey vessel was as much as 2.5 km away; this response increased in severity as the vessel approached and sound levels increased, but returned to normal after about two hours following cessation of airgun activity. Whiting exhibited a downward distributional shift upon exposure to 178 dB re 1 $\mu Pa_{0\text{-}p}$ airgun sound, but habituated to the sound after one hour and returned to normal depth (sound environments of 185-192 dB re 1 μPa) despite airgun activity (Chapman and Hawkins 1969). Whiting may also flee from airgun sound (Dalen and Knutsen 1986). Hake may redistribute downward (La Bella et al. 1996a). Lesser sandeels exhibited initial startle responses and upward vertical movements before fleeing from the survey area upon approach of an active seismic vessel (Hassel et al. 2003; Hassel et al. 2004). McCauley et al. (2000; 2000a) found smaller fish show startle responses at lower levels than larger fish in a variety of fish species and generally observed responses at received sound levels of 156–161 dB re 1 μPa_{rms}, but responses tended to decrease over time suggesting habituation. As with previous studies, caged fish showed increases in swimming speeds and downward vertical shifts. Pollock did not respond to airgun sounds received at 195–218 dB re 1 $\mu Pa_{0\text{-}p}$, but did exhibit continual startle responses and fled from the seismic source when visible (Wardle et al. 2001). Blue whiting and mesopelagic fishes were found to redistribute 20–50 m deeper in response to airgun ensonification and a shift away from the survey area was also found (Slotte et al. 2004). Startle responses were infrequently observed from salmonids receiving 142–186 dB re 1 $\mu Pa_{p\text{-}p}$ sound levels from an airgun (Thomsen 2002). Cod and haddock likely vacate seismic survey areas in response to airgun activity and estimated catchability decreased starting at received sound levels of 160–180 dB re 1 $\mu Pa_{0\text{-}p}$ (Dalen and Knutsen 1986; Engås et al. 1996; Engås et al. 1993; Løkkeborg 1991; Løkkeborg and Soldal 1993; Turnpenny et al. 1994). Increased swimming activity in response to airgun exposure, as well as reduced foraging activity, is supported by data collected by Lokkeborg et al. (2012). Bass did not appear to vacate during a shallow-water seismic survey with received sound levels of 163–191 dB re 1 $\mu Pa_{0\text{-}p}$ (Turnpenny and Nedwell 1994). Similarly, European sea bass apparently did not leave their inshore habitat during a 4-5 month seismic survey (Pickett et al. 1994). La Bella et al. (1996b) found no differences in trawl catch data before and after seismic operations and echosurveys of fish occurrence did not reveal differences in pelagic biomass. However, fish kept in cages did show behavioral responses to approaching airguns.

Squid responses to airguns have also been studied, although to a lesser extent than fishes. In response to airgun exposure, squid exhibited both startle and avoidance responses at received sound levels of 174 dB re 1 μPa_{rms} by first ejecting ink and then moving rapidly away from the area (McCauley and Fewtrell 2013b; McCauley et al. 2000a; McCauley et al. 2000b). The authors also noted some movement upward. During ramp-up, squid did not discharge ink but alarm responses occurred when received sound levels reached 156–161 dB re 1 μPa_{rms}. Guerra et al. (2004) suggested that giant squid mortalities were associated with seismic surveys based upon coincidence of carcasses with the surveys in time and space, as well as pathological information from the carcasses. Lobsters did not exhibit delayed mortality, or apparent damage to mechanobalancing systems after up to eight months post-exposure to airguns fired at 202 or 227 dB peak-to-peak pressure (Payne et al. 2013). However, feeding did increase in exposed individuals (Payne et al. 2013).

The overall response of fishes and squids is to exhibit startle responses and undergo vertical and horizontal movements away from the sound field. We do not expect krill (the primary prey of most listed baleen whales) to experience effects from airgun sound. Although humpback whales consume fish regularly, we expect that any disruption to their prey will be temporary, if at all. Therefore, we do not expect any adverse effects from lack of prey availability to baleen whales. Sperm whales regularly feed on squid and some fishes and we expect individuals to feed while in the action area during the proposed survey. Based upon the best available information, fishes and squids ensonified by the ~160 dB isopleths could vacate the area and/or dive to greater depths, and be more alert for predators. We do not expect indirect effects from airgun activities through reduced feeding opportunities for listed whales to be sufficient to reach a significant level. Effects are likely to be temporary and, if displaced, both sperm whales and their prey would re-distribute back into the area once survey activities have passed.

Marine mammal response to multibeam echosounder, ADCP, and sub-bottom profiler. We expect listed whales to experience ensonification from not only airguns, but also seafloor and ocean current mapping systems. Multibeam echosounder, ADCP, and sub-bottom profiler frequencies are much higher than frequencies used by all listed whales except blue, humpback, and sperm whales. We expect that these systems will produce harmonic components in a frequency range above and below the enter frequency similar to other commercial sonars (Deng et al. 2014). However, we do not expect these sub-harmonic frequencies in these systems to be audible to these species. Although Todd et al. (1992) found that mysticetes reacted to sonar sounds at 3.5 kHz within the 80-90 dB re 1 μPa range, it is difficult to determine the significance of this because the source was a signal designed to be alarming and the sound level was well below typical ambient noise. Goldbogen et al. (2013) found blue whales to respond to 3.5-4.0 kHz mid-frequency sonar at received levels below 90 dB re 1 μPa. Responses included cessation of foraging, increased swimming speed, and directed travel away from the source (Goldbogen et al. 2013). Hearing is poorly understood for listed baleen whales, but it is assumed that they are most sensitive to frequencies over which they vocalize, which are much lower than frequencies emitted by the multibeam echosounder and sub-bottom profiler systems (Ketten 1997; Richardson et al. 1995c). Thus, if fin, sei, or North Atlantic right whales are exposed, they are unlikely to hear these frequencies well (if at all) and a response is not expected.

Assumptions for blue, humpback, and sperm whale hearing are much different than for other listed whales. Humpback and sperm whales vocalize between 3.5-12.6 kHz and an audiogram of a juvenile sperm whale provides direct support for hearing over this entire range (Au 2000a; Au et al. 2006; Carder and Ridgway 1990; Erbe 2002a; Frazer and Mercado 2000; Goold and Jones 1995; Levenson 1974; Payne and Payne 1985; Payne 1970; Richardson et al. 1995c; Silber 1986; Thompson et al. 1986; Tyack 1983; Tyack and Whitehead 1983; Weilgart and Whitehead 1993; Weilgart and Whitehead 1997; Weir et al. 2007; Winn et al. 1970). The response of a blue whale to 3.5 kHz sonar supports this species ability to hear this signal as well (Goldbogen et al. 2013). Maybaum (1990; 1993) observed that Hawaiian humpbacks moved away and/or increased swimming speed upon exposure to 3.1-3.6 kHz sonar. Kremser et al. (2005) concluded the probability of a cetacean swimming through the area of exposure when such sources emit a pulse is small, as the animal would have to pass at close range and be swimming at speeds similar to the vessel. Sperm whales have stopped vocalizing in response to 6-13 kHz pingers, but did not respond to 12 kHz echo-sounders (Backus and Schevill 1966; Watkins 1977; Watkins and Schevill 1975). Sperm whales exhibited a startle response to 10 kHz pulses upon exposure while resting and feeding, but now while traveling (Andre and Jurado 1997; André et al. 1997).

Investigations stemming from a recent stranding event in Madagascar suggest a 12 kHz multibeam echosounder, similar in operating characteristics as that proposed for use aboard the *Langseth*, suggest that this sonar played a significant role in the mass stranding of a large group of melon-headed whales (Southall et al. 2013). Although pathological data to suggest a direct physical affect are lacking and the authors acknowledge that although the use of this type of sonar is widespread and common place globally without noted incidents like the Madagascar stranding, all other possibilities were either ruled out or believed to be of much lower likelihood as a cause or contributor to stranding compared to the use of the multibeam echosounder (Southall et al. 2013). This incident highlights the caution needed when interpreting effects that may or may not stem from anthropogenic sound sources, such as the *Langseth*'s multibeam echosounder and that of the chase vessel. Although effects such as this have not been documented for listed species, the combination of exposure to this stressor with other factors, such as behavioral and reproductive state, oceanographic and bathymetric conditions, movement of the source, previous experience of individuals with the stressor, and other factors may combine to produce a response that is greater than would otherwise be anticipated or has been documented to date (Ellison et al. 2012; Francis and Barber 2013).

Recent stranding events associated with the operation of naval sonar suggest that mid-frequency sonar sounds may have the capacity to cause serious impacts to marine mammals. The sonars proposed for use by L-DEO differ from sonars used during naval operations, which generally have a longer pulse duration and more horizontal orientation than the more downward-directed multibeam echosounder, ADCP, and sub-bottom profiler. The sound energy received by any individuals exposed to the multibeam echosounder, ADCP, and sub-bottom profiler sources during the proposed activities is lower relative to naval sonars, as is the duration of exposure. The area of possible influence for the multibeam echosounder, ADCP, and sub-bottom profiler is also much smaller, consisting of a narrow zone close to and below the source vessel. Although navigational sonars are operated routinely by thousands of vessels around the world, strandings have been correlated to use of these sonars. Because of these differences, we do not expect these systems to contribute to a stranding event.

We do not expect masking of blue, sperm, or humpback whale communications to appreciably occur due to multibeam echosounder or sub-bottom profiler signal directionality, low duty cycle, and the brief period when an individual could be within its beam. These factors were considered when Burkhardt et al. (2013) estimated the risk of injury from multibeam echosounder was less than 3% that of ship strike. We also do not anticipate any other adverse effects.

Sea Turtles

Sea turtle response to airguns. As with marine mammals, sea turtles may experience

- threshold shifts

- behavioral responses
- non-auditory physical or physiological effects

Sea turtles and threshold shifts. Although leatherback sea turtles detect low frequency sound, the potential effects on sea turtle biology remain largely unknown (Samuel et al. 2005). Few data are available to assess sea turtle hearing, let alone the effects seismic equipment may have on their hearing potential. The only study which addressed sea turtle TTS was conducted by Moein et al. (1994), in which a loggerhead experienced TTS upon multiple airgun exposures in a shallow water enclosure, but recovered within one day.

As with marine mammals, we assume that sea turtles will not move towards a source of stress or discomfort. Some experimental data suggest sea turtles may avoid seismic sources (McCauley et al. 2000a; McCauley et al. 2000b; Moein et al. 1994), but monitoring reports from seismic surveys in other regions suggest that some sea turtles do not avoid airguns and were likely exposed to higher levels of seismic airgun pulses (Smultea and Holst 2003). For this reason, mitigation measures are also in place to limit sea turtle exposure. Although data on the precise levels that can result in TTS or PTS are lacking, we do not expect either of these to occur to any sea turtle as a result of the proposed action.

Sea turtles and behavioral responses. As with listed whales, it is likely that sea turtles will experience behavioral responses in the form of avoidance. O'Hara and Wilcox (1990) found loggerhead sea turtles exhibited an avoidance reaction at an estimated sound level of 175–176 dB re 1 μPa $_{rms}$ (or slightly less) in a shallow canal. Green and loggerhead sea turtles avoided airgun sounds at received sound levels of 166 dB re 1 μPa and 175 dB re 1 μPa, respectively (McCauley et al. 2000a; McCauley et al. 2000b). Sea turtle swimming speed increased and becomes more erratic at 175 dB re 1 μPa, with individuals becoming agitated. Loggerheads also appeared to move towards the surface upon airgun exposure (Lenhardt 1994a; Lenhardt et al. 1983). However, loggerheads resting at the ocean surface were observed to startle and dive as active seismic source approached them (DeRuiter and Larbi Doukara 2012). Responses decreased with increasing distance of closest approach by the seismic array (DeRuiter and Larbi Doukara 2012). The authors developed a response curve based upon observed responses and predicted received exposure level. Recent monitoring studies show that some sea turtles move away from approaching airguns, although sea turtles may approach active seismic arrays within 10 m (Holst et al. 2006; LGL Ltd 2005a; LGL Ltd 2005b; LGL Ltd 2008; NMFS 2006e; NMFS 2006h).

Observational evidence suggests that sea turtles are not as sensitive to sound as are marine mammals and behavioral changes are only expected when sound levels rise above received sound levels of 166 dB re 1 μPa. This corresponds with previous reports of sea turtle hearing thresholds being generally higher than for marine mammals (DFO 2004). At 166 dB re 1 μPa, we anticipate some change in swimming patterns and a stress response of exposed individuals. Some turtles may approach the active seismic array to closer proximity, but we expect them to eventually turn away. We expect temporary displacement of exposed individuals from some portions of the action area while the *Langseth* transects through.

Sea turtles and stress. Direct evidence of seismic sound causing stress is lacking in sea turtles. However, we expect sea turtles to generally avoid high-intensity exposure to airguns in a fashion similar to predator avoidance. As predators generally induce a stress response in their prey (Dwyer 2004; Lopez and Martin 2001; Mateo 2007), we assume that sea turtles experience a stress response to airguns when they exhibit behavioral avoidance or when they are exposed to sound levels apparently sufficient to initiate an avoidance response (~166 dB re 1 μPa). We expect breeding adult females may experience a lower stress response, as female loggerhead, hawksbill, and green sea turtles appear to have a physiological mechanism to reduce or eliminate hormonal response to stress (predator attack, high temperature, and capture) in order to maintain reproductive capacity at least during their breeding season; a mechanism apparently not shared with males (Jessop 2001; Jessop et al. 2000; Jessop et al. 2004). Individuals may experience a stress response at levels lower than ~166 dB re 1 μPa, but data are lacking to evaluate this possibility. Therefore, we follow the best available evidence identifying a behavioral response as the point at which we also expect a significant stress response.

Sea turtle response to multibeam echosounder, ADCP, and sub bottom profiler. Sea turtles do not possess a hearing range that includes frequencies emitted by these systems. Therefore, listed sea turtles will not hear these sounds even if they are exposed and are not expected to respond to them.

9 CUMULATIVE EFFECTS

Cumulative effects include the effects of future state, tribal, local, or private actions that are reasonably certain to occur in the action area considered by this Opinion. Future federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to Section 7 of the ESA.

We expect that those aspects described in the *Environmental Baseline* will continue to impact listed resources into the foreseeable future. We expect climate change, habitat degradation, dredging, seismic surveys, military activities, entrapment and entanglement, invasive species impacts, wind energy projects, entrainment in power plants, ship-strikes, pollution, scientific research, and harvests to continue into the future. Movement towards bycatch reduction and greater foreign protections of sea turtles are generally occurring throughout the Atlantic Ocean, which may aid in abating the downward trajectory of sea turtle populations.

10 INTEGRATION AND SYNTHESIS OF EFFECTS

As explained in the *Approach to the Assessment* section, risks to listed individuals are measured using changes to an individual's "fitness" – i.e., the individual's growth, survival, annual reproductive success, as well as lifetime reproductive success. When listed plants or animals exposed to an action's effects are not expected to experience reductions in fitness, we would not expect the action to have adverse consequences on the viability of the population(s) those individuals represent or the species those populations comprise (Anderson 2000; Brandon 1978; Mills and Beatty 1979; Stearns 1992). As a result, if the assessment indicates that listed plants or animals are not likely to experience reductions in their fitness, we conclude our assessment. If possible, reductions in individuals' fitness are likely to occur, the assessment considers the risk posed to population(s) to which those individuals belong, and then to the species those population(s) represent.

Listed whales. The NSF proposes to allow the use of its vessel, the *Langseth*, to conduct a seismic survey by L-DEO that could incidentally harass several listed marine mammal species. These species include: blue whales, fin whales, humpback whales, North Atlantic right whales, sei whales, and sperm whales, all of whom are endangered throughout their ranges.

The *Status of Listed Resources* section identified commercial whaling as the primary reason for reduced populations, many of whom are a small fraction of their former abundance (Tables 3-9). Although large-scale commercial harvests no longer occur for these species, some harvests from subsistence and scientific research in regional and worldwide populations still occur. Other worldwide threats to the survival and recovery of listed whale species include: altered prey base and habitat quality as a result of global warming, ship strike, entanglement in fishing gear, toxic chemical burden and biotoxins, ship noise, competition with commercial fisheries, and killer whale predation. Populations of whales inhabiting the North Atlantic face area-specific threats identified in the *Environmental Baseline*.

Despite these pressures, available trend information indicates most local populations of listed whales are stable or increasing. As previously mentioned, the *Cumulative Effects* section identifies actions in the *Environmental Baseline* we expect to generally continue for the foreseeable future.

The *Effects Analysis* supports the conclusion of harassment to listed whales by proposed seismic activities. We expect up to 17 blue, 2 fin, 2 sei, 2 humpback, 3 North Atlantic right, and 18 sperm whales could be exposed to airgun sounds which will elicit a behavioral response of temporarily moving out of the area. We expect a low-level, transitory stress response to accompany this behavior. The number of individuals exposed is expected to generally represent a small fraction of the populations, with some individual re-exposure and reactions should not limit the fitness of any single individual. The other actions we considered in the Opinion, the operation of multibeam echosounder, ADCP, and sub-bottom profiler systems, are not expected to be audible to fin, North Atlantic right, or sei whales and consequently are not expected to have any direct effects on these species. However, blue, humpback, and sperm whales could hear sounds produced by these systems. Responses could include cessation of vocalization by sperm whales and/or movement out of the survey area by these species. Behavioral harassment caused by exposure to sound sources associated with the proposed seismic survey are expected to cause some individuals to cease these activities temporarily and possibly move out of the immediate area. However, we expect that individuals will either resume foraging in a secondary location or reoccupy the habitat from which they were displaced within a period of days. We do not expect these effects to have fitness consequences for any individual. The *Effects Analysis* also found that, although sperm whales may experience temporarily reduced feeding opportunities, this indirect effect would be transient and not reduce individual fitness of any whale. Overall, we do not expect a fitness reduction to any individual whale. As such, we do not expect fitness consequences to populations or listed whale species as a whole.

Listed turtles. Listed turtles that are expected to occur within the action area include green sea turtles, hawksbill sea turtles, leatherback sea turtles, loggerhead sea turtles, and Kemp's ridley sea turtles, which are either threatened or endangered. The *Status of Listed Resources* section found that most sea turtle populations have undergone significant to severe reduction by human harvesting of both eggs and turtles, as well as severe bycatch pressure in worldwide fishing industries. As previously mentioned, the *Cumulative Effects* section identified actions in the *Environmental Baseline* to generally continue for the foreseeable future.

From the *Effects Analysis*, we expect that 30 green, 130 hawksbill, 77 Kemp's ridley, 34 leatherback, and 166 loggerhead sea turtles could experience exposure to airgun sounds and be harassed by these sounds. These sounds may induce a temporary effect in low-level stress levels, swimming patterns, and movement out of the action area. Population size is not available to calculate the subset of all population affected. However, those that are available suggest a very small proportion of each population would be affected. We do expect transient responses that do not affect the fitness of any one individual. We do not expect impairment of local nesting by the proposed survey. As we do not expect any sea turtle to be capable of hearing signals produced by the multibeam echosounder, ADCP, and sub-bottom profiler systems, we do not expect direct effects from these systems on sea turtle fitness. We do not anticipate any indirect effects from the proposed actions to influence sea turtles. Overall, we do not expect any individual sea turtle to undergo a fitness consequence.

11 CONCLUSION

After reviewing the current status of blue, fin, sei, humpback, North Atlantic right, and sperm whales as well as green, hawksbill, leatherback, loggerhead, and Kemp's ridley sea turtles; the *Environmental Baseline* for the action area; the anticipated effects of the proposed activities; and the *Cumulative effects*, it is the NMFS' Opinion that NSF's proposed seismic survey off the New Jersey coast and NMFS' Permits and Conservation Division's issuance of an IHA for the seismic survey are not likely to jeopardize the continued existence of these species. The proposed action would have no effect on critical habitat.

12 INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and federal regulation pursuant to Section 4(d) of the ESA prohibit the "take" of endangered and threatened species, respectively, without special exemption. "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by the NMFS as an act which actually kills or injures wildlife, which may include significant habitat modification or degradation which actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of Sections 7(b)(4) and 7(o)(2), taking that is incidental and not intended as part of the agency action is not considered to be prohibited taking under the ESA provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

The measures described below are nondiscretionary, and must be undertaken by the NSF and the Permits Division so that they become binding conditions for L-DEO for the exemption in Section 7(o)(2) to apply. Section 7(b)(4) of the ESA requires that when a proposed agency action is found to be consistent with Section 7(a)(2) of the ESA and the proposed action may incidentally take individuals of listed species, NMFS will issue a statement that specifies the impact of any incidental taking of endangered or threatened species. To minimize such impacts, reasonable and prudent measures and term and conditions to implement the measures, must be provided. Only incidental take resulting from the agency actions and any specified reasonable and prudent measures and terms and conditions identified in the incidental take statement are exempt from the taking prohibition of Section 9(a), pursuant to Section 7(o) of the ESA.

Section 7(b)(4)(C) of the ESA specifies that in order to provide an incidental take statement for an endangered or threatened species of marine mammal, the taking must be authorized under Section 101(a)(5) of the MMPA. One of the federal actions considered in this Opinion is the Permits and Conservation Division's proposed authorization of the incidental taking of fin, blue, sei, humpback, North Atlantic right, and sperm whales pursuant to Section 101(a)(5)(D) of the MMPA. The final authorization will be issued and its mitigation and monitoring measures incorporated in this Incidental Take Statement as Terms and Conditions. With this authorization, the incidental take of listed whales is exempt from the taking prohibition of Section 9(a), pursuant to Section 7(o) of the ESA as long as such take occurs consistent with this statement.

12.1 Amount or Extent of Take

The NMFS anticipates the proposed seismic survey along New Jersey is likely to result in the incidental take of listed species by harassment. The proposed action is expected to take by harassment 17 blue, 2 fin, 2 sei, 2 humpback, 3 North Atlantic right, and 18 sperm whales as well as 30 green, 130 hawksbill, 77 Kemp's ridley, 34 leatherback, and 166 loggerhead sea turtles by exposing individuals to received seismic sound levels greater than 160 dB re 1 µPa by harassment (166 dB re 1 µPa for sea turtles). These estimates are based on the best available information of densities in the area to be ensonified above 160 dB re 1 µPa for whales during the proposed activities and 166 dB re 1 µPa for sea turtles. This incidental take would result primarily from exposure to acoustic energy during seismic operations and would be in the form of harassment, and is not expected to result in the death or injury of any individuals that are exposed.

Harassment of blue, fin, humpback, North Atlantic right, sei, and sperm whales exposed to seismic studies at levels less than 160 dB re 1 µPa, or of leatherback, loggerhead, green, hawksbill, and Kemp's ridley sea turtles at levels less than 166 dB re 1 µPa, is not expected. If overt adverse reactions (for example, startle responses, dive reactions, or rapid departures from the area) by listed whales or sea turtles are observed at less intense levels than 160 dB or 166 dB re 1 µPa, respectively, while airguns are operating, incidental take may be exceeded. If such reactions by listed species are observed while airguns are in operation, this may constitute take that is not covered in this Incidental Take Statement. The NSF and NMFS' Permits and Conservation Division must contact the ESA Interagency Cooperation Division to determine whether reinitiation of consultation is required because of such operations.

Any incidental take of blue, fin, humpback, North Atlantic right, sei, and sperm whales or leatherback, loggerhead, green, hawksbill, and Kemp's ridley sea turtles is restricted to the permitted action as proposed. If the actual incidental take exceeds the predicted level or type, the NSF and NMFS' Permits and Conservation Division must reinitiate consultation. All anticipated takes would be "takes by harassment", as described previously, involving temporary changes in behavior.

12.2 Effect of the Take

In the accompanying 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**.**

12.3 Reasonable and Prudent Measures

NMFS believes the reasonable and prudent measure described below is necessary and appropriate to minimize the amount of incidental take of listed whales and sea turtles resulting from the proposed actions. This measure is non-discretionary and must be a binding condition of the L-DEO and NMFS' authorization for the exemption in section 7(o)(2) to apply. If the L-

DEO or NMFS fail to ensure compliance with this term and conditions and its implementing terms and conditions, the protective coverage of section 7(o)(2) may lapse.

> The L-DEO must implement and monitor the effectiveness of mitigation measures incorporated as part of the proposed authorization of the incidental taking of blue, fin, sei, humpback, North Atlantic right, and sperm whales pursuant to section 101(a)(5)(D) of the MMPA and as specified below for green, hawksbill, Kemp's ridley, leatherback, and loggerhead sea turtles.

12.4 Terms and Conditions

In order to be exempt from the prohibitions of Section 9 of the ESA, NMFS' Permits and Conservation Division and L-DEO must comply with the following terms and conditions, which implement the Reasonable and Prudent Measures described above. These terms and conditions are non-discretionary.

To be exempt from the prohibitions of Section 9 of the ESA, the NSF, L-DEO, and Permits and Conservation Division must comply with the following terms and conditions, which implement the Reasonable and Prudent Measures described above and outlines the mitigation, monitoring and reporting measures required by the section 7 regulations (50 CFR 402.14(i)). These terms and conditions are non-discretionary. If NSF, L-DEO, and/or the Permits and Conservation Division fail to ensure compliance with these terms and conditions and their implementing reasonable and prudent measures, the protective coverage of section 7(o)(2) may lapse.

To implement the Reasonable and Prudent Measures, the L-DEO and the NMFS' Permits and Conservation Division shall ensure that:

<u>Mitigation and Monitoring Requirements</u>

A. Establish a safety radius corresponding to the anticipated 177-dB isopleth for full (1,400 or 700 in^3) and single (40 in^3) airgun operations.

B. Use two, NMFS-approved, vessel-based PSVOs to watch for and monitor marine mammals near the seismic source vessel during daytime airgun operations, start-ups of airguns at night, and while the seismic array and streamers are being deployed and retrieved. Vessel crew will also assist in detecting marine mammals, when practical. Observers will have access to reticle binoculars (7 X 50 Fujinon), and big-eye binoculars (25 X 150). PSVOs shifts will last no longer than 4 hours at a time. PSVOs will also observe during daytime periods when the seismic system is not operating for comparisons of animal abundance and behavior, when feasible.

C. Record the following information when a marine mammal is sighted:

> i. Species, group size, age/size/sex categories (if determinable), behavior when first sighted and after initial sighting, heading (if consistent), bearing and distance from seismic vessel, sighting cue, apparent reaction to the airguns or vessel (e.g., none, avoidance, approach, paralleling, etc., and including responses to ramp-up), and behavioral pace.
>
> ii. Time, location, heading, speed, activity of the vessel (including number of airguns operating and whether in state of ramp-up or power-down), Beaufort sea state and wind force, visibility, cloud cover, and sun glare.
>
> iii. The data listed under ii. would also be recorded at the start and end of each

observation watch and during a watch whenever there is a change in one or more of the variables.

D. Visually observe the entire extent of the safety radius using PSVOs, for at least 30 min prior to starting the airgun (day or night). If PSVOs find a marine mammal within the safety zone, L-DEO must delay the seismic survey until the marine mammal has left the area. If the PSVO sees a marine mammal that surfaces, then dives below the surface, the observer shall wait 30 minutes. If the PSVO sees no marine mammals during that time, they should assume that the animal has moved beyond the safety zone. If for any reason the entire radius cannot be seen for the entire 30 min (e.g. rough seas, fog, darkness), or if marine mammals are near, approaching or in the safety radius, the airguns may not be started up. If one airgun is already running at a source level of at least 180 dB, L-DEO may start subsequent guns without observing the entire safety radius for 30 min prior, provided no marine mammals are known to be near the safety radius. While it is considered unlikely, in the event a North Atlantic right whale (*Eubalaena glacialis*) is visually sighted, the airgun array will be shut-down regardless of the distance of the animal(s) to the sound source. The array will not resume firing until 30 min after the last documented whale visual sighting.

E. Use the passive acoustic monitoring system (PAM) to detect marine mammals around the *Langseth* during all airgun operations and during most periods when airguns are not operating. One PSVO and/or bioacoustician will monitor the PAM at all times in shifts of 1-6 hours. A bioacoustician shall design and set up the PAM system and be present to operate or oversee PAM, and available when technical issues occur during the survey.

F. Record the following when an animal is detected by the PAM:

i. Contact the PSVO immediately (and initiate power or shut-down, if required);

ii. Enter the information regarding the vocalization into a database. The data to be entered include an acoustic encounter identification number, whether it was linked with a visual sighting, date, time when first and last heard and whenever any additional information was recorded, position and water depth when first detected, bearing if determinable, species or species group, types and nature of sounds heard (e.g., clicks, continuous, sporadic, whistles, creaks, burst pulses, strength of signal, etc.), and any other notable information.

G. Apply a “ramp-up” procedure when starting up at the beginning of seismic operations or any time after the entire array has been shut down for more than 8 min, which means start the smallest gun first and add airguns in a sequence such that the source level of the array will increase in steps not exceeding approximately 6 dB per 5-min period. During ramp-up, the PSVOs will monitor the safety radius, and if marine mammals are sighted, a course/speed alteration, power-down, or shut-down will occur as though the full array were operational.

H. Alter speed or course during seismic operations if a marine mammal, based on its position and relative motion, appears likely to enter the safety zone. If speed or course alteration is not safe or practical, or if after alteration the marine mammal still appears likely to enter the safety zone, further mitigation measures, such as power-down or shut-down, will be taken.

I. Shut-down or power-down the airguns upon marine mammal detection within, approaching, or entering the safety radius. A power-down means shutting down one or more airguns and reducing the safety radius to the degree that the animal is outside of it. Following a power-down, if the marine mammal approaches the smaller designated safety radius, the airguns must completely shut down. Airgun activity will not resume until the marine mammal has cleared the safety radius, which means it was visually observed to have left the safety radius, or has not been seen within the radius for 15 min (small odontocetes) or 30 min (mysticetes and large odontocetes). The array will not resume firing until 30 min after the last documented whale visual sighting. The *Langseth* may operate a small-volume airgun (*i.e.*, mitigation airgun) during turns and maintenance at approximately one shot per minute. During turns or brief transits between seismic tracklines, one airgun would continue to operate.

J. To the maximum extent practicable, schedule seismic operations (i.e., shooting airguns) during daylight hours. Marine seismic surveys may continue into night and low-light hours if such segment(s) of the survey is initiated when the entire relevant exclusion zones are visible and can be effectively monitored. No initiation of airgun array operations is permitted from a shut-down position at night or during low-light hours (such as in dense fog or heavy rain) when the entire relevant exclusion zone cannot be effectively monitored by the PSVO(s) on duty.

Reporting Requirements

A. L-DEO is required to submit a report on all activities and monitoring results to the Office of Protected Resources, NMFS, within 90 days after the expiration of the IHA. This report must contain and summarize the following information:

i. Dates, times, locations, heading, speed, weather, and associated activities during all seismic operations.

ii. Species, number, location, distance from the vessel, and behavior of any marine mammals, as well as associated seismic activity (number of power-downs and shutdowns), observed throughout all monitoring activities.

iii. An estimate of the number (by species) of marine mammals that:

a. Are known to have been exposed to the seismic activity (visual observation) at received levels greater than or equal to 160 dB re 1 microPa (rms) and/or 177 dB re 1 microPa (rms) for cetaceans with a discussion of any specific behaviors those individuals exhibited.

b. May have been exposed (modeling results) to the seismic activity at received levels greater than or equal to 160 dB re 1 microPa (rms) and/or 177 dB re 1 microPa (rms) with a discussion of the nature of the probable consequences of that exposure on the individuals that have been exposed.

iv. A description of the implementation and effectiveness of the:

a. Terms and conditions of the Opinion's Incidental Take Statement.

b. Mitigation measures of the IHA. For the Opinion, the report will confirm the implementation of each term and condition and describe the effectiveness, as well as any conservation measures, for minimizing the adverse effects of the action on listed whales.

B. In the unanticipated event that any taking of a marine mammal in a manner prohibited by the proposed Authorization occurs, such as an injury, serious injury or mortality, and is judged to result from these activities, L-DEO will immediately cease operating all authorized sound sources and report the incident to the Chief of the Permits and Conservation Division, Office of Protected Resources, NMFS, at 301-427-8401. L-DEO will postpone the research activities until NMFS is able to review the circumstances of the take. NMFS will work with L-DEO to determine whether modifications in the activities are appropriate and necessary, and notify L-DEO that they may resume the seismic survey operations.

C. In the unanticipated event that any cases of marine mammal injury or mortality are judged to result from these activities (*e.g.*, ship-strike, gear interaction, and/or entanglement), L-DEO will cease operating seismic airguns and report the incident to NMFS' Office of Protected Resources at 301-427-8401 immediately. Airgun operation will then be postponed until NMFS is able to review the circumstances and work with L-DEO to determine whether modifications in the activities are appropriate and necessary. If the lead observer judged that the injury or mortality is not a result of the authorized activities, operations may continue.

D. L-DEO is required to comply with the Terms and Conditions of this Opinion's Incidental Take Statement issued to both the NSF and the NMFS' Office of Protected Resources.

13 Conservation Recommendations

Section 7(a)(1) of the ESA directs federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information.

We recommend the following conservation recommendations, which would provide information for future consultations involving seismic surveys and the issuance of incidental harassment authorizations that may affect endangered large whales as well as endangered or threatened sea turtles and fishes:

1. *Effects of seismic noise on sea turtles.* The NSF should promote and fund research examining the potential effects of seismic surveys on listed sea turtle species.

In order for the ESA Interagency Cooperation Division to be kept informed of actions minimizing or avoiding adverse effects on, or benefiting ESA-listed species or their habitats, NMFS' Permits and Conservation Division should notify the ESA Interagency Cooperation Division of any conservation recommendations they implement in their final action.

14 Reinitiation Notice

This concludes formal consultation on the proposed seismic source survey to be funded by the NSF and conducted by the L-DEO on board the *R/V Langseth* in the Atlantic Ocean off the New Jersey coast, and the issuance of an incidental harassment authorization for the proposed studies pursuant to Section 101(a)(5)(D) of the MMPA. As provided in 50 CFR §402.16, reinitiation of consultation will be required where discretionary Federal involvement or control over the action has been retained or is authorized by law, and: (1) if the amount or extent of incidental take is exceeded; (2) if new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion; (3) if the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this opinion; or (4) if a new species is listed or critical habitat designated that may be affected by the action.

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Appendix D

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Silver Spring, MD 20910

DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL MARINE FISHERIES SERVICE

INCIDENTAL HARASSMENT AUTHORIZATION

We hereby authorize the Lamont-Doherty Earth Observatory (Observatory), Columbia University, P.O. Box 1000, 61 Route 9W, Palisades, New York 10964-8000, under section 101(a)(5)(D) of the Marine Mammal Protection Act (MMPA) (16 U.S.C. 1371(a)(5)(D)) and 50 CFR 216.107, to incidentally harass small numbers of marine mammals incidental to a marine geophysical survey conducted by the R/V *Marcus G. Langseth* (*Langseth*) marine geophysical survey in the Atlantic Ocean, July through August, 2014.

1. EFFECTIVE DATES

This Authorization is valid from July 1, 2014 through August 17, 2014.

2. SPECIFIED GEOGRAPHIC REGION

This Authorization is valid only for specified activities associated with the R/V *Marcus G. Langseth*'s (*Langseth*) seismic operations as specified in the Observatory's Incidental Harassment Authorization (Authorization) application and the National Science Foundation's Environmental Assessment (EA) in the following specified geographic area:

(a) In the Atlantic Ocean, approximately 25 to 85 kilometers (km) off the coast of New Jersey. The area is within the following coordinates: between approximately 39.3° – 39.7° North and approximately 73.2° - 7.38° West, as specified in the Observatory's application and the National Science Foundation's EA.

3. SPECIES AUTHORIZED AND LEVEL OF TAKES

(a) This Authorization limits the incidental taking of marine mammals, by Level B harassment only, to the following species in the area described in Condition 2(a):

(i) Mysticetes – see Table 1 (attached) for authorized species and take numbers.

(ii) Odontocetes – see Table 1 (attached) for authorized species and take numbers.

(iii) Pinnipeds – see Table 1 (attached) for authorized species and take numbers.

(b) During the seismic activities, if the Holder of this Authorization encounters any marine mammal species not listed in Table 1 (attached) for authorized taking and may expose that species to sound pressure levels greater than or equal to 160 decibels (dB) re: 1 µPa, then the Holder must alter the *Langseth's* speed or course or shut-down the airguns to avoid take.

(c) This Authorization prohibits the taking by injury (Level A harassment), serious injury, or death of any of the species listed in Condition 3(a) or the taking of any kind of any other species of marine mammal. Thus, it may result in the modification, suspension or revocation of this Authorization.

(d) This Authorization limits the methods authorized for taking by Level B harassment to the following acoustic sources:

(i) A single airgun with a total discharge capacity of 40 cubic inches (in^3);

(ii) A 4-airgun subarray with a total discharge capacity of 700 in^3;

(iii) An 8-airgun subarray with a total discharge capacity of 1,400 in^3;

(iv) A multibeam echosounder (MBES);

(v) A sub-bottom profiler (SBP); and

(vi) A 75-kHz acoustic current Doppler profiler (ADCP).

4. PROHIBITED TAKE

The Holder of this Authorization must immediately report the taking of any marine mammal in a manner prohibited under this Authorization to the Office of Protected Resources, National Marine Fisheries Service, at 301-427-8401 and/or by email to Jolie.Harrison@noaa.gov and Jeannine.Cody@noaa.gov.

5. COOPERATION

We require the Holder of this Authorization to cooperate with the Office of Protected Resources, National Marine Fisheries Service and any other Federal, state or local agency monitoring the impacts of the activity on marine mammals.

6. MITIGATION AND MONITORING REQUIREMENTS

We require the Holder of this Authorization to implement the following mitigation and monitoring requirements when conducting the specified activities to achieve the least practicable adverse impact on affected marine mammal species or stocks:

Visual Observers

(a) Utilize two, National Marine Fisheries Service-qualified, vessel-based Protected Species Visual Observers (visual observers) to watch for and monitor marine mammals near the seismic source vessel during daytime airgun operations (from civil twilight-dawn to civil twilight-dusk) and before and during start-ups of airguns day or night.

(i) At least one visual observer will be on watch during meal times and restroom breaks.

(ii) Visual observer shifts will last no longer than four hours at a time.

(iii) Visual observers will have access to reticle binoculars (7x50 Fujinon), and big-eye binoculars (25x150).

(iv) Visual observers will also conduct monitoring while the *Langseth* crew deploys and recovers the airgun array and streamers from the water.

(v) When feasible, visual observers will conduct observations during daytime periods when the researchers are not operating the seismic system. This monitoring will help in the comparison of sighting rates and behavioral reactions during, between, and after airgun operations.

(vi) The *Langseth*'s crew will also assist in detecting marine mammals, when practicable.

Exclusion Zones

(b) Establish a 177-dB or 187-dB exclusion zone for cetaceans and pinnipeds, respectively, before starting either the 4-airgun (700 in^3); the 8-airgun (1,400 in^3) subarray; or the single airgun (40 in^3). Observers will use the predicted radius distance for the 177-dB and 187-dB exclusion zones for cetaceans and pinnipeds, respectively.

(c) See Table 2 (attached) for the distances of the exclusion zones.

Visual Monitoring at the Start of Airgun Operations

(d) Monitor the entire extent of the exclusion zones listed in Table 2 (attached) for at least 30 minutes (day or night) prior to the ramp-up of airgun operations after a shutdown.

(e) If a visual observer sees a marine mammal within the 177-dB or 187-dB exclusion zone for cetaceans or pinnipeds, respectively, the Holder of this Authorization must delay the start of airgun operations until the marine mammal(s) has left the area.

(i) If the visual observer sees a marine mammal that surfaces, then dives below the surface, the visual observer shall wait 30 minutes. If the observer sees no marine mammals during that time, he/she should assume that the animal has moved beyond the 177-dB or 187-dB exclusion zones for cetaceans and pinnipeds, respectively.

(ii) If for any reason the visual observer cannot see the full 177-dB or 187-dB exclusion zone for cetaceans or pinnipeds, respectively, for the entire 30 minutes (*i.e.*, rough seas, fog, darkness), or if marine mammals are near, approaching, or within the exclusion zone, the Holder of the Authorization may not resume airgun operations.

(iii) If one airgun is already running at a source level of at least 177 dB re: 1 μPa, the Holder of the Authorization may start the second gun–and subsequent airguns–without observing relevant exclusion zones for 30 minutes, provided that the observers have not seen any marine mammals near the relevant exclusion zones (in accordance with Condition 6(b)).

Passive Acoustic Monitoring

(f) Utilize the passive acoustic monitoring (PAM) system, to the maximum extent practicable, to detect and allow some localization of marine mammals around the *Langseth* during all airgun operations and during most periods when airguns are not operating. One visual observer and/or bioacoustician will monitor the PAM at all times in shifts no longer than 6 hours. A bioacoustician shall design and set up the PAM system and be present to operate or oversee PAM, and available when technical issues occur during the survey.

(g) Do and record the following when an animal is detected by the PAM:

(i) Notify the visual observer immediately of a vocalizing marine mammal so that the Holder of the Authorization can initiate a power-down or shut-down, if required; and

(ii) Enter the information regarding the vocalization into a database. The data includes an acoustic encounter identification number, whether it was linked with a visual sighting, date, time when first and last heard and whenever any additional information was recorded, position, and water depth when first detected, bearing if determinable, species or species group (*e.g.*, unidentified dolphin, sperm whale), types and nature of sounds heard (*e.g.*, clicks, continuous, sporadic, whistles, creaks, burst pulses, strength of signal, etc.), and any other notable information.

Ramp-Up Procedures

(h) Implement a "ramp-up" procedure when starting the airguns at the beginning of seismic operations or anytime after the entire array has been shutdown, which means start the smallest gun first and add airguns in a sequence such that the source level of the array will increase in steps not exceeding approximately 6 dB per 5-minute period. During ramp-up, the visual observers will monitor the exclusion zone, and if they sight marine mammals, the *Langseth* will implement a course/speed alteration, power-down, or shutdown as though the full array were operational.

Recording Visual Detections

(i) Visual observers must record the following information when they have sighted a marine mammal:

(i) Species, group size, age/size/sex categories (if determinable), behavior when first sighted and after initial sighting, heading (if consistent), bearing and distance from seismic vessel, sighting cue, apparent reaction to the airguns or vessel (*e.g.*, none, avoidance, approach, paralleling, etc., and including responses to ramp-up), and behavioral pace; and

(ii) Time, location, heading, speed, activity of the vessel (including number of airguns operating and whether in state of ramp-up or shut-down), Beaufort sea state and wind force, visibility, and sun glare; and

(iii) The data listed under 6(g)(ii) at the start and end of each observation watch and during a watch whenever there is a change in one or more of the variables.

Speed or Course Alteration

(j) Alter speed or course during seismic operations if a marine mammal, based on its position and relative motion, appears likely to enter the relevant exclusion zone. If speed or course alteration is not safe or practicable, or if after alteration the marine mammal still appears likely to enter the exclusion zone, the Holder of this Authorization will implement further mitigation measures, such as a shutdown.

Power-Down Procedures

(k) Power down the airguns if a visual observer detects a marine mammal within, approaching, or entering the relevant exclusion zones (as defined in Table 2, attached). A power-down means reducing the number of operating airguns to a single operating 40 in^3 airgun. This would reduce the exclusion zone to the degree that the animal(s) is outside of it.

Resuming Airgun Operations After a Power-Down

(l) Following a power-down, if the marine mammal approaches the smaller designated exclusion zone, the Holder of this Authorization must shutdown the airguns completely. Airgun activity will not resume until the visual observer sees the marine mammal(s) exiting the relevant exclusion zone and it is not likely to return, or the visual observer has not seen it within the relevant exclusion zone for 15 minutes for species with shorter dive durations (*i.e.,* small odontocetes) or 30 minutes for species with longer dive durations (*i.e.,* mysticetes and large odontocetes, including sperm, pygmy sperm, dwarf sperm, killer, and beaked whales).

(m) Following a power-down and subsequent animal departure, the Holder of this Authorization may resume airgun operations at full power. Initiation requires that the visual observers can effectively monitor the full exclusion zones described in Condition 6(b). If the visual observer sees a marine mammal within or about to enter the relevant exclusion zone, then the *Langseth* will implement a course/speed alteration, power-down, or shutdown.

Shutdown Procedures

(n) Shutdown the airgun(s) if a visual observer detects a marine mammal within, approaching, or entering the relevant exclusion zone (as defined in Table 2, attached). A shutdown means that the *Langseth* turns off all operating airguns.

(o) If a visual observer sees a north Atlantic right whale (*Eubalaena glacialis*) at any distance from the *Langseth*, the Holder of this Authorization will shut down the airgun array regardless of the distance of the animal(s) to the sound source. The array will not resume firing until 30 minutes after the last documented visual sighting of a north Atlantic whale.

Resuming Airgun Operations After a Shutdown

(p) Following a shutdown, if the visual observer has confirmed that the animal has departed the 177-dB or 187-dB exclusion zone within a period of less than or equal to 8 minutes after the shutdown, then the Holder of this Authorization may resume airgun operations at full power.

(q) Else, if the visual observer has not seen the animal depart the 177-dB or 187-dB exclusion zone, then the Holder of this Authorization shall not resume airgun activity until 15 minutes has passed for species with shorter dive times (*i.e.,* small odontocetes and pinnipeds) or 30 minutes has passed for species with longer dive durations (*i.e.,* mysticetes and large odontocetes, including sperm, pygmy sperm, dwarf sperm, killer, and beaked whales). The Holder of this Authorization will follow the ramp-up procedures described in Conditions 6(h).

Survey Operations at Night

(r) The *Langseth* may continue marine geophysical surveys into night and low-light hours if the Holder of the Authorization initiates these segment(s) of the survey when the observers can view and effectively monitor the full relevant exclusion zones.

(s) This Authorization does not permit the Holder of this Authorization to initiate airgun array operations from a shut-down position at night or during low-light hours (such as in dense fog or heavy rain) when the visual observers cannot view and effectively monitor the full relevant exclusion zones.

(t) To the maximum extent practicable, the Holder of this Authorization should schedule seismic operations (*i.e.*, shooting the airguns) during daylight hours.

Mitigation Airgun

(u) The *Langseth* may operate a small-volume airgun (*i.e.*, mitigation airgun) during turns and maintenance at approximately one shot per minute. During turns or brief transits between seismic tracklines, one airgun would continue to operate.

7. Reporting Requirements

This Authorization requires the Holder of this Authorization to:

(a) Submit a draft report on all activities and monitoring results to the Office of Protected Resources, National Marine Fisheries Service, within 90 days of the completion of the seismic survey. This report must contain and summarize the following information:

(i) Dates, times, locations, heading, speed, weather, sea conditions (including Beaufort sea state and wind force), and associated activities during all seismic operations and marine mammal sightings;

(ii) Species, number, location, distance from the vessel, and behavior of any marine mammals, as well as associated seismic activity (number of shutdowns), observed throughout all monitoring activities.

(iii) An estimate of the number (by species) of marine mammals with known exposures to the seismic activity (based on visual observation) at received levels greater than or equal to 160 dB re: 1 μPa and/or 177 and 187 dB re: 1 μPa for cetaceans and pinnipeds, respectively, and a discussion of any specific behaviors those individuals exhibited.

(iv) An estimate of the number (by species) of marine mammals with estimated exposures (based on modeling results) to the seismic activity at received levels greater than or equal to 160 dB re: 1 μPa and/or 177 and 187 dB re: 1 μPa for cetaceans and pinnipeds respectively, with a discussion of the nature of the probable consequences of that exposure on the individuals.

(v) A description of the implementation and effectiveness of the: (A) terms and conditions of the Biological Opinion's Incidental Take Statement (attached); and (B) mitigation measures of the Incidental Harassment Authorization. For the Biological Opinion, the report will confirm the implementation of each Term and Condition, as well as any conservation recommendations, and describe their effectiveness, for minimizing the adverse effects of the action on Endangered Species Act listed marine mammals.

(b) Submit a final report to the Chief, Permits and Conservation Division, Office of Protected Resources, National Marine Fisheries Service, within 30 days after receiving comments from us on the draft report. If the agency decides that the draft report is sufficient, we will consider the draft report to be the final report.

8. Reporting Prohibited Take

In the unanticipated event that the specified activity clearly causes the take of a marine mammal in a manner prohibited by this Authorization, such as an injury (Level A harassment), serious injury or mortality (*e.g.*, ship-strike, gear interaction, and/or entanglement), the Observatory shall immediately cease the specified activities and immediately report the incident to the Chief of the Permits and Conservation Division, Office of Protected Resources, NMFS, at 301-427-8401 and/or by email to Jolie.Harrison@noaa.gov and ITP.Cody@noaa.gov and the Northeast Regional Stranding Coordinator at (978) 281-9300.

The report must include the following information:

- Time, date, and location (latitude/longitude) of the incident;
- Name and type of vessel involved;
- Vessel's speed during and leading up to the incident;
- Description of the incident;
- Status of all sound source use in the 24 hours preceding the incident;
- Water depth;
- Environmental conditions (e.g., wind speed and direction, Beaufort sea state, cloud cover, and visibility);
- Description of all marine mammal observations in the 24 hours preceding the incident;
- Species identification or description of the animal(s) involved;
- Fate of the animal(s); and
- Photographs or video footage of the animal(s) (if equipment is available).

The Observatory will not resume their activities until we are able to review the circumstances of the prohibited take. We will work with the Observatory to determine what is necessary to minimize the likelihood of further prohibited take and ensure Marine Mammal Protection Act compliance. The Observatory may not resume their activities until we notify them by letter, email, or telephone.

9. Reporting an Injured or Dead Marine Mammal with an Unknown Cause of Death

In the event that the Observatory discovers an injured or dead marine mammal, and the lead visual observer determines that the cause of the injury or death is unknown and the death is relatively recent (*i.e.*, in less than a moderate state of decomposition as described in the next paragraph), the Observatory will immediately report the incident to the Chief of the Permits and Conservation Division, Office of Protected Resources, NMFS, at 301-427-8401 and/or by email to Jolie.Harrison@noaa.gov and ITP.Cody@noaa.gov and the Northeast Regional Stranding Coordinator at (978) 281-9300.

The report must include the same information identified in Condition 8. Activities may continue while we review the circumstances of the incident. We will work with the Observatory to determine whether modifications in the activities are appropriate.

10. Reporting an Injured or Dead Marine Mammal not Related to the Activities

In the event that the Observatory discovers an injured or dead marine mammal, and the lead visual observer determines that the injury or death is not associated with or related to the activities authorized in the Authorization (*e.g.*, previously wounded animal, carcass with moderate to advanced decomposition, or scavenger damage), the Observatory will report the incident to the Chief of the Permits and Conservation Division, Office of Protected Resources, NMFS, at 301-427-8401 and/or by email to Jolie.Harrison@noaa.gov and Jeannine.Cody@noaa.gov and the Northeast Regional Stranding Coordinator at (978) 281-9300 within 24 hours of the discovery. Activities may continue while NMFS reviews the circumstances of the incident. The Observatory will provide photographs or video footage (if available) or other documentation of the stranded animal sighting to us.

11. Endangered Species Act Biological Opinion and Incidental Take Statement

The Observatory is required to comply with the Terms and Conditions of the Incidental Take Statement corresponding to the Endangered Species Act Biological Opinion issued to both the National Science Foundation and the National Marine Fisheries Service's Office of Protected Resources, Permits and Conservation Division.

A copy of this Authorization and the Incidental Take Statement must be in the possession of all contractors and protected species observers operating under the authority of this Incidental Harassment Authorization.

JUL - 1 2014

Donna S. Wieting
Director,
Office of Protected Resources
National Marine Fisheries Service

Date

Attachments

Attachment

Table 1 – Authorized Level B harassment take levels.

Species	Proposed Take Authorization[2]
North Atlantic right whale	3
Humpback whale	2
Common minke whale	2
Sei whale	2
Fin whale	2
Blue whale	17
Sperm whale	18
Dwarf sperm whale	3
Pygmy sperm whale	3
Cuvier's beaked whale	4
Gervais' beaked whale	4
Sowerby's beaked whale	4
Unidentified Mesoplodon or Ziphid: True's, Blainville, Northern bottlenose whale	4
Rough-toothed dolphin	0
Bottlenose dolphin (pelagic)	349
Bottlenose dolphin (coastal)	
Pantropical spotted dolphin	0
Atlantic spotted dolphin	113
Spinner dolphin	0
Striped dolphin	59
Short-beaked common dolphin	23
White-beaked dolphin	0
Atlantic white-sided dolphin	19
Risso's dolphin	44
False killer whale	0
Pygmy killer whale	0
Killer whale	0
Long-finned pilot whale	12
Short-finned pilot whale	12
Harbor porpoise	3
Gray seal	15
Harbor seal	140
Harp seal	5

Table 2 –Exclusion zones (EZ) for marine mammals in the survey area.

Source and Volume (in^3)	Tow Depth (m)	Water Depth (m)	Predicted RMS Distances[1] (m)		
			187 dB	177 dB	160 dB
Single Bolt airgun (40 in^3)	6	< 100	31	109	995
4-Airgun subarray (700 in^3)	4.5	< 100	151	561	5,240
4-Airgun subarray (700 in^3)	6	< 100	175	651	6,100
8-Airgun subarray (1,400 in^3)	4.5	< 100	190	709	6,670
8-Airgun subarray (1,400 in^3)	6	< 100	234	886	8,150

Appendix E

NOAA FISHERIES

PROPOSED ACTION: Issuance of an Incidental Harassment Authorization to Lamont Doherty Earth Observatory to Take Marine Mammals by Harassment Incidental to a Marine Geophysical Survey in the Northwest Atlantic Ocean, June – August, 2014.

TYPE OF STATEMENT: Environmental Assessment

LEAD AGENCY: U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service

RESPONSIBLE OFFICIAL: Donna S. Wieting, Director
Office of Protected Resources,
National Marine Fisheries Service

FOR FURTHER INFORMATION: Jeannine Cody
National Marine Fisheries Service
Office of Protected Resources
Permits and Conservation Division
1315 East West Highway
Silver Spring, MD 20910
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LOCATION: The Northwest Atlantic Ocean, approximately 25 to 85 kilometers (15.5 to 52.8 miles) off the coast of New Jersey.

ABSTRACT: This Environmental Assessment analyzes the environmental impacts of the National Marine Fisheries Service, Office of Protected Resources proposal to issue an Incidental Harassment Authorization to Lamont Doherty Earth Observatory, for the taking, by Level B harassment, of small numbers of marine mammals, incidental to a marine geophysical survey in the Atlantic Ocean, June - August, 2014.

DATE: June 2014

CONTENTS

LIST OF ABBREVIATIONS OR ACRONYMS

ACRC	U.S. Navy's Atlantic City Range Complex
ADCP	acoustic Doppler current profiler
Authorization	Incidental Harassment Authorization
CFR	Code of Federal Regulations
Commission	Marine Mammal Commission
CZMA	Coastal Zone Management Act (16 U.S.C. §§ 1451 *et seq*.)
dB	decibel
EA	Environmental Assessment
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
ESA	Endangered Species Act of 1973 (16 U.S.C. 1531 *et seq*.)
EZ	exclusion zone
FONSI	Finding of No Significant Impact
FR	*Federal Register*
ft	feet
Hz	hertz
IHA	Incidental Harassment Authorization
ITA	Incidental Take Authorization
ITS	Incidental Take Statement
kHz	kilohertz
km	kilometer
km^2	square kilometer
m	meter
mi	mile
mi^2	square mile
MMPA	Marine Mammal Protection Act of 1972, as amended (16 U.S.C. 1631 *et seq*.)
MSFCMA	Magnuson-Stevens Fishery Conservation and Management Act
µPa	micropascal
NAO	NOAA Administrative Order
NEPA	National Environmental Policy Act of 1969 (42 U.S.C. 4321 *et seq*.)
NMFS	National Marine Fisheries Service
NOAA	National Oceanographic and Atmospheric Administration
NSF	National Science Foundation
OMB	Office of Management and Budget
Opinion	Biological Opinion
UME	Unusual Mortality Event
USFWS	U.S. Fish and Wildlife Service

CHAPTER 1 – INTRODUCTION AND PURPOSE AND NEED

1.1 DESCRIPTION OF PROPOSED ACTION

The Marine Mammal Protection Act of 1972, as amended (MMPA; 16 U.S.C. 1631 *et seq*.) prohibits the incidental taking of marine mammals. The incidental take of a marine mammal falls under four categories: mortality, serious injury, injury, or harassment. The MMPA defines harassment as any act of pursuit, torment, or annoyance which: (1) has the potential to injure a marine mammal or marine mammal stock in the wild (Level A harassment); or (2) has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering (Level B harassment).

There are exceptions, however, to the MMPA's prohibition on take. The National Marine Fisheries Service, Office of Protected Resources, Permits and Conservation Division (NMFS, hereinafter, we) may authorize the incidental taking of small numbers of marine mammals by harassment upon the request of a U.S. citizen provided we follow certain statutory and regulatory procedures and make determinations. We discuss this exception in more detail in section 1.2.

In response to the Observatory's request, we propose to issue an Incidental Harassment Authorization (Authorization) to Lamont-Doherty Earth Observatory of Columbia University (the Observatory) under Section 101(a)(5)(D) of the MMPA, which would allow the Observatory to take small numbers of marine mammals, incidental to the conduct of a marine geophysical (seismic) survey in federal waters in the northwest Atlantic Ocean approximately 25 to 85 kilometers (km) (15.5 to 52.8 miles (mi)) offshore New Jersey, June through August, 2014. We do not have the authority to permit, authorize, or prohibit the Observatory's research seismic activities under Section 101(a)(5)(D) of the MMPA, as that authority lies with a different Federal agency.

Our issuance of an Authorization to the Observatory is a major federal action under the National Environmental Policy Act of 1969 (NEPA; 42 U.S.C. 4321 *et seq*.), the Council on Environmental Quality (CEQ) regulations in 40 CFR §§ 1500-1508, and NOAA Administrative Order (NAO) 216-6. Thus, we are required to analyze the effects of our proposed action on the human environment.

This Environmental Assessment (EA)addresses the potential environmental impacts of three choices available to us under section 101(a)(5)(D) of the MMPA, namely:

- Issue the Authorization to the Observatory for take, by Level B harassment, of marine mammals during the seismic survey, taking into account the prescribed means of take, mitigation measures, and monitoring requirements;
- Not issue an Authorization to the Observatory in which case, for the purposes of NEPA analysis only, we assume that the activities would proceed and cause incidental take without the mitigation and monitoring measures prescribed in the Authorization[1]; or
- Issue the Authorization to the Observatory for take, by Level B harassment, of marine mammals during the seismic survey by incorporating additional required mitigation measures in addition to the Observatory's proposed measures.

[1] The Foundation's EA states that the Observatory would not conduct the proposed survey without an Incidental Harassment Authorization.

1.1.1 Background on the Observatory's MMPA Application

The Observatory proposes to use the R/V *Marcus G. Langseth* (*Langseth*)– a research vessel owned by the National Science Foundation (Foundation) and operated under a cooperative agreement with the Observatory– 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. The three-dimensional (3-D) seismic reflection survey would investigate features such as river valleys cut into coastal plain sediments now buried under a kilometer of younger sediment and flooded by today's ocean.

The Foundation supports basic scientific research in the mathematical, physical, medical, biological, social, and other sciences pursuant to the National Science Foundation Act of 1950, as amended (NSF Act; 42 U.S.C. 1861-75). The Foundation considers proposals submitted by organizations and makes contracts and/or other arrangements (*i.e.*, grants, loans, and other forms of assistance) to support research activities. In 2014, a Foundation-expert panel recommended a research proposal titled, *Collaborative Research: Community-Based 3D Imaging That Ties Clinoform Geometry to Facies Successions and Neogene Sea-Level Change* (Award #1260237) for funding and ship time on the *Langseth*. As the federal action agency for this award, the Foundation has funded the proposed seismic survey in the Atlantic Ocean, June through August, 2014 as a part of the NSF Act of 1950.

Acoustic stimuli generated by the seismic airgun array have the potential to cause behavioral disturbances to marine mammals in the proposed project area. We describe the Foundation-supported seismic survey in more detail in section 2.2.

1.1.2 Marine Mammals in the Action Area

There are 34 marine mammal species with confirmed or potential occurrence off the coast of New Jersey (Tables 1a, b, and c). Of the 34 species listed in Tables 1a, b, and c, 27 species would most likely to be harassed incidental to conducting the seismic survey. (See Table 6 - 3.2.1 Affected Environment, Marine Mammals).

Table 1(a) – Mysticetes with possible/confirmed occurrence in the proposed activity area.

Mysticetes		
1	**North Atlantic right whale***	*Eubalaena glacialis*
2	**Humpback whale***	*Megaptera novaeangliae*
3	Common minke whale	*Balaenoptera acutorostrata*
4	**Sei whale***	*Balaenoptera borealis*
5	**Fin whale***	*Balaenoptera physalus*
6	**Blue whale***	*Balaenoptera musculus*

Table 1(b) – Odontocetes with possible/confirmed occurrence in the proposed activity area.

Odontocetes		
1	**Sperm whale***	*Physeter macrocephalus*
2	Dwarf sperm whale	*Kogia sima*
3	Pygmy sperm whale	*K. breviceps*
4	Blainville's beaked whale	*Mesoplodon densirostris*
5	Cuvier's beaked whale	*Ziphius cavirostris*
6	Gervais' beaked whale	*M. europaeus*
7	Sowerby's beaked whale	*M. bidens*

8	True's beaked whale	*M. mirus*
9	Northern bottlenose whale	*Hyperoodon ampullatus*
10	Rough-toothed dolphin	*Steno bredanensis*
11	Bottlenose dolphin	*Tursiops truncatus*
12	Pantropical spotted dolphin	*Stenella attenuate*
13	Atlantic spotted dolphin	*S. frontalis*
14	Spinner dolphin	*S. longirostris*
15	Striped dolphin	*S. coeruleoalba*
16	Short-beaked common dolphin	*Delphinus delphis*
17	White-beaked dolphin	*Lagenorhynchus albirostris*
18	Atlantic white-sided-dolphin	*L. acutus*
19	Risso's dolphin	*Grampus griseus*
20	False killer whale	*Pseudorca crassidens*
21	Pygmy killer whale	*Feresa attenuate*
22	Killer whale	*Orcinus orca*
23	Long-finned pilot whale	*Globicephala melas*
24	Short-finned pilot whale	*G. macrorhynchus*
25	Harbor porpoise	*Phocoena phocoena*

Table 1(c) – Pinnipeds with possible/confirmed occurrence in the proposed activity area.

Pinnipeds		
1	Gray seal	*Halichoerus grypus*
2	Harbor seal	*Phoca vitulina*
3	Harp seal	*Pagophilus groenlandicus*

[*] Listed as threatened or endangered under the Endangered Species Act of 1973 (16 U.S.C. 1531 *et seq*.).

1.1.3 Species Not Considered Due to Rarity in the Action Area

We do not consider the following species in this EA because their range does not overlap with the survey area or the species are so rarely sighted that their presence in the proposed survey area, and therefore take, is unlikely (LGL, 2013; NSF, 2014).

Table 2 – Species with rare occurrence in the proposed activity area.

Species Not Considered Further in this EA		
1	**Beluga whale**	*Delphinapterus leucas*
2	Hooded seal	*Cystophora cristata*
3	Clymene dolphin	*Stenella clymene*
4	Fraser's dolphin	*Lagenodelphis hosei*
5	Melon-headed whale	*Peponocephala electra*
6	Bryde's whale	*Balaenoptera brydei*
7	West Indian manatee[1]	*Trichechus manatus*

[1] This species is under the jurisdiction of the U.S. Fish and Wildlife Service.

1.2 Purpose and Need

The MMPA prohibits "takes" of marine mammals with only a few specific exceptions. The applicable exception in this case is an exemption for incidental take of marine mammals in section 101(a)(5)(D) of the MMPA.

Section 101(a)(5)(D) of the MMPA directs the Secretary of Commerce (Secretary) to authorize, upon request, the incidental, but not intentional, taking of small numbers of marine mammals of a species or population stock, by United States citizens who engage in a specified activity (other than commercial fishing) within a specified geographical region if we make certain findings and provide a notice of a proposed authorization to the public for review.

We have issued regulations to implement the Incidental Take Authorization provisions of the MMPA (50 CFR § 216) and have produced Office of Management and Budget (OMB)-approved application instructions (OMB Number 0648-0151) that prescribe the procedures necessary to apply for authorizations. All applicants must comply with the regulations at 50 CFR § 216.104 and submit applications requesting incidental take according to the provisions of the MMPA.

Purpose: The primary purpose of our proposed action is to authorize the take of marine mammals incidental to the Observatory's proposed seismic survey. The Authorization would exempt the Observatory from the take prohibitions contained in the MMPA.

To authorize the take of small numbers of marine mammals, we must evaluate the best available information to determine whether the take would have a negligible impact on marine mammals or stocks and have an unmitigable impact on the availability of affected marine mammal species for certain subsistence uses.

In addition, we must prescribe, where applicable, the permissible methods of taking and other means of effecting the least practicable impact on the species or stocks of marine mammals and their habitat (*i.e*., mitigation), paying particular attention to rookeries, mating grounds, and other areas of similar significance. If appropriate, we must also prescribe the means of effecting the least practicable impact on the availability of the species or stocks of marine mammals for subsistence uses. Authorizations must also include requirements or conditions pertaining to the monitoring and reporting of such taking—in large part to better understand the effects of such taking on the species.

Need: On December 17, 2013, the Observatory submitted an adequate and complete application demonstrating both the need and potential eligibility for issuance of an Authorization in connection with the activities described in section 1.1.1. We now have a corresponding duty to determine whether and how we can authorize take by Level B harassment incidental to the activities described in the Observatory's application. Our responsibilities under section 101(a)(5)(D) of the MMPA and its implementing regulations establish and frame the need for this proposed action.

Any alternatives considered under NEPA must meet the agency's statutory and regulatory requirements. Our described purpose and need guide us in developing reasonable alternatives for consideration, including alternative means of mitigating potential adverse effects.

1.3 THE ENVIRONMENTAL REVIEW PROCESS

NEPA compliance is necessary for all "major" federal actions with the potential to significantly affect the quality of the human environment. Major federal actions include activities fully or partially funded, regulated, conducted, authorized, or approved by a federal agency. Because our issuance of an Authorization would allow for the taking of marine mammals consistent with provisions under the MMPA, we consider this as a major federal action subject to NEPA.

Under the requirements of NAO 216-6 section 6.03(f)(2)(b) for incidental harassment authorizations, we prepared this EA to determine whether the direct, indirect and cumulative impacts related to the issuance of an Authorization for incidental take of marine mammals during the conduct of the Observatory's seismic survey activities in the Atlantic Ocean could be significant. If we deem the potential impacts to be not significant, this analysis, in combination with other analyses incorporated by reference—may support the issuance of a Finding of No Significant Impact (FONSI) for the proposed Authorization.

1.3.1 Laws, Regulations, or Other NEPA Analyses Influencing the EA's Scope

We have based the scope of the proposed action and nature of the three alternatives considered in this EA on the relevant requirements in section 101(a)(5)(D) of the MMPA. Thus, our authority under the MMPA bounds the scope of our alternatives. We conclude that this analysis—when combined with the analyses in the following documents—fully describes the potential impacts associated with the proposed seismic survey program, including any required mitigation and monitoring measures. After conducting an independent review of the information and analyses for sufficiency and adequacy, we incorporate by reference the relevant analyses on the Observatory's proposed action as well as a discussion of the affected environment and environmental consequences within the following documents per 40 CFR 1502.21 and NAO 216-6 § 5.09(d):

- our notice of the proposed Authorization in the *Federal Register* (79 FR 14779, March 17, 2014);
- *Request for an Incidental Harassment Authorization to Allow the Incidental Take of Marine Mammals during a Marine Geophysical Survey by the R/V Marcus G. Langseth in the Atlantic Ocean off New Jersey, June–July 2014* (LGL, 2013);
- *Draft Environmental Assessment of a Marine Geophysical Survey by the R/V Marcus G. Langseth in the Atlantic Ocean off New Jersey, June–July 2014* (NSF, 2014); and
- *Programmatic Environmental Impact Statement/Overseas Environmental Impact Statement for Marine Seismic Research Funded by the National Science Foundation or Conducted by the U.S. Geological Survey* (NSF, 2011).

MMPA Application and Notice of the Proposed IHA

The CEQ regulations (40 CFR § 1502.25) encourage federal agencies to integrate NEPA's environmental review process with other environmental review laws. We rely substantially on the public process for developing proposed Authorizations and evaluating relevant environmental information and provide a meaningful opportunity for public participation as we develop corresponding EAs. We fully consider public comments received in response to our publication of the notice of proposed Authorization during the corresponding NEPA review process.

On March 17, 2014, we published a notice of a proposed Authorization in the *Federal Register* (79 FR 14779) which included the following:

- A detailed description of the proposed action and an assessment of the potential impacts on marine mammals and their habitat;
- Plans for the Observatory's mitigation and monitoring measures to avoid and minimize potential adverse impacts to marine mammals and their habitat and proposed reporting requirements; and

- Our preliminary findings under the MMPA.

We considered the Observatory's proposed seismic survey and associated mitigation and monitoring measures and preliminarily determined that the proposed 3-D seismic survey in the Atlantic Ocean, from June through August 2014, would result, at worst, in a modification in behavior and/or low-level physiological effects (Level B harassment) of certain species of marine mammals. In addition, we determined that the activity would not have an unmitigable adverse impact on the availability of marine mammals for subsistence uses. The notice afforded the public a 30-day comment period on our proposed MMPA Authorization. In response to a request by several environmental organizations and others, we extended the comment period for an additional 30 days. (79 FR 19580, April 9, 2014).

1.3.2 Scope of Environmental Analysis

Given the limited scope of the decision for which we are responsible, this EA intends to provide more focused information on the primary issues and impacts of environmental concern related specifically to our issuance of the Authorization. This EA does not further evaluate effects to the elements of the human environment listed in Table 3 because previous environmental reviews for similar seismic activities, incorporated by reference (NSF, 2011, 2014), have (1) already evaluated the effects of these activities on other elements of the human environment (as noted in Table 3); and (2) we have determined that the issuance of our Authorization would not affect those components of the human environment.

Table 3 – Components of the human environment not affected by our issuance of an Authorization.

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

1.3.3 NEPA Public Scoping Summary

NAO 216-6 established agency procedures for complying with NEPA and the implementing NEPA regulations issued by the CEQ. Consistent with the intent of NEPA and the clear direction in NAO 216-6 to involve the public in NEPA decision-making, we requested comments on the potential environmental impacts described in the Observatory's MMPA application and in the *Federal Register* notice of the proposed Authorization (79 FR 14779, March 17, 2014). The CEQ regulations further encourage agencies to integrate the NEPA review process with review under the environmental statutes. Consistent with agency practice we integrated our NEPA review and preparation of this EA with the public process required by the MMPA for the proposed issuance of an Authorization.

The *Federal Register* notice of the proposed Authorization, combined with our preliminary determinations, supporting analyses, and corresponding public comment periods are instrumental in providing the public with information on relevant environmental issues and offering the public a meaningful opportunity to provide comments to us for consideration in both the MMPA and NEPA decision-making processes.

The *Federal Register* notice of the proposed Authorization summarized our proposed action; included a statement that we would evaluate the Foundation's draft EA (NSF, 2014) and determine whether or not to adopt it or prepare a separate NEPA analysis and incorporate relevant portions of the Foundation's draft EA by reference. We invited interested parties to submit written comments concerning the application and our preliminary analyses and findings including those relevant to consideration in the EA. The notice of the proposed Authorization was available for public review and comment from March 17 through May 16, 2014.

We posted the Observatory's application on our website concurrently with the release of the *Federal Register* notice of the proposed Authorization. We base this EA on the information included in our *Federal Register* notice, the documents it references, and the public comments provided in response. At the conclusion of this process, we will post the final EA, and, if appropriate, FONSI, on the same website.

1.3.4 RELEVANT COMMENTS ON OUR *FEDERAL REGISTER* NOTICE

During the 60-day public comment period on the notice of the proposed Authorization, we received comment letters from the following:

Table 4a – Members of the U.S. Congress who submitted comments on our proposed action.

Congressional	
Sen. Cory Booker, (D-NJ)	Rep. Frank Pallone, (D-NJ)
Rep. Frank A. LoBiondo, (R-NJ)	Rep. Chris Smith, (R-NJ)

Table 4b – Federal or state agencies who submitted comments on our proposed action.

Federal / State Agencies	
U.S. Marine Mammal Commission	State of New Jersey Department of Environmental Protection

Table 4c – Organizations and individuals who submitted comments on our proposed action.

Organizations and Private Citizens	
Alaska Inter-Tribal Council	Lincoln S. Hollister, private citizen
American Littoral Society	Natural Resources Defense Council
Asbury Park Fishing Club	New Jersey Beach Buggy Association
Association of NJ Environmental Commissions	Marine Trades Association of New Jersey
Center for Biological Diversity	Marcus Langseth Science Oversight Committee
Cetacean Society International	Oceana
Clean Ocean Action	Paddleout.org
Clean Water Action	reEarth

CWA Local 1075	SandyHook SeaLife Foundation
Drew Martin, private citizen	Save Barnegat Bay
Fisherman's Dock Cooperative	Surfers' Environmental Alliance
Hands Across the Sand	Surfrider Foundation
International Game Fish Association	WATERSPIRIT
League of Women Voters of New Jersey	Whale and Dolphin Action League
Lenape Nation PA	

The public comments related to the potential environmental impacts associated with our action of issuing an Authorization for the Observatory's action include:

- Ensuring that the Authorization complies with the MMPA;
- Re-evaluating our preliminary determinations for negligible impact on marine mammals;
- Providing justification that our determination that Level A harassment would not occur during the conduct of the seismic survey is based on the best available science;
- Considering and incorporating the latest information on species present in the area;
- Consideration of additional mitigation measures such as establishing larger exclusion zones; lowering the acoustic thresholds for take estimates; suspending activities at night; conducting the survey at an alternative time; and using additional methods to detect marine mammals;
- Ensuring consideration of cumulative effects of other anthropogenic sound producing activities in the action area, including future seismic exploration activities and the use of active acoustic sources; and
- Evaluating the impacts to North Atlantic right whales and bottlenose dolphins.

The Marine Mammal Commission (Commission) provides comments on all proposed incidental take authorizations as part of their established role under the MMPA (§ 202 (a)(2))The Commission submitted the following recommendations:

- Require the Observatory to take in-situ measurements at the survey location to verify, refine, and if needed, recalculate exclusion zone estimates;
- Require the Observatory to revise their take estimates; and
- Consult with the Foundation and the Observatory to develop, validate, and implement a monitoring program that provides a scientifically sound, reasonably accurate assessment of the types of marine mammal takes and the actual numbers of marine mammals taken.

We fully considered all of the public comments in preparing the final Authorization and this EA by reviewing the pertinent comments and information provided to us. We address any comments specific to the Observatory's application that address the statutory and regulatory requirements or findings that we must make in order to issue an Authorization. We will provide responses to the public comments in the *Federal Register* notice announcing the issuance of the Authorization

1.4 Other Permits, Licenses, or Consultation Requirements

This section summarizes federal, state, and local permits, licenses, approvals, and consultation requirements necessary to implement the proposed action. We incorporate those descriptions by reference in this EA and briefly summarize them in this section.

1.4.1 ENDANGERED SPECIES ACT

Section 7 of the ESA and implementing regulations at 50 CFR § 402 require consultation with the appropriate federal agency (either NMFS or the U.S. Fish and Wildlife Service) for federal actions that "may affect" a listed species or critical habitat. Our issuance of an Authorization is a federal action subject to the section 7 consultation requirements. Accordingly, we are required to ensure that our action is not likely to jeopardize the continued existence of any threatened or endangered species or result in destruction or adverse modification of critical habitat for such species.

There are six marine mammal species under our jurisdiction listed as endangered under the ESA with confirmed or possible occurrence in the proposed project area: blue, fin, humpback, North Atlantic right, sei, and sperm whales. There is no designated critical habitat for any of the ESA-listed species within the action area; thus, our Authorization will not affect any of these species' critical habitats.

On December 17, 2013, the Foundation requested authorization for the incidental take of three marine mammals listed as endangered under the ESA under our jurisdiction: fin, sei, and sperm whales. Under section 7 of the ESA, the Foundation, the lead Federal agency which owns and operates the *Langseth*, initiated formal consultation on their action with the National Marine Fisheries Service, Office of Protected Resources, Endangered Species Act Interagency Cooperation Division.

On February 3, 2014, we also initiated formal consultation on our proposed action with the National Marine Fisheries Service, Office of Protected Resources, Endangered Species Act Interagency Cooperation Division. For the proposed Authorization, NMFS reviewed the Observatory's take estimates for listed species under the ESA presented in Table 3 of their application (LGL, 2013). Based on the best available information, we requested consultation on the issuance of incidental take for two additional species (i.e., blue and North Atlantic right whales) in addition to the Foundation's original incidental take request for fin, humpback, sei, and sperm whales.

The formal consultation under section 7 of the ESA will conclude with a single Biological Opinion for the National Science Foundation's Division of Ocean Sciences and to the National Marine Fisheries Service's Office of Protected Resources, Permits and Conservation Division for the seismic survey and associated Authorization under the MMPA.

1.4.2 MARINE MAMMAL PROTECTION ACT

We discuss the MMPA and its provisions that pertain to the proposed action described within section 1.2.

1.4.3 MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT

Under the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA; 16 U.S.C. 1801 *et seq*.), Federal agencies are required to consult with the Secretary of Commerce with respect to any action authorized, funded, or undertaken, or proposed to be authorized, funded, or undertaken, by such agency which may adversely affect essential fish habitat (EFH) identified under the MSFCMA.

Table 4 (page 29) of the Foundation's EA (NSF, 2014) identifies 39 marine species with EFH overlapping the proposed survey area. As the federal action agency funding the Observatory's activities, the Foundation will consult with the NMFS Greater Atlantic Regional Office on EFH.

On February 26, 2014, we determined that mitigation and monitoring measures required by the Authorization for the action would not result in adverse effects to EFH. Thus, the issuance of an Authorization for the taking of marine mammals incidental to the Observatory's seismic survey would not impact EFH and would not require an EFH consultation .

1.4.4 Coastal Zone Management Act

Congress enacted the Coastal Zone Management Act (CZMA) (16 U.S.C. §§ 1451 *et seq*.) to encourage states to manage land and water uses that may affect coastal uses and resources. Once state coastal management programs and the policies within them receive federal approval from NOAA, federal agency activities that may have reasonably foreseeable effects on coastal uses or resources are required to be consistent with those enforceable policies.

On May 20, 2014, NOAA's Office of Ocean and Coastal Resource Management (OCRM) received from the State of New Jersey (State) a request for approval to review under CZMA § 307(d), 15 CFR 930, subpart F the Foundation's funding to Rutgers State University as an unlisted activity that occurs outside of the state's coastal zone. On June 18, 2014, OCRM denied the State of New Jersey's request to review Rutgers' application as an unlisted activity because the State's request for approval to review the activity was not made in a timely manner as required under 15 C.F.R. § 930.98. The State has not requested OCRM approval to review the Authorization as an unlisted activity.

CHAPTER 2 – ALTERNATIVES

2.1 INTRODUCTION

The NEPA and the implementing CEQ regulations (40 CFR §§ 1500-1508) require consideration of alternatives to proposed major federal actions and NAO 216-6 provides agency policy and guidance on the consideration of alternatives to our proposed action. An EA must consider all reasonable alternatives, including the No Action Alternative. This provides a baseline analysis against which we can compare the other alternatives.

To warrant detailed evaluation as a reasonable alternative, an alternative must meet our purpose and need. In this case, and as we previously explained, an alternative meets the purpose and need if it satisfies the requirements under section 101(a)(5)(D) the MMPA. We evaluated each potential alternative against these criteria; identified two action alternatives along with the No Action Alternative; and carried these forward for evaluation in this EA.

Alternatives 1 and 3 include a suite of mitigation measures intended to minimize any potential adverse effects to marine mammals. This chapter describes both alternatives and compares them in terms of their environmental impacts and their achievement of objectives.

2.2 DESCRIPTION OF THE OBSERVATORY'S PROPOSED ACTIVITIES

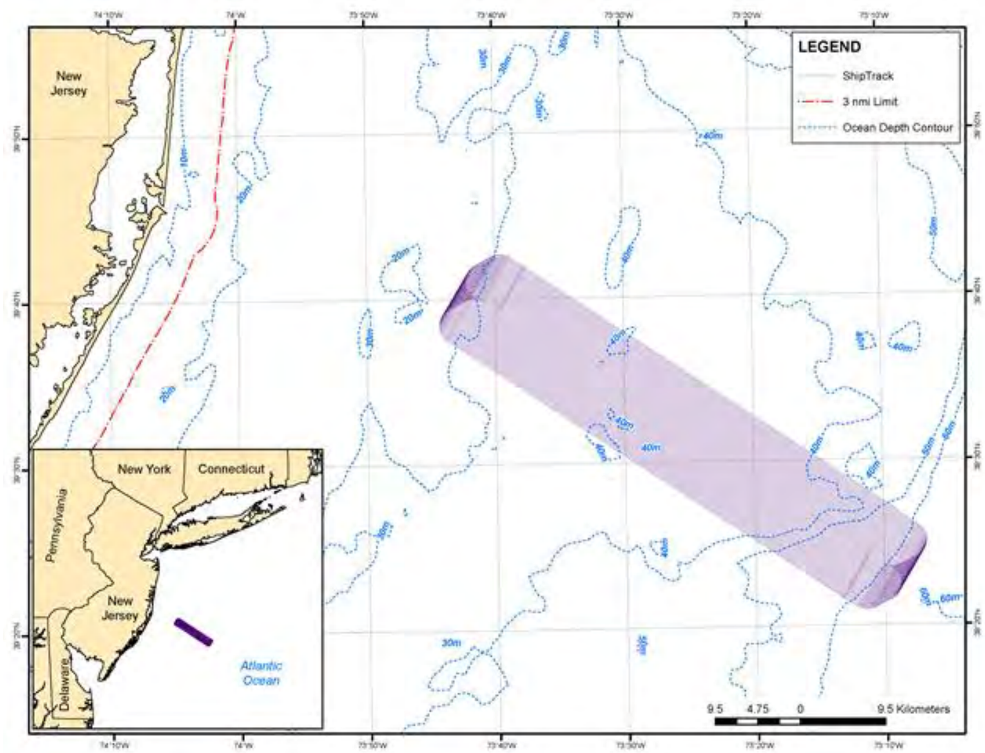
We presented a general overview of the Observatory's proposed 3-D seismic survey operations in our *Federal Register* notice of the proposed Authorization (79 FR 14779, March 17, 2014). Also, the Observatory's application (LGL, 2013) and the Foundation's draft EA (NSF, 2014), describe the survey protocols in detail. We incorporate those descriptions by reference in this EA and briefly summarize them here.

2.2.1 SPECIFIED TIME AND SPECIFIED AREA

The Observatory proposes to conduct the seismic survey from the period of June 3 through July 9, 2014. The proposed study (e.g., equipment testing, startup, line changes, repeat coverage of any areas, and equipment recovery) would include approximately 720 hours of airgun operations (i.e., 30 days over 24 hours). Some minor deviation from the Observatory's requested dates of June through July, 2014, is possible, depending on logistics, weather conditions, and the need to repeat some lines if data quality is substandard. However, because of the extension of the public comment period, the Observatory has agreed to delay the proposed start date of the survey. Therefore, we propose to issue an Authorization that is effective from June 30, 2014 to August 17, 2014. The revised date range falls within the effective date range that we proposed within the *Federal Register* notice of the proposed Authorization (79 FR 14779, March 17, 2014) and the Observatory would still be able to conduct the 30-day survey within the effective date range.

The Observatory proposes to conduct the seismic survey in the Atlantic Ocean, approximately 25 to 85 km (15.5 to 52.8 mi) off the coast of New Jersey between approximately 39.3–39.7° N and approximately 73.2–73.8° W (Figure 1). Water depths in the survey area are approximately 30 to 75 m (98.4 to 246 ft). They would conduct the proposed survey outside of New Jersey state waters and within the U.S. Exclusive Economic Zone.

Figure 1 – Proposed location of the seismic survey in the Atlantic Ocean off the coast of New Jersey during June through August, 2014.



2.2.2 3-D Seismic Survey Operations

Source Vessel: The *Langseth* is 71.5 m (235 ft) long vessel with a gross tonnage of 3,834 pounds. The vessel's speed during operations would be approximately 4.5 knots (kt) (8.3 km/hour (hr); 5.1 miles per hour (mph)). It has an observation tower that is 21.5 m (71 ft) above sea level providing protected species observers an unobstructed view around the entire vessel.

Transit: The *Langseth* would depart from New York and transit for approximately eight hours to the proposed survey area. Setup, deployment, and streamer ballasting would occur over approximately three days. At the end of the survey, the *Langseth* would return to New Jersey**.**

Transects: The proposed survey would cover approximately 4,900 km (3,045 mi) of transect lines within a 12 by 50 km (7.5 by 31 mi) area. Each transect line would have a spacing interval of 150 m (492 ft) in two 6-m (19.7-ft) wide race-track patterns.

Seismic Airguns: During the survey, the *Langseth* would deploy two pairs of subarrays of four or eight airguns as an energy source. The airguns are a mixture of Bolt 1500LL and Bolt 1900LLX airguns ranging in size from 40 to 220 cubic inches (in^3), with a firing pressure of 1,950 pounds per square inch. The dominant frequency components range from zero to 188 Hertz (Hz). The nominal source levels of the airgun subarrays on the *Langseth* range from 246 to 253 dB re: 1 μPa (peak-to-peak). The subarrays would fire alternately, with a total volume of either approximately 700 cubic inches (in^3) or 1,400 in^3. In either configuration, the source volume would not exceed 700 in^3 (i.e., the four-string subarray) or 1,400 in^3 (i.e., the eight-string subarray) at any time during acquisition. The *Langseth* would tow each subarray at a depth of either 4.5 or 6 m (14.8 or 19.7 ft) resulting in a shot interval of approximately 5.4 seconds (12.5 m; 41 ft). During acquisition the airguns will emit a brief (approximately 0.1 second) pulse of sound. During the intervening periods of operations, the airguns are silent.

Hydrophones: The receiving system would consist of four 3,000-m (1.9-mi) hydrophone streamers with a spacing interval of 75 m (246 ft) between each streamer. As the *Langseth* tows the airgun subarrays along the survey lines, the hydrophone streamers would receive the returning acoustic signals and transfer the data to the on-board processing system.

Multibeam Echosounder: The *Langseth* will operate a Kongsberg EM 122 multibeam echosounder concurrently during airgun operations to map characteristics of the ocean floor. The hull-mounted echosounder emits brief pulses of sound (also called a ping) (10.5 to 13.0 kilohertz (kHz) in a fan-shaped beam that extends downward and to the sides of the ship. The nominal source level for the multibeam echosounder is 242 dB re: 1 μPa.

Sub-bottom Profiler: The *Langseth* will also operate a Knudsen Chirp 3260 sub-bottom profiler concurrently during airgun and echosounder operations to provide information about the sedimentary features and bottom topography. The hull-mounted profiler emits a ping with a dominant frequency component at 3.5 kHz. The nominal source level for the profiler is 204 dB re: 1 μPa.

Acoustic Doppler Current Profiler: The Observatory would measure currents using a Teledyne OS75 75-kilohertz (kHz) acoustic Doppler current profiler (ADCP). The ADCP's configuration consists of a 4-beam phased array with a beam angle of 30°. The source level is proprietary information but has a maximum acoustic source level of 224 dB re: 1 μPa.

Support Vessel: The Observatory would use a support vessel to prevent the *Langseth's* streamer entangling with fixed fishing gear. The vessel would be a multi-purpose offshore utility vessel similar to the *Northstar Commander*, which is 28 m (91.9 ft) long with a beam of 8 m (26.2 ft) and a draft of 2.6 m (8.5 ft).

2.2.2 APPROACH TO DEVELOPING MITIGATION EXCLUSION ZONES

The Observatory's application (LGL, 2013) and Appendix A in the Foundation's draft EA (NSF, 2014), describe the approach to establishing mitigation exclusion zones in detail. We incorporate those descriptions by reference in this EA and briefly summarize them here.

In summary, the Observatory acquired sound propagation measurements for several array configurations at shallow- and deep-water depths during acoustic verification studies conducted in the northern Gulf of Mexico in 2003 (Tolstoy et al., 2004) and in 2007 and 2008 (Tolstoy et al., 2009). Based on the empirical data from those studies, the Observatory developed a sound propagation modeling approach[2] that conservatively predicts received sound levels as a function of distance from a particular airgun array configuration in deep water (Diebold et al., 2010).

In 2010, the Observatory assessed the accuracy of their modeling approach by comparing the sound levels of the field measurements in the Gulf of Mexico study to their model predictions (Diebold, et al., 2010). They reported that the observed sound levels from the field measurements fell almost entirely below the predicted mitigation radii curve for deep water (Diebold, et al., 2010). Based on this information, the Observatory has shown that their model can reliably estimate mitigation radii in deep water. We acknowledge that the Observatory based their

[2] The modeling approach uses ray tracing (*i.e.*, a graphical representation of the effects of refracting sound waves) for the direct wave traveling from the array to the receiver and its associated source ghost (reflection at the air-water interface in the vicinity of the array), in a constant-velocity half-space (infinite homogeneous ocean layer, unbounded by a seafloor).

modeling approach on the environmental variability present in the Gulf of Mexico, but the model has limited ability to capture the variability resulting from site-specific factors present in the marine environment offshore New Jersey.

The Observatory used a similar process to develop mitigation radii (i.e., exclusion and buffer zones) for a shallow-water seismic survey in the northeast Pacific Ocean offshore Washington in 2012. The Observatory conducted the shallow-water survey using an airgun configuration that was approximately 78 or 89 percent larger than the total discharge volumes proposed for this shallow-water survey (i.e., 6,600 in^3) compared to 700 in^3 or 1,400 in^3) and recorded the received sound levels on the shelf and slope off Washington using the Langseth's 8-km hydrophone streamer. Crone et al. (2013) analyzed those received sound levels from the 2012 survey and reported that the actual distances for the exclusion and buffer zones were two to three times smaller than what the Observatory's modeling approach predicted. While the results confirm bathymetry's role in sound propagation, Crone et al. (2013) were able to confirm that the empirical measurements from the Gulf of Mexico calibration survey (the same measurements used to inform the Observatory's modeling approach for this survey in shallow water) overestimated the size of the exclusion and buffer zones for the shallow-water 2012 survey off Washington and were thus precautionary, in that particular case, for effecting the least practicable impact marine mammals.

Following is a brief summary of the process used to predict the mitigation exclusion zones (Tables 5a and 5b) for the proposed study.

1. For an 18-gun, 3,300-in^3 array towed at a depth of 6 m (19.6 ft), the model predicted that the 160-, 180-, and 190-dB isopleths would result in radii (*i.e*., exclusion zones) of 4,500, 450, and 142 m (2.8, 0.3, and 0.1 mi) respectively, in deep water (Figure A3 in Appendix A of the Foundation's EA). The empirical data for the airgun configurations indicated that, for deep water, the Observatory's modeling approach overestimates the received sound levels at a given distance and is thus precautionary (Diebold, et al., 2010; Tolstoy, et al., 2009).
2. Using the modeling approach, the Observatory modeled the exclusion zones for the proposed suite of array configurations for this study in deep water (Figures A4-A8 in Appendix A of the Foundation's EA).
3. The Gulf of Mexico calibration study did not obtain measurements for the smaller array (i.e., 700 or 1,400 in^3) proposed for use in this survey. To account for this difference, the Observatory developed a scaling factor to extrapolate exclusion zones for the proposed study (NSF, 2014).
4. The Observatory calculated the ratios (*i.e*., scaling factors) between the model's deep-water exclusion zones for the 18-gun, 3,300-in^3 array and the model's deep-water exclusion zones for the study's various airgun configurations. This is an appropriate comparison of the sound exposure level outputs between two different types of airgun configurations.
5. To calculate the exclusion zones for the study's various array configurations in shallow water, the Observatory multiplied the scaling factors by the empirically-derived shallow water exclusion zones reported for an 18-gun, 3,300-in^3 array in the Gulf of Mexico (Diebold, et al., 2010). These empirically-derived exclusion zones from the Gulf of Mexico are approximately three times larger than the exclusion zones modeled for the 18-gun 3,300-in^3 array in deep water.

In summary, the Observatory used the ratio of the size of safety zones of a large airgun in deep water compared to this airgun array in deep water to determine the size of the safety zone for this airgun in shallow water, given the known zone for the same large airgun in shallow water. We believe that this is a rational method for best using the available information to estimate the safety zones.

The comparisons of the Observatory's model results and the field data collected in the Gulf of Mexico and Washington illustrate a degree of conservativeness built into the Observatory's model for deep water, which would be expected to offset some of the limited ability of the model to capture the variability resulting from site-specific factors, especially in shallow water. However, in the interest of additional protection, we have required more conservative and precautionary mitigation and monitoring measures within this Authorization. Following our consideration of those conservative factors, we have included an additional layer of conservativeness by increasing the 180-dB and 190-dB exclusion zones for this survey by a factor of 50 percent (approximately a 3-dB difference) to be precautionary and to account for sound levels falling well below the estimated radii. Thus, enlarging the exclusion zone should be able to account for any environmental variability within the study area in addition to the other conservative factors that we have considered in estimating the exclusion zones.

Table 5a in this EA shows the original predicted distances and Table 5b shows the revised distances.

Table 5a – Original modeled exclusion zones (EZ) for marine mammals in the survey area.

Source and Volume (in^3)	Tow Depth (m)	Water Depth (m)	Predicted RMS Distances[1] (m)		
			190 dB	180 dB	160 dB
Single Bolt airgun (40 in^3)	6	< 100	21	100	995
4-Airgun subarray (700 in^3)	4.5	< 100	101	378	5,240
4-Airgun subarray (700 in^3)	6	< 100	118	439	6,100
8-Airgun subarray (1,400 in^3)	4.5	< 100	128	478	6,670
8-Airgun subarray (1,400 in^3)	6	< 100	157	585	8,150

[1] Predicted distances based on Table 1 of the Foundation's EA (NSF, 2014).

Table 5b – Revised modeled exclusion zones (EZ) for marine mammals in the survey area.

Source and Volume (in^3)	Tow Depth (m)	Water Depth (m)	Predicted RMS Distances[1] (m)		
			187 dB	177 dB	160 dB
Single Bolt airgun (40 in^3)	6	< 100	31	109	995
4-Airgun subarray (700 in^3)	4.5	< 100	151	561	5,240
4-Airgun subarray (700 in^3)	6	< 100	175	651	6,100
8-Airgun subarray (1,400 in^3)	4.5	< 100	190	709	6,670
8-Airgun subarray (1,400 in^3)	6	< 100	234	886	8,150

[1] Predicted distances based on information submitted by the Observatory on June 27, 2014.

2.3 Description of Alternatives

2.3.1 Alternative 1 – Issuance of an Authorization with Mitigation Measures

The Proposed Action constitutes Alternative 1 and is the Preferred Alternative. Under this alternative, we would issue an Authorization (valid from June through August 2014) to the Observatory allowing the incidental take, by Level B harassment, of 27 species of marine mammals subject to the mandatory mitigation and monitoring measures and reporting requirements set forth in the proposed Authorization, along with any additions based on consideration of public comments.

Mitigation Measures

As described in Section 1.2.1, we must prescribe the means of effecting the least practicable adverse impact on the species or stocks of marine mammals and their habitat. In order to do so, we must consider the Observatory's proposed mitigation measures, as well as other potential measures, and assess how such measures could benefit the affected species or stocks and their habitat. Our evaluation of potential measures includes consideration of the following factors in relation to one another: (1) the manner in which, and the degree to which, we expect the successful implementation of the measure to minimize adverse impacts to marine mammals; (2) the proven or likely efficacy of the specific measure to minimize adverse impacts as planned; and (3) the practicability of the measure for applicant implementation.

Any additional mitigation measure proposed by us beyond what the applicant proposes should be able to or have a reasonable likelihood of accomplishing or contributing to the accomplishment of one or more of the following goals:

- Avoidance or minimization of marine mammal injury, serious injury, or death wherever possible;
- A reduction in the numbers of marine mammals taken (total number or number at biologically important time or location);
- A reduction in the number of times the activity takes individual marine mammals (total number or number at biologically important time or location);
- A reduction in the intensity of the anticipated takes (either total number or number at biologically important time or location);
- Avoidance or minimization of adverse effects to marine mammal habitat, paying special attention to the food base; activities that block or limit passage to or from biologically important areas; permanent destruction of habitat; or temporary destruction/disturbance of habitat during a biologically important time; and
- For monitoring directly related to mitigation, an increase in the probability of detecting marine mammals, thus allowing for more effective implementation of the mitigation.

To reduce the potential for disturbance from acoustic stimuli associated with the activities, the Observatory has agreed to implement the following monitoring and mitigation measures for marine mammals. These include:

1) Utilize NMFS-qualified, vessel-based Protected Species Observers (PSOs) to visually watch for and monitor marine mammals near the seismic source vessel during daytime operations (from nautical twilight-dawn to nautical twilight-dusk) and before and during start-ups of sound sources day or night. Two PSOs would observe the exclusion and disturbance zones.

When practicable, as an additional means of visual observation, the *Langseth's* vessel crew may also assist in detecting marine mammals.

2) Establish a 177 dB re: 1 µPa and 187 dB re: 1 µPa exclusion zone (EZ) for marine mammals before the full array (either 700 or 1,400 in^3) or a single airgun (40 in^3) is in operation (Table 4).

3) Visually observe the entire extent of the EZ (177 dB re: 1 µPa for cetaceans and 187 dB re: 1 µPa for pinnipeds) using NMFS-qualified PSOs, for at least 30 minutes (min) prior to starting the airgun array (day or night).

4) Implement a ramp-up procedure when initiating the seismic operations or any time after the entire array has been shut down for more than 8 minutes, which means start the smallest sound source first and add sound sources in a sequence such that the source level of the array shall increase in steps not exceeding approximately 6 dB per 5-minute period. During ramp-up, the PSOs shall monitor the EZ, and if they sight marine mammals, they shall implement a power-down or shutdown as though the full array were operational. Therefore, initiation of ramp-up procedures from shutdown requires that the PSOs be able to visually observe the full EZ described in Measures 2 and 3.

5) Power-down or shutdown the sound source(s) if a PSO detects a marine mammal that is within, approaches, or enters the applicable EZ. A shutdown means that the crew shuts down all operating sound sources (i.e., turned off). A power-down means reducing the number of operating sound sources to a single operating 40 in^3 airgun, which reduces the EZ to the degree that the animal(s) is no longer within or about to enter it.

6) The shot interval for the single operating 40 in^3 airgun should be set to one shot per minute.

7) Following a power-down, the *Langseth* crew would not resume full airgun activity until the marine mammal has cleared the 177- or 187-dB exclusion zone. The observers would consider the animal to have cleared the exclusion zone if:
   a. the observer has visually observed the animal leave the exclusion zone; or
   b. an observer has not sighted the animal within the exclusion zone for 15 minutes for species with shorter dive durations (*i.e.*, small odontocetes or pinnipeds), or 30 minutes for species with longer dive durations (*i.e.*, mysticetes and large odontocetes, including sperm, pygmy sperm, dwarf sperm, and beaked whales).

8) Following a power-down, the *Langseth* crew would resume operating the airguns at full power after 15 minutes of sighting any species with short dive durations (*i.e.*, small odontocetes or pinnipeds). Likewise, the crew would resume airgun operations at full power after 30 minutes of sighting any species with longer dive durations (*i.e.*, mysticetes and large odontocetes, including sperm, pygmy sperm, dwarf sperm, and beaked whales).

9) Considering the conservation status of North Atlantic right whales, the *Langseth* crew will be required to shut down the airgun(s) immediately in the unlikely event that observers detect this species, regardless of the distance from the vessel. The *Langseth* would only begin ramp-up if observers have not seen a North Atlantic right whale for 30 minutes.

10) Following a shutdown for more than 8 minutes and subsequent animal departure, survey operations may resume following ramp-up procedures described in Measure 4.

11) The seismic survey may continue into night and low-light hours if such segment(s) of the survey is initiated when the entire applicable EZs can be effectively monitored visually (*i.e.*, PSO(s) must be able to see the extent of the entire applicable EZ).

12) No initiation of survey operations involving the use of sound sources is permitted from a shutdown position at night or during low-light hours (such as in dense fog or heavy rain) unless at least one airgun (40-in^3 or similar) has been operating during the interruption of seismic survey operations. Given these provisions, it is likely that the vessel's crew would not ramp up the airgun array from a complete shutdown at night or in thick fog, because the outer part of the EZ would not be visible during those conditions.

13) Alter speed or course during seismic operations if a marine mammal, based on its position and relative motion, appears likely to enter the relevant EZ. If speed or course alteration is not safe or practicable, or if after implementing an alteration the marine mammal still appears likely to enter the EZ, further mitigation measures, such as a power-down or shutdown, shall be taken.

MONITORING MEASURES

The Observatory proposes to sponsor marine mammal monitoring during the present project, in order to implement the mitigation measures that require real-time monitoring and to satisfy the monitoring requirements of the Authorization. The Observatory understands that we would review the monitoring plan and may require refinements to the plan.

The Authorization would require the Observatory to use a passive acoustic monitoring (PAM) system, to the maximum extent practicable, to detect, and allow some localization of marine mammals around the *Langseth* during all airgun operations and during most periods when airguns are not operating. When the PAM operator detects an animal, he/she must notify the PSO immediately of a vocalizing marine mammal so the *Langseth* crew can initiate a power-down or shut-down, if required.

REPORTING MEASURES

The Observatory would submit a report to us and the Foundation within 90 days after the end of the cruise. The report would describe the operations conducted and sightings of marine mammals near the operations. The report would provide full documentation of methods, results, and interpretation pertaining to all monitoring. The report must contain and summarize the following information:

1) Dates, times, locations, heading, speed, weather, sea conditions (including Beaufort sea state and wind force), and associated activities during all seismic operations and marine mammal sightings;
2) Species, number, location, distance from the vessel, and behavior of any marine mammals, as well as associated seismic activity (number of power-downs and shutdowns), observed throughout all monitoring activities;
3) An estimate of the number (by species) of: (A) pinnipeds that have been exposed to the seismic activity (based on visual observation) at received levels greater than or equal to 160 dB re: 1 µPa and/or 187 dB re: 1 µPa with a discussion of any specific behaviors those individuals exhibited; and (B) cetaceans that have been exposed to the seismic activity (based on visual observation) at received levels greater than or equal to 160 dB re: 1 µPa and/or 177 dB re: 1 µPa with a discussion of any specific behaviors those individuals exhibited.
4) A description of the implementation and effectiveness of the: (A) terms and conditions of the Biological Opinion's Incidental Take Statement (ITS); and (B) mitigation measures required by our Authorization. For the Biological Opinion, the report shall confirm implementation of each Term and Condition, as well as any conservation recommendations, and describe their

effectiveness, for minimizing the adverse effects of the action on ESA-listed marine mammals.

In the unanticipated event that the specified activity clearly causes the take of a marine mammal in a manner prohibited by the Authorization, such as an injury (Level A harassment), serious injury, or mortality (*e.g*., ship-strike, gear interaction, and/or entanglement), the Observatory shall immediately cease the specified activities and immediately report the incident to the Chief of the Permits and Conservation Division, Office of Protected Resources, NMFS, her designees, and the Northeast Regional Stranding Coordinator. The Observatory may not resume activities until we are able to review the circumstances of the prohibited take. The report must include the following information:

1) Time, date, and location (latitude/longitude) of the incident;
2) The *Langseth's* speed during and leading up to the incident;
3) Description of the incident;
4) Status of all sound source use in the 24 hours preceding the incident;
5) Water depth;
6) Environmental conditions (e.g., wind speed and direction, Beaufort sea state, cloud cover, and visibility);
7) A description of marine mammal observations in the 24 hours preceding the incident;
8) Species identification or description of the animal(s) involved;
9) The fate of the animal(s); and
10) Photographs or video footage of the animal (if equipment is available).

In the event that the Observatory discovers an injured or dead marine mammal, and the PSO determines that the cause of the injury or death is unknown and the death is relatively recent (*i.e*., in less than a moderate state of decomposition as we describe in the next paragraph), the Observatory will immediately report the incident to the Incidental Take Program Supervisor, Permits and Conservation Division, Office of Protected Resources, NMFS, her designees, and the Northeast Regional Stranding Coordinator. The report must include the same information identified in the paragraph above this section. Activities may continue while we review the circumstances of the incident. We would work with the Observatory to determine whether modifications in the activities are appropriate.

In the event that the Observatory discovers an injured or dead marine mammal, and the lead visual observer determines that the injury or death is not associated with or related to the authorized activities (e.g., previously wounded animal, carcass with moderate to advanced decomposition, or scavenger damage), the Observatory would report the incident to the Incidental Take Program Supervisor, Permits and Conservation Division, Office of Protected Resources, NMFS, her designees, and the and the Northeast Regional Stranding Coordinator within 24 hours of the discovery. The Observatory would provide photographs or video footage (if available) or other documentation of the stranded animal sighting to NMFS. Activities may continue while we review the circumstances of the incident.

TAKE ESTIMATES

The Observatory modeled the number of different individuals that could be exposed to airgun sounds with received levels greater than or equal to 160 dB re: 1 μPa on one or more occasions by multiplying the total marine area that would be within the 160-dB radius around the operating seismic source on at least one occasion (2,502 km^2 which includes a 25 percent contingency factor to account for repeated tracklines), along with the expected density of animals in the area. NSF acknowledged in their application that this approach does not allow for turnover in the mammal populations in the area during the course of the survey as the actual number of individuals exposed may be underestimated because it does not account for new animals entering or passing through the ensonification area (LGL, 2013; NSF, 2014), however, the Observatory suggested that the 25% contingency factor would cover any potential underestimate of individuals.

Based on public comments received on the *Federal Register* notice of proposed Authorization, we re-evaluated the mitigation and monitoring proposed for incorporation in the Authorization. NMFS determined—based on the best available information—that the revised mitigation measures (which include larger exclusion zones) and revised take estimates are presently the most feasible and effective measures for implementation (Wright, 2014). Thus, this Preferred Alternative would satisfy the purpose and need of our proposed action under the MMPA–issuance of an Authorization, along with required mitigation measures and monitoring that meets the standards set forth in section 101(a)(5)(D) of the MMPA and the implementing regulations.

2.3.2 ALTERNATIVE 2 – NO ACTION ALTERNATIVE

Under the No Action Alternative, the Observatory could choose not to proceed with their proposed activities or to proceed without an Authorization. If they choose the latter, the Observatory would not be exempt from the MMPA take prohibitions and would be in violation of the MMPA if take of marine mammals occurs.

For purposes of this EA, we characterize the No Action Alternative as the Observatory not receiving an Authorization and the Observatory conducting the 3-D seismic survey program without the protective measures and reporting requirements required by an Authorization under the MMPA. We take this approach to meaningfully evaluate the primary environmental issues—the impact on marine mammals from these activities in the absence of protective measures.

2.3.3 ALTERNATIVE 3 – ISSUANCE OF AUTHORIZATION WITH ADDITIONAL MITIGATION MEASURES

Under Alternative 3, we would issue an Authorization to the Observatory, allowing the incidental take by Level B harassment only of small numbers of marine mammal species incidental to conducting seismic survey activities in the Atlantic Ocean during the effective period of the Authorization. Alternative 3 would consist of all of the mitigation, monitoring, and reporting measures contained in Alternative 1, including the following additional measures derived from the public comment process on our notice of the proposed Authorization.

(1) **Alternate Survey Timing:** This measure would require the Observatory to postpone their research after the summer season to minimize interactions with marine life.

(2) **Operational Restrictions**: This measure would require the Observatory to suspend their activities in low-light/nighttime conditions and minimize the number of repeated tracklines for the survey.

(3) **Augmented Monitoring**: This measure would require the use of alternative technologies (e.g., night vision devices) to detect marine mammals beyond the proposed visual and acoustic monitoring.

2.4 ALTERNATIVES CONSIDERED BUT ELIMINATED FROM FURTHER CONSIDERATION

We considered whether other alternatives could meet the purpose and need and support the Observatory's activities. We considered an alternative that would allow for the issuance of an Authorization with no required mitigation or monitoring but eliminated that Alternative from consideration, as it would not be in compliance with the MMPA and therefore would not meet the purpose and need. For that reason, we do not analyze this alternative further in this document.

CHAPTER 3 – AFFECTED ENVIRONMENT

This chapter describes existing conditions in proposed survey area. Descriptions of the physical and biological environment of the action area are contained in the documents incorporated by reference (see section 1.3.1) and summarized here.

3.1 PHYSICAL ENVIRONMENT

As discussed in Chapter 1, our proposed action and alternatives relate only to the proposed issuance of our Authorization of incidental take of marine mammals and not to the physical environment. Certain aspects of the physical environment are not relevant to our proposed action (see section 1.3.2 - Scope of Environmental Analysis). Because of the requirements of NAO 216.6, however, we briefly summarize the physical components of the environment here.

In summary, the New Jersey shelf lies between the Hudson and the Delaware shelf valleys from 38°40' to 40°30'N and 72°30' to 74°40'W and covers a 25,000-square kilometer (km^2) (9,653-square mile (mi^2)) area. The shelf ranges from 120 to 150 km (75 to 93 mi) in width, sloping to the east and becomes steeper where the shelf break begins at the 120- and 160-m (394- to 525-ft) isobath (Carey et al., 1998). The bottom type of the shelf is categorized as soft, consisting of sandy to muddy-sandy bottom substrate (Navy, 2013).

3.1.1 MARINE MAMMAL HABITAT

We presented information on marine mammal habitat and the potential impacts to marine mammal habitat in our notice of the proposed Authorization. Also, the Foundation presented more detailed information on the physical and oceanographic aspects of the New Jersey environment in their draft EA (NSF, 2014). In summary, the marine mammals in the survey area use the nearshore, shelf, shelf break, and continental slope waters, but may have differing habitat preferences based on their life history functions (NJDEP, 2010).

3.2 BIOLOGICAL ENVIRONMENT

3.2.1 MARINE MAMMALS

We provide information on the occurrence of marine mammals with possible or confirmed occurrence in the survey area in section 1.1.2 of this EA (Tables 1a, b, and c). The marine mammals most likely to be present in the action area are in Table 6. This includes 6 mysticetes, 18 odontocetes, and 3 pinniped species under our jurisdiction.

The *Federal Register* notice on the proposed Authorization provided information on the stock, regulatory status, abundance, occurrence, seasonality, and hearing ability of the marine mammals in the action area. The Observatory's application and the Foundation's EA also provided distribution, life history, and population size information for marine mammals within the action area. We incorporate those descriptions by reference and briefly summarize the information in Tables 6 and 7.

Table 6 – Marine mammals most likely to be harassed incidental to the Observatory's survey.

Species	Stock Name	Regulatory Status[1, 2]	Abundance[3]	Occurrence and Range	Season
North Atlantic right whale	Western Atlantic	MMPA - D ESA – EN	455	common coastal/shelf	year-round[4]
Humpback whale	Gulf of Maine	MMPA - D ESA – EN	823	common coastal	spring - fall
Common minke whale	Canadian East Coast	MMPA - D ESA – NL	20,741	rare coastal/shelf	spring - summer
Sei whale	Nova Scotia	MMPA - D ESA – EN	357	uncommon shelf edge	spring
Fin whale	Western North Atlantic	MMPA - D ESA – EN	3,522	common pelagic	year-round
Blue whale	Western North Atlantic	MMPA - D ESA – EN	440	uncommon coastal/pelagic	occasional
Sperm whale	Nova Scotia	MMPA - D ESA – EN	2,288	common pelagic	year-round
Dwarf sperm whale	Western North Atlantic	MMPA - NC ESA – NL	1,783	uncommon shelf	year-round
Pygmy sperm whale	Western North Atlantic	MMPA - NC ESA – NL	1,783	uncommon shelf	year-round
Blainville's beaked whale	Western North Atlantic	MMPA - NC ESA – NL	7,092	uncommon shelf/pelagic	spring - summer
Cuvier's beaked whale	Western North Atlantic	MMPA - NC ESA – NL	6,532	uncommon shelf/pelagic	spring - summer
Gervais' beaked whale	Western North Atlantic	MMPA - NC ESA – NL	7,092	uncommon shelf/pelagic	spring - summer
Sowerby's beaked whale	Western North Atlantic	MMPA - NC ESA – NL	7,092	uncommon shelf/pelagic	spring - summer
True's beaked whale	Western North Atlantic	MMPA - NC ESA – NL	7,092	uncommon shelf/pelagic	spring - summer
Northern bottlenose whale	Western North Atlantic	MMPA - NC ESA – NL	unknown	rare pelagic	unknown
Bottlenose dolphin	Western North Atlantic Offshore	MMPA - NC ESA – NL	77,532	common pelagic	spring - summer
	Western North Atlantic Northern Migratory Coastal	MMPA - D ESA – NL	11,548	common coastal	summer
Atlantic spotted dolphin	Western North Atlantic	MMPA - NC ESA – NL	44,715	common coastal	summer - fall
Striped dolphin	Western North Atlantic	MMPA - NC ESA – NL	54,807	uncommon shelf	summer
Short-beaked common dolphin	Western North Atlantic	MMPA - NC ESA – NL	173,486	common shelf/pelagic	summer - fall
Atlantic white-sided-dolphin	Western North Atlantic	MMPA - NC ESA – NL	48,819	uncommon shelf/slope	summer - winter
Risso's dolphin	Western North Atlantic	MMPA - NC ESA – NL	18,250	common shelf/slope	year-round
Long-finned pilot whale	Western North Atlantic	MMPA - NC ESA – NL	26,535	uncommon shelf/pelagic	summer
Short-finned pilot whale	Western North Atlantic	MMPA - NC ESA – NL	21,515	uncommon shelf/pelagic	summer

Table 6 (cont.) – Marine mammals most likely to be harassed incidental to the Observatory's survey.

Species	Stock Name	Regulatory Status[1, 2]	Abundance[3]	Occurrence and Range	Season
Harbor porpoise	Gulf of Maine/Bay of Fundy	MMPA - NC ESA – NL	79,833	common coastal	year-round
Gray seal	Western North Atlantic	MMPA - NC ESA – NL	331,000	common coastal	fall - spring
Harbor seal	Western North Atlantic	MMPA - NC ESA – NL	70,142	common coastal	fall - spring
Harp seal	Western North Atlantic	MMPA - NC ESA – NL	7,100,000	rare, pack ice	Jan - May

[1] MMPA: D = Depleted, S = Strategic, NC = Not Classified.
[2] ESA: EN = Endangered, T = Threatened, DL = Delisted, NL = Not listed.
[3] 2013 NMFS Stock Assessment Report (Waring et al., 2014).
[4] Seasonality based on Whitt et al., 2013.

Table 7 – Classification of marine mammals that could potentially occur in the proposed activity area in May through August, 2014 by functional hearing group (Southall et. al., 2007).

Low Frequency Hearing Range	North Atlantic right, humpback, common minke, sei, fin, and blue whale
Mid-Frequency Hearing Range	Sperm whale, Blainville's beaked whale, Cuvier's beaked whale, Gervais' beaked whale, Sowerby's beaked whale, True's beaked whale, northern bottlenose whale, bottlenose dolphin, Atlantic spotted dolphin, spinner dolphin, striped dolphin, short-beaked common dolphin, Atlantic white-sided-dolphin, Risso's dolphin, long-finned pilot whale, short-finned pilot whale
High Frequency Hearing Range	Dwarf sperm whale, pygmy sperm whale, harbor porpoise
Pinnipeds in Water Hearing Range	Gray seal, harbor seal, harp seal

Pinnipeds: For the proposed Authorization, we considered authorizing take for pinnipeds based upon the best available density information (Navy, 2007) and other anecdotal sources (MMSC, 2014). This section includes a brief summary on life history information for gray, harp, and harbor seals.

Harbor Seals: Harbor seals are part of the "true seal" family, *Phocidae*. True seals lack external ear flaps and have short forelimbs that result in limited locomotion on land. Harbor seals typically inhabit temperate coastal habitats and use rocks, reefs, beaches, and drifting glacial ice as haul outs and pupping sites (Waring et al., 2014). On the east coast, they range from the Canadian Arctic to southern New England, New York, and occasionally the Carolinas (Waring et al., 2010). There are three well known, long-term haul out sites in New Jersey: Sandy Hook, Barnegat Inlet, and Great Bay (NJDEP, 2010). The best estimate of abundance for harbor seals is 70,142 (CV=0.29) with a minimum population estimate of 55,409 based on corrected available counts along the Maine coast in 2012 (Waring, et al., 2014). Harbor seals eat a variety of prey consisting mainly of fish, shellfish, and crustaceans. Researchers have found that seals complete both shallow and deep dives during hunting depending on the availability of prey (Tollit et al., 1997).

Gray Seals: Gray seals, also from the Phocid family, inhabit coastal waters and typically haul out on rocky coasts and islands, sandbars, ice shelves, and icebergs. The best abundance estimate for the Western North Atlantic stock is 331,000 (Hammill et al., 2012, in prep.). Gray seal abundance is likely increasing in the U.S. Atlantic Exclusive Economic Zone (EEZ), but the rate of increase is unknown (Waring, et al., 2014). Gray seals are opportunistic feeders that consume between 4-6% of their body weight per day. Food sources include fish, crustaceans, squid, octopus, and even seabirds on occasion.

Harp Seals: The harp seal has a widespread distribution in the Arctic and in cold waters of the North Atlantic (Jefferson et al. 2008). It is the most abundant seal in the North Atlantic, with most seals aggregating off the east coast of Newfoundland and Labrador to pup and breed; the remainder congregates in the Gulf of St. Lawrence (Lavigne & Kovacs, 1988). These seals are highly migratory (Stenson & Sjare, 1997) and the southern limit of their habitat extends into the U.S. Atlantic Exclusive Economic Zone during winter and spring (Waring, et al., 2014). The best estimate of abundance for harp seals is 7.1 million (Hammill et al., 2012, in prep.). Jefferson et al. (2008) indicate that vagrant harp seals reach as far south as New York. Sightings of harp seals off the U.S. east coast, from Maine to New Jersey, are rare but have been increasing in recent years, particularly from January to May (Harris & Gupta, 2006). Harp seals are modest divers by pinniped standards. The average maximum dive is to about 1,200 feet (370 m), lasting approximately 16 minutes. They eat a variety of fish and invertebrates, but mainly focus on smaller fish such as capelin, arctic and polar cod, and invertebrates including krill.

CHAPTER 4 – ENVIRONMENTAL CONSEQUENCES

This chapter of the EA includes a discussion of the impacts of the three alternatives on the human environment. The Observatory's application, our notice of a proposed Authorization, and other related environmental analyses identified previously, inform our analysis of the direct, indirect, and cumulative effects of our proposed issuance of an Authorization.

Under the MMPA, we have evaluated the potential impacts of the Observatory's seismic survey activities in order to determine whether to authorize incidental take of marine mammals. Under NEPA, we have determined that an EA is appropriate to evaluate the potential significance of environmental impacts resulting from the issuance of our Authorization.

4.1 EFFECTS OF ALTERNATIVE 1 – ISSUANCE OF AN AUTHORIZATION WITH MITIGATION MEASURES

Alternative 1 is the Preferred Alternative where we would issue an Authorization to the Observatory allowing the incidental take, by Level B harassment, of 27 species of marine mammals from June through August 2014, subject to the mandatory mitigation and monitoring measures and reporting requirements set forth in the Authorization, if issued.

4.1.1 IMPACTS TO MARINE MAMMAL HABITAT

Our proposed action would have no additive or incremental effect on the physical environment beyond those resulting from the proposed activities. The Observatory's proposed seismic survey is not located within a marine sanctuary, wildlife refuge, a National Park, or other conservation area. The proposed activity— which uses one seismic source vessel—would minimally add to vessel traffic in the region and would not result in substantial damage to ocean and coastal habitats that might constitute marine mammal habitats. Finally, the Authorization would not impact physical habitat features, such as substrates and/or water quality.

Prey: In examining impacts to fish as prey species for marine mammals, we expect fish to exhibit a range of behaviors including no reaction or habituation (Peña et al., 2013) to startle responses and/or avoidance (Fewtrell & McCauley, 2012). We expect that the seismic survey would have no more than a temporary and minimal adverse effect on any fish or invertebrate species. Although there is a potential for injury to fish or marine life in close proximity to the vessel, we expect that the impacts of the seismic survey on fish and other marine life specifically related to acoustic activities would be temporary in nature, negligible, and would not result in substantial impact to these species or to their role in the ecosystem.

4.1.2 IMPACTS TO MARINE MAMMALS

We expect that the Observatory's 3-D seismic survey has the potential to take marine mammals by Level B harassment, as defined by the MMPA. Acoustic stimuli generated by the airgun arrays (and to a lesser extent the multibeam echosounder, sub-bottom profiler, and acoustic Doppler current profiler) may affect marine mammals in one or more of the following ways: behavioral disturbance, tolerance, masking of natural sounds, and temporary or permanent hearing impairment, or non-auditory physical effects (Richardson et al., 1995).

Our *Federal Register* notice of proposed Authorization, the Observatory's application (LGL, 2013), and the Foundation's EA on this action (NSF, 2014) provide detailed descriptions of these potential effects of seismic surveys on marine mammals. We incorporate those discussions by reference here and summarize our consideration of additional studies submitted during the public comment period in the following sections.

The effects of noise on marine mammals are highly variable, ranging from minor and negligible to potentially significant, depending on the intensity of the source, the distances between the animal and the source, and the overlap of the source frequency with the animals' audible frequency. Nevertheless, monitoring and mitigation measures required by us for the Observatory's proposed activities will effectively reduce any significant adverse effects of these sound sources on marine mammals.

Behavioral Disturbance: The studies discussed in the *Federal Register* notice for the proposed Authorization note that there is variability in the behavioral responses of marine mammals to noise exposure. However, it is important to consider the context in predicting and observing the level and type of behavioral response to anthropogenic signals (Ellison et al., 2012).

Marine mammals may react to sound when exposed to anthropogenic noise. These behavioral reactions are often shown as: changing durations of surfacing and dives, number of blows per surfacing, or moving direction and/or speed; reduced/increased vocal activities; changing/cessation of certain behavioral activities (such as socializing or feeding); visible startle response or aggressive behavior (such as tail/fluke slapping or jaw clapping); avoidance of areas where noise sources are located; and/or flight responses (e.g., pinnipeds flushing into water from haul-outs or rookeries). The onset of behavioral disturbance from anthropogenic noise depends on both external factors (characteristics of noise sources and their paths) and the receiving animals (hearing, motivation, experience, demography) and is also difficult to predict (Richardson, et al., 1995; Southall et al., 2007).

Studies have shown that underwater sounds from seismic activities are often readily detectable by marine mammals in the water at distances of many kilometers (Castellote et al., 2012). Many studies have also shown that marine mammals at distances more than a few kilometers away often show no apparent response when exposed to seismic activities (e.g., Akamatsu et al., 1993; Harris et al., 2001; Madsen & Møhl, 2000; Malme et al., 1983, 1984; Richardson et al., 1986; Weir, 2008). Other studies have shown that marine mammals continue important behaviors in the presence of seismic pulses (e.g., Dunn & Hernandez, 2009; Greene Jr. et al., 1999; Holst & Beland, 2010; Holst & Smultea, 2008; Holst et al., 2005; Nieukirk et al., 2004; Richardson, et al., 1986; Smultea et al., 2004).

In a passive acoustic research program that mapped the soundscape in the North Atlantic Ocean, Clark and Gagnon (2006) reported that some fin whales stopped singing for an extended period starting soon after the onset of a seismic survey in the area. The study did not provide information on received levels or distance from the sound source. The authors could not determine whether or not the whales left the area ensonified by the survey, but the evidence suggests that most if not all singers remained in the area (Clark & Gagnon, 2006). Support for this statement comes from the fact that when the survey stopped temporarily, the whales resumed singing within a few hours and the number of singers increased with time (Clark and Gagnon, 2006). Also, they observed that one whale continued to sing while the seismic survey was actively operating (Figure 4, Clark & Gagnon, 2006). The authors conclude that there is not enough scientific knowledge to adequately evaluate whether or not these effects on singing or mating behaviors are significant or would alter survivorship or reproductive success. It is important to note that the Observatory's study area is well away from any known breeding or calving grounds for low frequency cetaceans and approximately 20 km (12 mi) away from the identified habitats for coastal bottlenose dolphins and their calves in Toth et al. (2011, 2012) thereby reducing further the likelihood of causing an effect on marine mammals.

MacLeod et al. (2006) discussed the possible displacement of fin and sei whales related to distribution patterns of the species during a large-scale seismic survey offshore the west coast of Scotland in 1998. The authors hypothesized about the relationship between the whale's absence and the concurrent seismic activity, but could not rule out other contributing factors (Macleod, et al., 2006; Parsons et al., 2009). We would expect that marine mammals may briefly respond to underwater sound produced by the Observatory's seismic survey by slightly changing their behavior or relocating a short distance. Based on the best available information, we expect short-term disturbance reactions that are confined to relatively small distances and durations (Thompson et al., 1998; Thompson et al., 2013), with no long-term effects on recruitment or survival.

McDonald et al. (1995) tracked blue whales relative to a seismic survey with a 1,600 in^3 airgun array (slightly higher than the Observatory's largest proposed airgun array [1,400 in^3]). The whale started its call sequence within 15 km (9.3 mi) from the source, then followed a pursuit track that decreased its distance to the vessel where it stopped calling at a range of 10 km (6.2 mi) (estimated received level at 143 dB re: 1 μPa (peak-to-peak)). After that point, the ship increased its distance from the whale which continued a new call sequence after approximately one hour and 10 km (6.2 mi) from the ship. The authors suggested that the whale had taken a track paralleling the ship during the cessation phase but observed the whale moving diagonally away from the ship after approximately 30 minutes continuing to vocalize (McDonald, et al., 1995). The authors also suggest that the whale may have approached the ship intentionally or perhaps was unaffected by the airguns. They concluded that there was insufficient data to infer conclusions from their study related to blue whale responses (McDonald, et al., 1995).

McCauley et al. (2000; 1998) studied the responses of migrating humpback whales off western Australia to a full-scale seismic survey with a 16-airgun array (2,678 cubic inches (in^3)) and to a single, 20-in^3airgun. Both studies point to a contextual variability in the behavioral responses of marine mammals to sound exposure. The mean received level for initial avoidance of an approaching airgun was 140 dB re: 1 μPa for humpback whale pods containing females. In contrast, some individual humpback whales, mainly males, approached within distances of 100 to 400 m (328 to 1,312 ft), where sound levels were 179 dB re: 1 μPa (McCauley, et al., 2000). The authors hypothesized that the males gravitated towards the single operating air gun possibly due to its similarity to the sound produced by humpback whales breaching. Despite the evidence that some humpback whales exhibited localized avoidance reactions at received levels below 160 dB re: 1 μPa, the authors found no evidence of any gross changes in migration routes, such as inshore/offshore displacement during seismic operations (McCauley, et al., 2000; McCauley, et al., 1998).

DeRuiter et al. (2013) recently observed that beaked whales (considered a particularly sensitive species) exposed to playbacks (*i.e.*, simulated) of U.S. tactical mid-frequency sonar from 89 to 127 dB re: 1 μPa at close distances responded notably by altering their dive patterns . In contrast, individuals showed no behavioral responses when exposed to similar received levels from *actual* U.S. tactical mid-frequency sonar operated at much further distances (DeRuiter, et al., 2013). As noted earlier, one must consider the importance of context (*e.g.*, the distance of a sound source from the animal) in predicting behavioral responses.

Tolerance: With repeated exposure to sound, many marine mammals may habituate to the sound at least partially (Richardson & Wursig, 1997). Bain and Williams (2006) examined the effects of a large airgun array (maximum total discharge volume of 1,100 in^3) on six species in shallow waters off British Columbia and Washington: harbor seal, California sea lion (*Zalophus californianus*), Steller sea lion (*Eumetopias jubatus*), gray whale (*Eschrichtius robustus*), Dall's porpoise (*Phocoenoides dalli*), and the harbor porpoise. Harbor porpoises showed "apparent avoidance response" at received levels less than 145 dB re: 1 µPa at a distance of greater than 70 km (43 miles) from the seismic source (Bain & Williams, 2006). However, the tendency for greater responsiveness by harbor porpoise is consistent with their relative responsiveness to boat traffic and some other acoustic sources (Richardson, et al., 1995; Southall, et al., 2007). In contrast, the authors reported that gray whales seemed to tolerate exposures to sound up to approximately 170 dB re: 1 µPa (Bain & Williams, 2006) and Dall's porpoises occupied and tolerated areas receiving exposures of 170–180 dB re: 1 µPa (Bain & Williams, 2006; Parsons, et al., 2009). The authors observed several gray whales that moved away from the airguns toward deeper water where sound levels were higher due to propagation effects resulting in higher noise exposures (Bain & Williams, 2006). However, it is unclear whether their movements reflected a response to the sounds (Bain & Williams, 2006). Thus, the authors surmised that the gray whale data (i.e., voluntarily moving to areas where they are exposed to higher sound levels) are ambiguous at best because one expects the species to be the most sensitive to the low-frequency sound emanating from the airguns (Bain & Williams, 2006).

Pirotta et al. (2014) observed short-term responses of harbor porpoises to a 2-D seismic survey in an enclosed bay in northeast Scotland which did not result in broad-scale displacement. The harbor porpoises that remained in the enclosed bay area reduced their buzzing activity by 15% during the seismic survey (Pirotta, et al., 2014). Thus, animals exposed to anthropogenic disturbance may make trade-offs between perceived risks and the cost of leaving disturbed areas (Pirotta, et al., 2014). However, unlike the semi-enclosed environment described in the Scottish study area, the Observatory's seismic study occurs in the open ocean. Because the Observatory would conduct the survey in an open ocean area, we do not anticipate that the seismic survey would entrap marine mammals between the sound source and the shore as marine mammals can temporarily leave the offshore survey area during the operation of the airgun(s) to avoid acoustic harassment.

Masking: Studies have shown that marine mammals are able to compensate for masking by adjusting their acoustic behavior such as shifting call frequencies and increasing call volume and vocalization rates. For example, blue whales increase call rates when exposed to seismic survey noise in the St. Lawrence Estuary (Di Iorio & Clark, 2010). North Atlantic right whales exposed to high shipping noise increased call frequency (Parks et al., 2007), while some humpback whales respond to low-frequency active sonar playbacks by increasing song length (Miller et al., 2000).

Risch et al. (2012) documented reductions in humpback whale vocalizations in the Stellwagen Bank National Marine Sanctuary concurrent with transmissions of the Ocean Acoustic Waveguide Remote Sensing (OAWRS) low-frequency fish sensor system at distances of 200 kilometers (km) from the source. The recorded OAWRS produced series of frequency modulated pulses and the signal received levels ranged from 88 to 110 dB re: 1 µPa (Risch, et al., 2012). The authors hypothesize that individuals did not leave the area but instead ceased singing and noted that the duration and frequency range of the OAWRS signals (a novel sound to the whales) were similar to those of natural humpback whale song components used during mating (Risch, et al., 2012). Thus, the novelty of the sound to humpback whales in the study area provided a compelling contextual probability for the observed effects (Risch, et al., 2012). However, the authors did not state or imply that these changes had long-term effects on individual animals or populations (Risch, et al., 2012), nor did they necessarily rise to the level of an MMPA take. The Observatory's study area is well away from any known breeding/calving grounds for low frequency cetaceans and approximately 20 km (12 mi) away from the identified habitats for bottlenose dolphins and their calves in Toth et al. (2011, 2012) thereby reducing further the likelihood of causing an effect on marine mammals

We expect that masking effects of seismic pulses would be limited in the case of smaller odontocetes given the intermittent nature of seismic pulses (5.4 seconds) plus the fact that sounds important to them are predominantly at much higher frequencies than are the dominant components of airgun sounds. Pinnipeds have best hearing sensitivity and/or produce most of their sounds at frequencies higher than the dominant components of airgun sounds, but there is some overlap in the frequencies of the airgun pulses and the calls. However, the intermittent nature of airgun pulses presumably reduces the potential for masking.

Hearing Impairment: Marine mammals exposed to high intensity sound repeatedly or for prolonged periods can experience hearing threshold shift (TS), which is the loss of hearing sensitivity at certain frequency ranges (Finneran et al., 2005; Finneran & Schlundt, 2013; Finneran et al., 2000; Kastak & Schusterman, 1998; Kastak et al., 1999; Schlundt et al., 2013; Schlundt et al., 2000). However, there has been no specific documentation of temporary threshold shift (TTS) or permanent hearing damage, *i.e.*, permanent threshold shift (PTS) in free-ranging marine mammals exposed to sequences of airgun pulses during realistic field conditions (NSF, 2014).

Regarding the Lucke et al. (2009) study, the authors found a threshold shift (TS) of a harbor porpoise after exposing it to airgun noise (single pulse) with a received sound pressure level (SPL) at 200.2 dB (peak –to-peak) re: 1 µPa, which corresponds to a sound exposure level of 164.5 dB re: 1 µPa2 s after integrating exposure. We currently use the root-mean-square (rms) of received SPL at 180 dB and 190 dB re: 1 µPa as the threshold above which permanent threshold shift (PTS) could occur for cetaceans and pinnipeds, respectively. Because the airgun noise is a broadband impulse, one cannot directly extrapolate the equivalent of rms SPL from the reported peak-to-peak SPLs reported in Lucke et al. (2009). However, applying a conservative conversion factor of 16 dB for broadband signals from seismic surveys (Harris, et al., 2001; McCauley, et al., 2000) to correct for the difference between peak-to-peak levels reported in Lucke et al. (2009) and rms SPLs; the rms SPL for TTS would be approximately 184 dB re: 1 µPa, and the received levels associated with PTS (Level A harassment) would be higher. This is still above the current 180 dB rms re: 1 µPa threshold for injury. Yet, we recognize that the temporary threshold shift (TTS) of harbor porpoise is lower than other cetacean species empirically tested (Finneran & Schlundt, 2010; Finneran et al., 2002; Kastelein & Jennings, 2012).

Recent studies by Kujawa and Liberman (2009) and Lin et al. (2011) found that despite completely reversible threshold shifts that leave cochlear sensory cells intact, large threshold shifts could cause synaptic level changes and delayed cochlear nerve degeneration in mice and guinea pigs, respectively. We note that the high level of TTS that led to the synaptic changes shown in these studies is in the range of the high degree of TTS that Southall et al. (2007) used to calculate PTS levels. It is unknown whether smaller levels of TTS would lead to similar changes. We, however, acknowledge the complexity of noise exposure on the nervous system, and will re-examine this issue as more data become available.

A recent study on bottlenose dolphins (Schlundt, et al., 2013) measured hearing thresholds at multiple frequencies to determine the amount of TTS induced before and after exposure to a sequence of impulses produced by a seismic air gun. The air gun volume and operating pressure varied from 40-150 in^3 and 1000-2000 psi, respectively. After three years and 180 sessions, the authors observed no significant TTS at any test frequency, for any combinations of air gun volume, pressure, or proximity to the dolphin during behavioral tests (Schlundt, et al., 2013). Schlundt et al. (2013) suggest that the potential for airguns to cause hearing loss in dolphins is lower than previously predicted, perhaps as a result of the low-frequency content of air gun impulses compared to the high-frequency hearing ability of dolphins.

The predicted distances at which sound levels could result in Level A harassment are relatively small (886 m for cetaceans, and 234 m for pinnipeds). The avoidance behaviors discussed in the notice of proposed authorization (79 FR 14779, March 17, 2014) supports our expectations that individuals will avoid exposure at higher levels. Also, it is unlikely that animals would encounter repeated exposures at very close distances to the sound source because the Observatory would implement the required shutdown and power down mitigation measures to ensure that marine mammals do not approach the applicable exclusion zones for Level A harassment. We also expect that Level A harassment will be prevented through the required vessel-based visual monitoring of the exclusion zones and implementation of mitigation measures.

Strandings: In 2013, an International Scientific Review Panel (ISRP) investigated a 2008 mass stranding of approximately 100 melon-headed whales in a Madagascar lagoon system (Southall et al., 2013) associated with the use of a high-frequency mapping system. The report indicated that the use of a 12-kHz multibeam echosounder was the most plausible and likely initial behavioral trigger of the mass stranding event. This was the first time that a relatively high-frequency mapping sonar system had been associated with a stranding event. However, the report also notes that there were several site- and situation-specific secondary factors that may have contributed to the avoidance responses that lead to the eventual entrapment and mortality of the whales within the Loza Lagoon system (*e.g*., the survey vessel transiting in a north-south direction on the shelf break parallel to the shore may have trapped the animals between the sound source and the shore driving them towards the Loza Lagoon). They concluded that for odontocete cetaceans that hear well in the 10-50 kHz range, where ambient noise is typically quite low, high-power active sonars operating in this range may be more easily audible and have potential effects over larger areas than low frequency systems that have more typically been considered in terms of anthropogenic noise impacts (Southall, et al., 2013). However, the risk may be very low given the extensive use of these systems worldwide on a daily basis and the lack of direct evidence of such responses previously (Southall, et al., 2013).

We have considered the potential for behavioral responses and indirect injury or mortality from the Observatory's use of the multibeam echosounder. Given that the Observatory proposes to conduct the survey offshore and the *Langseth* is not conducting the survey parallel to any coastline, we do not anticipate that the use of the source during the seismic survey would entrap marine mammals between the vessel's sound sources and the New Jersey coastline. In addition the Authorization outlines reporting measures and response protocols intended to minimize the impacts of, and enhance the analysis of, any potential stranding in the survey area.

NOAA has declared an Unusual Mortality Event (UME) for bottlenose dolphins along the Atlantic coast from early July 2013 through the present. Elevated strandings of bottlenose dolphins have occurred in New York, New Jersey, Delaware, Maryland, Virginia, North Carolina, South Carolina, Georgia and Florida (through Brevard County). All age classes of bottlenose dolphins are involved and strandings range from a few live animals to mostly dead animals with many very decomposed. Many dolphins have presented with lesions on their skin, mouth, joints, or lungs (NMFS, 2014a). Based upon preliminary diagnostic testing and discussion with disease experts the tentative cause of this UME could be cetacean morbillivirus (NMFS, 2014b). However the investigation is still ongoing and additional contributory factors to the UME are under investigation including other pathogens, biotoxins, range expansion, etc. (NMFS, 2014b).

In two studies on habitat preferences of bottlenose dolphins inhabiting coastal waters of New Jersey, Toth et al. (2011, 2012) identified two groups that displayed site fidelity within a 70 linear km 2-km wide strip of coastal waters from the northern tip of Long Beach Island to southern Longport, New Jersey. In the 2011 study, the authors note that bottlenose dolphins were more prevalent closer to shore within the 2-km width (Toth, et al., 2011). In the 2012 study, the authors sighted and characterized two groups: one that occurred within 2 km of shore, and another that occurred within 1.9–6 km offshore (Toth, et al., 2012).

We expect that the survey's activities would result, at worst, in a temporary modification in behavior, temporary changes in animal distribution, and/or low-level physiological effects (Level B harassment) of bottlenose dolphins. We expect these impacts to be minor because we do not anticipate measurable changes to the population or impacts to rookeries, mating grounds, and other areas of similar significance.

The Authorization outlines reporting measures and response protocols with the Northeast Regional Stranding Coordinator intended to minimize the impacts of, and enhance the analysis of, any potential stranding in the survey area. The Observatory's activities are approximately 20 km (12 mi) away from the habitat in which the coastal bottlenose dolphins the commenter expressed concern are expected to occur (Toth, et al., 2011, 2012), which means that the area is not expected to be ensonified above 160 dB and that take of calves of this stock is not anticipated. Additionally, airgun pulses are outside of the range of frequencies in which dolphin hearing is most sensitive, and Schlundt et al.'s (2013) study suggests that the low-frequency content of air gun impulses may have fewer predicted impacts on bottlenose dolphins. Based on the fact that the acoustic effects are expected to be limited to behavioral harassment, and the survey is constantly moving (predominantly far offshore and well away from coastal species and the associated calving areas), we do not anticipate any focused adverse effects to animals involved in the UME.

No studies are available that would inform our analysis of whether seismic surveys have any additional impacts on marine mammal species subject to a UME. As discussed above, we have evaluated the potential effects of seismic surveys on a number of marine mammal species, including bottlenose dolphins, and have concluded that the Observatory's proposed seismic survey would, at most, result in a temporary modification in behavior, temporary changes in animal distribution, and/or low-level physiological effects. We base this conclusion on the following factors: (1) the available literature supports our conclusion that the low-frequency content of air gun impulses may have fewer predicted impacts on bottlenose dolphins; (2) the proposed project will occur approximately 20 km away from identified coastal habitats for bottlenose dolphins thereby reducing significantly the probability of coastal bottlenose dolphin exposure; (3) the mitigation and monitoring measures are expected to limit the occurrence and intensity of any exposure; and (4) any effect on the human environment due to the project's impacts on dolphins is not expected to be significant.

In sum, we interpret these effects on all marine mammals as falling within the MMPA definition of Level B (behavioral) harassment. We expect these impacts to be minor because we do not anticipate measurable changes to the population or impacts to rookeries, mating grounds, and other areas of similar significance.

Under the Preferred Alternative, we would authorize incidental take, by Level B harassment only, of 27 species of marine mammals. Based on our best professional judgment and our evaluation of all of the available data, we expect no long-term or substantial adverse effects on marine mammals, their habitats, or their role in the environment.

The Observatory proposed a number of monitoring and mitigation measures for marine mammals as part of our evaluation for the Preferred Alternative. In consideration of the potential effects of the proposed seismic survey, we determined that the mitigation and monitoring measures described in section 2.3.1 of this EA would be appropriate for the preferred alternative to meet the Purpose and Need.

Injury: The Observatory did not request authorization to take marine mammals by injury (Level A harassment), serious injury, or mortality. Based on the results of our analyses, the Observatory's environmental analyses, and previous monitoring reports for the same activities, we do not expect the Observatory's planned activities to result in injury, serious injury, or mortality within the action area. The required mitigation and monitoring measures would minimize any potential risk for marine mammals.

Vessel Strikes: The potential for striking marine mammals is a concern with vessel traffic. Studies have associated ship speed with the probability of a ship strike resulting in an injury or mortality of an animal. However, it is highly unlikely that the Observatory would strike a marine mammal given the *Langseth's* slow survey speed (8 to 12 km/hr; 4 to 6 kt). Moreover, mitigation measures would be required of the Observatory to reduce speed or alter course if a collision with a marine mammal appears likely.

Estimated Take of Marine Mammals by Level B Incidental Harassment: The Observatory has requested take by Level B harassment as a result of the acoustic stimuli generated by their proposed seismic survey. We expect that the survey would cause a short-term behavioral disturbance for marine mammals in the proposed area.

As mentioned previously, we estimate that the activities could potentially affect, by Level B harassment only, 27 species of marine mammals under our jurisdiction. For each species, these estimates are small numbers (less than three percent for each species, except blue whales for which estimated takes are 3.86 percent) relative to the population sizes. Table 8 outlines, the regional density estimates for marine mammals in the action area, the number of Level B harassment takes that we propose to authorize in this Authorization, the percentage of each population or stock proposed for take as a result of the Observatory's activities, and the population trend for each species.

Table 8 –Level B harassment take levels, species or stock abundance, and percentage of population proposed for take.

Species	Density Estimate[1]	Modeled Number of Individuals Exposed to Sound Levels ≥ 160 dB	Proposed Take Authorization[2]	Percent of Species or Stock[3]	Population Trend[3]
North Atlantic right whale	0.283[4]	1	3	0.66	Increasing
Humpback whale	0.044[5]	1	2[2]	0.24	Increasing
Common minke whale	0	0	2[2]	0.01	No data
Sei whale	0.161	1	2[2]	0.56	No data
Fin whale	0.002	1	2[2]	0.06	No data
Blue whale	6.73[6]	17	17	3.86	No data
Sperm whale	7.06	18	18	0.79	No data
Dwarf sperm whale	0.001	2	3	0.17	No data
Pygmy sperm whale	0.001	2	3	0.17	No data
Cuvier's beaked whale	0.124	3	4	0.06	No data
Gervais' beaked whale	0.124	3	4	0.06	No data
Sowerby's beaked whale	0.124	3	4	0.06	No data
Unidentified Mesoplodon /Ziphid: True's, Blainville, northern bottlenose whale	0.124	1	4	0.06	No data
Rough-toothed dolphin	0	0	0	0	No data
Bottlenose dolphin (pelagic)	111.3	279	349	0.45	No data
Bottlenose dolphin (coastal)	111.3	279	349	3.02	No data
Pantropical spotted dolphin	0	0	0	0	No data
Atlantic spotted dolphin	36.1	90	113	0.25	No data
Spinner dolphin	0	0	0	0	No data
Striped dolphin	0	0	59	0.11	No data
Short-beaked common dolphin	0	0	23	0.01	No data
White-beaked dolphin	0	0	0	0	No data
Atlantic white-sided dolphin	0	0	19	0.04	No data
Risso’s dolphin	13.6	35	44	0.24	No data
False killer whale	0	0	0	0	No data
Pygmy killer whale	0	0	0	0	No data
Killer whale	0	0	0	0	No data
Long-finned pilot whale	0.184	1	12	0.05	No data
Short-finned pilot whale	0.184	1	12	0.06	No data
Harbor porpoise	0.008[4]	1	3	0.0038	No data
Gray seal	0	0	15	0.005	Increasing
Harbor seal	44.43[4]	112	140	0.20	No data
Harp seal	0	0	5	0.00007	Increasing

[1] Except where noted, densities are the mean values for the survey area calculated from the SERDP SDSS NODES summer model (Read et al., 2009) as presented in Table 3 of the Observatory’s application.
[2] Proposed take includes increases for mean group size or cow/calf pairs based on Palka, 2012; NJDEP, 2010; or increases for gray and harp seals based on stranding data from the NJ Marine Mammal Stranding Center. We have also increased the proposed take estimates by a factor of 25 percent to conservatively account for new animals entering or passing through the ensonified area.
[3] Table 1 in this notice lists the stock species abundance estimates used in calculating the percentage of species/stock. Population trend information from Waring et al., 2013. No data = Insufficient data to determine population trend.
[4] NMFS revised estimate based on the NODES model using the spring mean density estimate for that species in survey area.
[5] NMFS revised estimate based on the SERDP SDSS Duke Habitat Model using the summer mean density estimate for humpback whales in survey area.
[6] NMFS revised estimate based on the SERDP SDSS Duke Habitat Model using the summer mean density estimate for baleen whales in survey area.

Whitt et al. (2013) conducted acoustic and visual surveys for North Atlantic right whales off the coast of New Jersey from January 2008 to December 2009 and observed one sighting of a cow-calf pair in May 2008, but no other sightings of cow-calf pairs throughout the remainder of the study. NMFS considered this information (presented on page 15 of NSF's draft EA and in the notice for the proposed authorization and concluded that it was appropriate to increase the Observatory's original request for incidental take related to North Atlantic right whales from zero to three (3) to be conservative in estimating potential take for cow/calf pairs.

Our *Federal Register* notice for the proposed Authorization and the Observatory's application contain complete descriptions of how we derived the take estimates. We do not expect the proposed activities to impact rates of recruitment or survival for any affected species or stock. Further, the activities would not adversely affect marine mammal habitat.

Under Alternative 1, the proposed action has no unmitigable adverse impact to subsistence uses, because there are no permitted subsistence uses of marine mammals in the region.

4.2 Effects of Alternative 2– No Action Alternative

Under the No Action Alternative, we would not issue an Authorization to the Observatory. As a result, the Observatory would not receive an exemption from the MMPA prohibitions against the take of marine mammals and would, if they proceeded with their activities, be in violation of the MMPA if take of marine mammals occurs.

The impacts to elements of the human environment resulting from the No Action alternative—conducting the 3-D seismic survey program in the absence of required protective measures for marine mammals under the MMPA—would be greater than those impacts resulting from Alternative 1, the Preferred Alternative.

4.2.1 Impacts to Marine Mammal Habitat

Under the No Action Alternative, the survey would have no additive effects on the physical environment beyond those resulting from the Observatory's activities, which we evaluated in the referenced documents. This Alternative would result in similar effects on the physical environment as Alternative 1.

4.2.2 Impacts to Marine Mammals

Under the No Action Alternative, the Observatory's activities would likely result in increased amounts of Level B harassment to marine mammals and possibly takes by injury (Level A harassment), serious injury, or mortality—specifically related to acoustic stimuli—due to the absence of mitigation and monitoring measures required under the Authorization.

While it is difficult to provide an exact number of takes that might occur under the No Action Alternative, we would expect the numbers to be larger than those presented in Table 8 because of the lack of restrictions imposed on the Observatory's survey operations. The Observatory could take significantly more marine mammals by harassment due to the lack of required mitigation measures including shutdowns and power downs for marine mammals.

If the activities proceeded without the protective measures and reporting requirements required by a final Authorization under the MMPA, the direct, indirect, or cumulative effects on the human or natural environment of not issuing the Authorization would include the following:

- Marine mammals within the survey area could experience injury (Level A harassment) and potentially serious injury or mortality. The lack of mitigation measures that would otherwise be required in an Authorization could lead to vessels not altering their course or speed around marine mammals, not ramping up or powering or shutting down airguns when marine mammals are within applicable injury harassment zones; and not shutting down for North Atlantic right whales;
- Increases in the number of behavioral responses and frequency of changes in animal distribution because of the lack of mitigation measures required in the Authorization. Thus, the incidental take of marine mammals would likely occur at higher levels than we have already identified and evaluated in our *Federal Register* notice on the proposed Authorization; and
- We would not be able to obtain the monitoring and reporting data needed to assess the anticipated impact of the activity upon the species or stock; and increased knowledge of the species as required under the MMPA.

Under Alternative 2, the action has no unmitigable adverse impact to subsistence uses, as there are no permitted subsistence uses of marine mammals in the region.

4.3 Effects of Alternative 3 – Issuance of with Additional Mitigation Measures

4.3.1 Impacts to Marine Mammal Habitat

Effects to the physical environment would be the same under Alternative 3 as those described above for Alternative 1. We would expect no additional effects beyond those already described.

4.3.2 Impacts to Marine Mammals

Under this Alternative, marine mammals would still experience harassment by the Observatory's proposed seismic survey in the Atlantic Ocean. As described in Alternative 1, anticipated impacts to marine mammals associated with the Observatory proposed activities primarily result from noise propagation. Potential impacts to marine mammals might include one or more of the following: tolerance, masking of important natural signals, behavioral disturbance, and temporary or permanent hearing impairment or non-auditory effects. These are the same types of reactions that we would anticipate under the Preferred Alternative (Alternative 1)

The primary difference under Alternative 3 is that we would require additional mitigation and monitoring measures for detecting marine mammals. These additional measures include requiring an alternate time for the survey; implementing operational restrictions for nighttime operations; and the use of alternate technologies to augment monitoring.

Alternate Survey Timing: This measure would require the Observatory to postpone their research after the summer season to minimize interactions with marine life. The Foundation considered this mitigation measure in their EA (NSF, 2014) and concluded that the proposed dates for the cruise (June – August) met the Purpose and Need of their action because the personnel and equipment essential to meet the overall project objectives were available. This measure, however, may have the added effect of increasing the number of takes for North Atlantic right whales due to their increased presence off the New Jersey in the fall and winter.

Whitt et al. (2013) concluded that right whales were not present in large numbers off New Jersey during the summer months (Jun 22 – Sep 27) which corresponds to the effective dates of the seismic survey (June – August). In contrast, peak acoustic detections for the whales occurred in the winter (Dec 18 – Apr 9) and in the spring (Apr 10– Jun 21) for north Atlantic right whales (Whitt, et al., 2013).

Operational Restrictions: This measure would require the Observatory to suspend their activities in low-light/nighttime conditions and minimize the number of repeated tracklines for the survey. This measure fails to meet the meet one of the Observatory's research requirements which is to conduct the survey in the shortest time span possible, day and night. The MMPA requires NMFS to take into account the practicability of mitigation measures. Restricting activities to daytime operations only would unnecessarily lengthen the time to complete the survey which would not be practicable from an operational standpoint.,. Suspending the survey at night would inevitably increase the number of days to complete the survey and would likely result in increased amounts of Level B harassment to marine mammals over a longer duration of time. While the additional measure may provide some added protection for marine mammals present in the research area during nighttime operations, we do not expect that this measure would reduce the overall level of effects. Level B harassment of marine mammals would still occur.

Augmented Monitoring: This measure would require the use of alternative methods to detect marine mammals beyond the proposed visual observation and acoustic monitoring. The Foundation considered this mitigation measure in their EA (NSF, 2014) and concluded that at the present time, these technologies are still not feasible, commercially viable, or appropriate to meet their Purpose and Need.

While the technologies for these monitoring methods are still being developed and refined, we expect that they would allow for additional detection of marine mammals beyond visual observations from shipboard observers. These additional monitoring measures could allow for necessary mitigation measures (*i.e.*, power-downs and shutdowns) to be implemented more quickly and more frequently, thereby potentially reducing further the number of marine mammal takes. However, until these technologies are developed and fully tested, we are unable to provide a reasonable estimate of this reduction in take levels.

Under Alternative 3, the action has no unmitigable adverse impact to subsistence uses, as there are no permitted subsistence uses of marine mammals in the region.

4.4 Compliance with Necessary Laws – Necessary Federal Permits

We have determined that the issuance of an Authorization is consistent with the applicable requirements of the MMPA, ESA, MSFMCA, and CZMA, and our regulations. Please refer to section 1.4 of this EA for more information.

4.5 Unavoidable Adverse Impacts

The Observatory's application, our *Federal Register* notice of a proposed Authorization, and other environmental analyses identified previously summarize unavoidable adverse impacts to marine mammals or the populations to which they belong or on their habitats, as well as subsistence uses of marine mammals, occurring in the seismic survey area. We incorporate those documents by reference.

We acknowledge that the incidental take authorized would potentially result in unavoidable adverse impacts. However, we do not expect the Observatory's activities to have adverse consequences on the viability of marine mammals in the Atlantic Ocean. We do not expect the marine mammal populations in that area to experience reductions in reproduction, numbers, or distribution that might appreciably reduce their likelihood of surviving and recovering in the wild. We expect that the numbers of individuals of all species taken by harassment would be small (relative to species or stock abundance), that the seismic survey and the take resulting from the seismic survey activities would have a negligible impact on the affected species or stocks of marine mammals, and that there would not be an unmitigable adverse impact to subsistence uses of marine mammals in the northwest Atlantic Ocean.

4.6 Cumulative Effects

NEPA defines cumulative effects as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other actions" (40 CFR §1508.7). Cumulative impacts can result from individually minor but collectively significant actions that take place over a period of time.

The proposed seismic survey would add another, albeit temporary activity to the marine environment in the Atlantic Ocean and the proposed survey would be limited to a relatively small area for a comparatively short period of time. The Foundation's EA (NSF, 2014) summarizes the potential cumulative effects to marine mammals or the populations to which they belong or on their habitats occurring in the survey area. This section incorporates the Foundation's EA by reference and provides a brief summary of the human-related activities affecting the marine mammal species in the action area.

4.6.1 Previous Seismic Research Surveys in the Same Area

The Foundation's EA (NSF, 2014) acknowledges that scientists have conducted numerous 2-D seismic surveys in the general vicinity of the proposed survey from 1979 to 2002. The previous surveys used different airgun array configurations (*e.g.*, a 6-airgun, 1,350-in^3 array in 1990; a single, 45-in^3 GI Gun in 1996 and 1998; and two 45-in^3 GI Guns in 2002).

4.6.2 Future Seismic Research in the Atlantic Ocean

The U.S. Geological Survey (USGS) has proposed to conduct a seismic survey to support the delineation of the U.S. Extended Continental Shelf (ECS) in the Atlantic Ocean August through September, 2014, and April to August, 2015. The USGS would use the *Langseth* to conduct survey for approximately 18 to 21 days covering approximately 3,000 km of seismic tracklines. On June 23, 2014, NMFS announced a proposed Authorization for the USGS's proposed survey (79 *Fed. Reg*. 35641) and preliminarily determined that 34 species of marine mammals could be potentially affected by Level B harassment related to acoustic disturbance. We also preliminarily determined that that the taking by Level B harassment would have a negligible impact on the affected marine mammal species and/or stocks. This project would not overlap with the proposed survey area and the USGS has prepared a separate EA for their action.

The Observatory has also proposed to conduct a 2-D seismic survey to investigate the Eastern North American Margin (ENAM) on the *Langseth* in the Atlantic Ocean off the coast of North Carolina September through October, 2014. The seismic survey would take place outside of North Carolina state waters and almost entirely within the federal waters. This project would not overlap with the proposed survey area and the Foundation has prepared a separate EA for their action.

Both surveys are dispersed both geographically and temporally, are short-term in nature, and all of the Authorization holders would be required to use mitigation and monitoring measures to minimize impacts to marine mammals and other living marine resources in the activity area. We are unaware of any synergistic impacts to marine resources associated with reasonably foreseeable future actions that may be planned or occur within the same region of influence as the proposed survey.

4.6.3 Unusual Mortality Event (UME) for Bottlenose Dolphins

NOAA has declared an UME for bottlenose dolphins along the Atlantic coast from early July 2013 through the present. Elevated strandings of bottlenose dolphins have occurred in New Jersey. All age classes of bottlenose dolphins are involved and strandings range from a few live animals to mostly dead animals with many very decomposed (NMFS, 2014a).. Based upon preliminary diagnostic testing and discussion with disease experts, the tentative cause of this UME could be cetacean morbillivirus (NMFS, 2014b). However the investigation is still ongoing and additional contributory factors to the UME are under investigation including other pathogens, biotoxins, range expansion, etc. (NMFS, 2014b).

4.6.4 Military Activities

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 within 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 (NSF, 2014).

4.6.5 Future Oil and Gas Exploration

The proposed survey site is outside of the Outer Continental Shelf proposed geological and geophysical activities in the Mid-Atlantic and South Atlantic Planning Areas (NSF, 2014).

4.6.6 Climate Change

The 2007 Intergovernmental Panel on Climate Change concluded that there is very strong evidence for global warming and associated weather changes and that humans have "very likely" contributed to the problem through burning fossil fuels and adding other "greenhouse gases" to the atmosphere (IPCC, 2007a, 2007b). This study involved numerous models to predict changes in temperature, sea level, ice pack dynamics, and other parameters under a variety of future conditions, including different scenarios for how human populations respond to the implications of the study.

Increased ocean temperatures will reduce oxygen, and atmospheric CO_2 will reduce ocean pH and threaten the health of the marine ecosystem. Ocean circulation patterns will change, with less mixing of cold and warm water in tropical and subtropical areas, affecting the ability of near-surface species to reach nutrients at lower depths (NJCAA, 2014). At more northern latitudes mixing could actually increase with melting of sea ice, but general ocean warming will alter migration and breeding patterns and push species further northward (NJCAA, 2014).

With the large degree of uncertainty on the impact of climate change to marine mammals in the northwest Atlantic Ocean, we recognize that warming of this region could affect the prey base and habitat quality for marine mammals. Nonetheless, we expect that the conduct of the seismic survey and the issuance of an Authorization to the Observatory would not result in any noticeable contributions to climate change.

Chapter 5 – List of Preparers and Agencies Consulted

Agencies Consulted:

Marine Mammal Commission
4340 East West Highway, Room 700
Bethesda, Maryland 20814

NOAA – National Marine Fisheries Service
Office of Protected Resources
Endangered Species Act Interagency Cooperation Division
1315 East West Highway, SSMC 3
Silver Spring, MD 20910

National Science Foundation
Office of General Counsel
4201 Wilson Blvd.
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Appendix F

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Washington, D.C. 20240

In Reply Refer To:
FWS/AES/DER/BCH/056843
FWS 2014-I-0002

MAR 0 5 2014

Holly Smith
National Science Foundation
Division of Ocean Sciences
4201 Wilson Blvd., Suite 25
Arlington, VA 22230

Subject: Informal Consultation on the High-Energy, 3-D Marine Geophysical Survey in the Atlantic Ocean off the Coast of New Jersey

Dear Ms. Smith:

This letter is in response to your February 3, 2014, email requesting the U.S. Fish and Wildlife Service's (Service) concurrence that the proposed high-energy, 3-D marine geophysical survey in the Atlantic Ocean off the coast of New Jersey is not likely to adversely affect the endangered roseate tern (*Sterna dougallii*) and the threatened piping plover (*Charadrius melodus*), pursuant to section 7 of the Endangered Species Act of 1973 (16 U.S.C. 1531 -1544), as amended (ESA). This consultation is based on the draft Environmental Assessment entitled a Marine Geophysical Survey by the R/V *Marcus G. Langseth* in the Atlantic Ocean off New Jersey, June – July 2014.

Lamont-Doherty Earth Observatory (L-DEO), with funding from the U.S. National Science Foundation (NSF) plans to conduct high-energy, 3-D geophysical surveys in the northwest Atlantic Ocean approximately 25-85 kilometers from the coast of New Jersey, outside of U.S. waters and within the U.S. Exclusive Economic Zone (located between approximately 39.3 and 39.7°N and approximately 73.2 and 78.8°W). The seismic survey will take place from June through July, 2014, and will take place in water depths between 30 to 75 meters.

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. The procedures to be used for the surveys would be similar to those used during previous seismic
surveys by L-DEO and would use conventional seismic methodology. The surveys would involve one source vessel, the R/V *Langseth*. The *Langseth* would deploy a small towed subarray of 4 or 8 airguns with a total discharge volume of approximately 700 to 1400 cubic

inches. The receiving system would consist of four 3000 meter hydrophone streamer. As the airguns are towed along the survey lines, the hydrophone streamer would receive the returning acoustic signals and transfer the data to the on-board processing system.

A total of approximately 4,900 kilometers of 3-D survey lines, including turns, would be shot and some additional seismic operations associated with airgun testing and repeat coverage will occur. In addition to the operations of the airgun array, a multibeam echosounder, a subbottom profiler, and an acoustic Doppler current profiler will 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 or off the *Langseth* by a small vessel.

Although unlikely to be encountered, the roseate tern and the piping plover could occur at or near the project site. The roseate tern 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. During the breeding season, roseate terns forage over shallow coastal waters, especially in water depths less than 5 meters, sometimes near the colony and at other times at distances of over 30 kilometers away. They usually forage over shallow bays, tidal inlets and channels, tide rips, and sandbars. Because of its distribution during the breeding season, the roseate tern likely would not be encountered at the proposed survey site.

The piping plover breeds on coastal beaches from Newfoundland to North Carolina during March-August. Its marine nesting habitat consists of sandy beaches, sandflats, and barrier islands. Feeding areas include intertidal portions of ocean beaches, mudflats, sandflats, and shorelines of coastal ponds, lagoons, or salt marshes. Because it is strictly coastal, the piping plover likely would not be encountered at the proposed survey site.

In the rare event one of these species is in the vicinity of the survey area, there is the potential that the bird might be affected slightly by seismic sound from the proposed study. The impact would not be expected to be significant to the individual bird or their population because the majority of observed sound levels are below the water surface. Additionally, the proposed action includes precautionary measures of powering or shutting down the airguns if a listed bird is seen diving in the area.

Based upon the unlikely chance a bird of either species will be in the action area as well as the precautionary measures in place, we do not anticipate any adverse impacts to the listed roseate tern or piping plover. Thus, we concur that the activities covered under the NSF's proposed high-energy, 3-D marine geophysical survey "may affect" but "are not likely to adversely affect" the roseate tern or piping plover. Coordination with National Marine Fisheries Service on listed species under their jurisdiction is still required.

We are pleased that NSF, L-DEO and its contractors are committed to applying proactive protective measures in order to minimize effects on marine animals. We appreciate the collaboration your staff has provided. If you have any question please contact Dr. Collette Thogerson of my office at (703) 358-2103.

Sincerely,

Patrice Ashfield
Chief, Branch of Consultation and Habitat
Conservation Plans, Ecological Services

Appendix G

MARINE MAMMAL COMMISSION

31 March 2014

Ms. Jolie Harrison, Supervisor
Incidental Take Program
Permits and Conservation Division
Office of Protected Resources
National Marine Fisheries Service
1315 East-West Highway
Silver Spring, MD 20910-3225

Dear Ms. Harrison:

The Marine Mammal Commission (the Commission), in consultation with its Committee of Scientific Advisors on Marine Mammals, has reviewed the application submitted by Lamont-Doherty Earth Observatory (LDEO), in collaboration with the National Science Foundation (NSF), seeking authorization under section 101(a)(5)(D) of the Marine Mammal Protection Act (the MMPA) to take small numbers of marine mammals by harassment. The taking would be incidental to a marine geophysical survey to be conducted off New Jersey from June–July 2014. The Commission also has reviewed the National Marine Fisheries Service's (NMFS) 17 March 2014 notice announcing receipt of the application and proposing to issue the authorization, subject to certain conditions (79 Fed. Reg. 14780).

Some issues raised in previous letters regarding geophysical surveys reflect Commission concerns that apply more broadly to incidental take authorization applications beyond LDEO's proposed application. The Commission has recommended numerous times that NMFS adjust density estimates using some measure of uncertainty when available density data originate from different geographical and temporal scales and formulate policy or guidance regarding a consistent approach for how applicants should incorporate uncertainty in density estimates. NMFS has indicated that it is currently evaluating available density information and is working on guidance that would outline a consistent approach for addressing uncertainty in specific situations where certain types of data are or are not available (78 Fed. Reg. 57354). Further, the Commission has recommended that NMFS follow a consistent approach of requiring the assessment of Level B harassment takes for specific types of sound sources (e.g., sub-bottom profilers, echosounders, side-scan sonar, and fish-finding sonar) by all applicants who propose to use them. NMFS has indicated that it is evaluating the broader use of those types of sources to determine under what specific circumstances requests for incidental taking would be advisable (or not) and also is working on guidance that would outline a consistent approach for addressing potential impacts from those types of sources (78 Fed. Reg. 57354). The Commission is unsure of the status of the guidance documents but would welcome an opportunity to meet with NMFS to review the higher-level recommendations, as well as those specific to LDEO's application.

RECOMMENDATIONS

<u>The Marine Mammal Commission recommends</u> that the National Marine Fisheries Service—

- require LDEO to re-estimate the proposed exclusion and buffer zones and associated takes of marine mammals using site-specific parameters (including at least sound speed profiles, bathymetry, and sediment characteristics) for the proposed incidental harassment authorizations—NMFS should impose the same requirement for all future incidental harassment authorizations submitted by LDEO, NSF, Antarctic Support Contract (ASC), U.S. Geological Survey (USGS), Scripps Institution of Oceanography (Scripps), or any other related entity;
- require LDEO to estimate the numbers of marine mammals that could be taken based on the total ensonified area in any given day multiplied by 30 and the applicable densities; and
- consult with the funding agency (i.e., NSF) and individual applicants (e.g., LDEO, ASC, Scripps, and USGS) to develop, validate, and implement a monitoring program that provides a scientifically sound, reasonably accurate assessment of the types of marine mammal takes and the actual numbers of marine mammals taken—the assessment should account for applicable g(0) and f(0) values.

BACKGROUND

LDEO proposes to conduct a high-energy, 3D geophysical survey 25 km offshore of New Jersey from 39.3 to 39.7º N and 73.2 to 73.8º W. The purpose of the proposed survey 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. The survey would be conducted in waters estimated to be 30 to 75 m in depth with approximately 4,900 km of tracklines. LDEO would use the R/V *Marcus G. Langseth* to operate a four- and eight-airgun array (nominal source level of up to 253 dB re 1μPa at 1 m (peak-to-peak) with a maximum discharge volume of 700 or 1,400 in^3, respectively) at 4.5 or 6 m depth, respectively. The arrays would be used in an alternating (flip-flopping) firing sequence. The *Langseth* also would tow four hydrophone streamers, 3,000 m in length, during the survey. In addition, LDEO would operate a 10.5- to 13-kHz multibeam echosounder, a 3.5-kHz sub-bottom profiler, and a 75-kHz Acoustic Doppler Current Profiler (ADCP) continuously throughout the survey. The survey is expected to last for 30 days.

NMFS preliminarily has determined that, at most, the proposed activities would result in a temporary modification in the behavior of small numbers of up to 26 species of marine mammals and that any impact on the affected species would be negligible. NMFS does not anticipate any take of marine mammals by death or serious injury. It also believes that the potential for temporary or permanent hearing impairment will be at the least practicable level because of the proposed mitigation and monitoring measures. Those measures include monitoring exclusion and buffer zones and using power-down, shut-down, and ramp-up procedures. In addition, the Observatory would shutdown the airguns immediately if and when a North Atlantic right whale is sighted, regardless of the distance from the *Langseth*. Ramp-up procedures would not be initiated until the right whale has not been seen at any distance for 30 minutes.

Staff members from the NSF, NMFS, USGS, LDEO, and the Commission met in March 2013 to discuss some of the Commission's ongoing concerns regarding the potential effects of geophysical surveys. Although a number of concerns were discussed and several resolved, the following paragraphs highlight areas that, in the Commission's view, warrant further attention.

RATIONALE

Uncertainty in estimating exclusion and buffer zones

The Commission continues to have concerns regarding the method used to estimate exclusion and buffer zones and the numbers of takes for NSF-funded geophysical research. These concerns date back to 2010 (please refer to the Commission's 12 March, 19 April, and 24 June 2013 and 30 January 2014 letters for detailed rationale). Briefly, LDEO conducts acoustic modeling for NSF-funded geophysical research. For at least 6 years (and likely more than the last 10 years), LDEO has estimated exclusion and buffer zones (based on Level A and B harassment, respectively) using a simple ray trace–based modeling approach that assumes spherical spreading, a constant sound speed, and no bottom interactions (Diebold et al. 2010). That model does not incorporate environmental characteristics of the specific study area including sound speed profiles and refraction within the water column, bathymetry/water depth, sediment properties/bottom loss, or absorption coefficients. However, LDEO believes that its model generally is conservative when compared to in-situ sound propagation measurements of the R/V *Maurice Ewing*'s arrays (i.e., 6-, 10-, 12-, and 20-airgun arrays) and the R/V *Langseth*'s 36-airgun array from the Gulf of Mexico (Tolstoy et al. 2004, Tolstoy et al. 2009, Diebold et al. 2010[1]). LDEO also notes the model is most directly applicable to deep water (> 1,000 m). Diebold et al. (2010) noted the limited applicability of LDEO's model when sound propagation is dependent on water temperature, water depth, bathymetry, and bottom-loss parameters, all of which are of concern for a survey in water depths as shallow as 30 m. They further indicated that modeling could be improved by including realistic sound speed profiles within the water column. In addition, Tolstoy et al. (2009) acknowledged that sound propagation depends on water depth, bathymetry, and tow depth of the array and that sound propagation varies with environmental conditions and should be measured at multiple locations.

LDEO has stated that empirical data for shallow water (< 100 m) indicated that the model underestimated actual received levels. For previous applications, LDEO has applied correction factors to the distances reported by Tolstoy et al. (2009) for shallow-water depths (76 Fed. Reg. 6430, 61463). Those factors ranged from 1.7 to 5.2 times greater than the distances in deep water, which have been applied to derive appropriate shallow-water zones from the modeled radii for the *Langseth's* 18-airgun array (Tolstoy et al. 2009). Rather than adjust the modeled distances using that same method for the proposed incidental harassment authorization, LDEO applied correction factors (or a scaling approach) to empirical shallow-water zones[2] based on modeled deep-water zones for the various arrays[3]. The Commission is unsure why LDEO would assume that the ratio of modeled zones in deep water would equate to empirical zones in shallow water, as those two quantities are not comparable and LDEO itself indicated that the model underestimated received levels in shallow water. Nevertheless, the new approach effectively reduced the zones for the

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[1] Diebold et al. (2010) also presented data on the 18-airgun array from the Gulf of Mexico.

[2] LDEO used the empirical values from an 18-airgun array in shallow water and also assumed that the sound pressure level (rms; SPL_{rms}) values were 10 dB greater than sound exposure level (SEL) values. However, Tolstoy et al. (2009) indicated that the difference between SPL_{rms} and SEL values were highly dependent on water depth, specifically the difference in shallow water was approximately 8 dB. Therefore, the exclusion and buffer zones likely were underestimated because of inaccurate received levels as well as methodological deficiencies.

[3] LDEO compared the deep-water modeled values of the 4- and 8-airgun array to the 18-airgun array using accuracy out to the ten-thousandths, which is not appropriate for LDEO's simplistic model in two entirely different environments.

mitigation airgun from 150 to 21 m for the 190-dB re 1 μPa threshold, 296 to 100 m for the 180-dB re 1 μPa threshold, and 1,050 to 995 m for the 160-dB re 1 μPa threshold (see Table 2 in 77 Fed. Reg. 25966, Table 1 in 76 Fed. Reg. 41463, Table 1 in 76 Fed. Reg. 26255, and Table 1 in 76 Fed. Reg. 6430). The new approach would likely reduce the applicable zones for the other airgun arrays proposed for use as well. Tolstoy et al. (2009) verified that in shallow water, sound is expected to reverberate in the water column and upper seafloor, therefore, sound propagation in shallow water would be highly dependent on local seafloor geology[4]—not scaling factors based on modeled results in deep water. Further, although calibration experiments for both the *Ewing* and *Langseth* occurred in the Gulf of Mexico, Tolstoy et al. (2009) also indicated that data differences between the two studies at shallow-water depths may have been attributed to site-specific differences. All these shortcomings reinforce the Commission's ongoing concerns regarding the estimation of exclusion and buffer zones for NSF-funded geophysical surveys.

Those concerns are based primarily on the failure to test and verify the use of LDEO's model under the specific environmental conditions that would be encountered with each survey. For that reason, the Commission has recommended that NMFS or the relevant entity estimate exclusion and buffer zones using either empirical measurements from the particular survey site or a model that accounts for the conditions in the proposed survey area. The model should incorporate operational parameters (e.g., tow depth, source level, number/spacing of active airguns) and site-specific environmental parameters (e.g., sound speed profiles, refraction in the water column, bathymetry/water depth, sediment properties/bottom loss, and wind speed). In March 2013, LDEO indicated that it might be able to compare its model to hydrophone data collected during previous surveys in environmental conditions other than those in the Gulf of Mexico[5] (i.e., deep and intermediate waters in cold water environments that may have surface ducting conditions, shallow-water environments, etc.). The Commission understands that LDEO has been analyzing hydrophone data from waters off Washington to compare to the estimated exclusion and buffer zones, but LDEO does not seem to use that method for the current proposed authorization. The Commission encourages LDEO to make such comparisons using those methods to estimate its zones at various sites, not just in waters off Washington. The Commission recommended in its 24 June 2013 letter that those comparisons be made prior to the submittal of applications for geophysical surveys to be conducted in 2014. The Commission further recommended that if LDEO and NSF either do not have enough data to compare LDEO's model to other environments or do not assess the accuracy of the model, then they should re-estimate the exclusion and buffer zones and associated takes of marine mammals using site-specific parameters (including sound speed profiles, bathymetry, and bottom characteristics) for all future applications that use LDEO's model. Neither approach was used for the proposed incidental harassment authorization.

NMFS has indicated that NSF, LDEO, and other relevant entities (USGS, Scripps) are providing sufficient scientific justification for their take estimates. The Commission disagrees with this conclusion, given that the estimates are based on LDEO's model or empirical measurements in

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[4] Tolstoy et al. (2009) further indicated that empirical data confirm significantly different propagation loss rates in shallow and deep water as previously observed for the R/V *Ewing* (Tolstoy et al., 2004), with lesser propagation loss rates in shallow water.

[5] Diebold et al. (2010) supported such an approach, stating that streamer data can provide an accurate assessment of SELs at the relevant ranges for mitigation in shallow-water environments (≤ 100 m). They further indicated it seems logical and advantageous that those data be monitored in real time to fine tune a priori mitigation zones in shallow-water environments.

the Gulf of Mexico, while recent activities would occur in other areas such as the North Atlantic and the Antarctic. Environmental conditions in waters of the continental shelf off New Jersey indicate a surface duct at 50 m, in-water refraction, and bathymetry and sediment characteristics that reflect sound[6]. None of these site-specific parameters are accounted for in LDEO's model.

In a recent sound exposure modeling workshop that was attended by numerous entities (NMFS, NSF, LDEO, USGS, and the Commission), experts confirmed that sound speed profiles and bathymetry/sediment characteristics were the most important factors affecting underwater sound propagation and should be included in related modeling. While LDEO presented various aspects of its model during the workshop and indicated that the model was fast, inexpensive, and simple to use, none of those attributes support its applicability or accuracy. Further, LDEO indicated that the model is more closely related to a source model that compares airgun arrays and that it is not representative of modeling in the actual environment. Therefore, the Commission remains concerned that the LDEO model is not based on best available science and does not support its continued use. For all of these reasons, the Commission recommends that NMFS require LDEO to re-estimate the proposed exclusion and buffer zones and associated takes of marine mammals using site-specific parameters (including at least sound speed profiles, bathymetry, and sediment characteristics) for the proposed incidental harassment authorizations—NMFS should impose the same requirement for all future incidental harassment authorizations submitted by LDEO, NSF, ASC, USGS, Scripps, or any other related entity.

A few years ago, NSF and USGS modeled sound propagation under various environmental conditions in their programmatic environmental impact statement for geophysical surveys worldwide. LDEO and NSF (in cooperation with Pacific Gas and Electric Company) also used a similar modeling approach in the recent incidental harassment authorization application and associated environmental assessment for a geophysical survey of Diablo Canyon in California (77 Fed. Reg. 58256). These recent examples indicate that LDEO, NSF, and related entities are able to implement the recommended modeling approach, if required to do so by NMFS. The Commission understands the constraints imposed by the current budgetary environment, but notes that other agencies that contend with similar funding constraints incorporate modeling based on site-specific parameters. LDEO, NSF, and related entities (ASC, USGS, Scripps) should be held to that same standard.

Enumerating takes for surveys in a small area

To determine the numbers of marine mammals that could be taken incidental to the proposed geophysical survey, LDEO multiplied the total ensonified area of 2,502 km^2 (which includes a 25 percent contingency) by the applicable densities. However, LDEO would be conducting the survey, consisting of 4,900 km of tracklines (spaced 150 m apart), in an area of 12 by 50 km. The survey would occur in that small area for approximately 30 days, 24 hours per day. At the March 2013 meeting, the Commission discussed with NMFS and the other relevant entities the fact that a simple area*density method is not appropriate in such circumstances. Rather, the applicant should be determining the total ensonified area in a given day, which then should be multiplied by the number of survey days (30) and the applicable densities. Otherwise, the method

[6] NSF and USGS's programmatic environmental impact statement for geophysical surveys included environmental data from the continental shelf close to the proposed survey.

LDEO used in the current request (and has used in the past) very likely underestimated the numbers of marine mammals that could be taken. Therefore, the Commission recommends that NMFS require LDEO to estimate the numbers of marine mammals that could be taken based on the total ensonified area in any given day multiplied by 30 and the applicable densities.

Monitoring measures

In previous letters, the Commission has indicated that monitoring and reporting requirements should provide a reasonably accurate assessment of the types of taking and the numbers of animals taken by the proposed activity. Those assessments also should account for animals at the surface but not detected and for animals present but underwater and not available for sighting, which are accounted for by g(0) and f(0) values. Those adjustments are essential for making accurate estimates of the numbers of marine mammals taken during surveys. To be useful, the corrections should be based on the ability of the protected species observers to detect marine mammals rather than a hypothetical optimum derived from scientific studies (e.g., from NMFS's shipboard surveys). Therefore, the Commission again recommends that NMFS consult with the funding agency (i.e., NSF) and individual applicants (e.g., LDEO, ASC, Scripps, USGS) to develop, validate, and implement a monitoring program that provides a scientifically sound, reasonably accurate assessment of the types of marine mammal takes and the actual numbers of marine mammals taken—the assessment should account for applicable g(0) and f(0) values. NMFS indicated that it was working to develop recommendations for how applicants can correct marine mammal detections appropriately to better estimate the number of animals likely taken during specified activities, considering those that are not detected (79 Fed. Reg. 14219, 78 Fed. Reg. 57354). The Commission encourages NMFS to consult with the Commission and NMFS scientists before finalizing such recommendations.

The Commission is grateful for the opportunity to provide comments on the application submitted by LDEO. Please contact me if you have questions concerning the Commission's recommendation.

Sincerely,

Rebecca J. Lent

Rebecca J. Lent, Ph.D.
Executive Director

References

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Clean Ocean Action · Oceana · The Ocean Foundation · Natural Resources Defense Council · Center for Biological Diversity · Alaska Inter-Tribal Council · International Game Fish Association · Cetacean Society International · Whale and Dolphin Action League · Surfrider Foundation · League of Women Voters of New Jersey · American Littoral Society · Hands Across the Sand · New Jersey Sierra Club · Fisherman's Dock Cooperative · Natural Resources Protective Association · Surfers' Environmental Alliance · WATERSPIRIT · SandyHook SeaLife Foundation · Lenape Nation PA · CWA Local 1075 · Paddleout.org · reEarth · Clean Water Action · Association of NJ Environmental Commissions · Asbury Park Fishing Club · Save Barnegat Bay · Concerned citizens

March 25, 2014
Revised with additional signatures: April 2, 2014

Via electronic mail sent to ITP.Cody@noaa.gov
Ms. Jolie Harrison
Supervisor, Incidental Take Program
Permits and Conservation Division
Office of Protected Resources
National Marine Fisheries Service
1315 East-West Highway
Silver Spring, Maryland 20910

RE: Request for a 60-day extension on the comment period for Takes of Marine Mammals Incidental to Specified Activities; Marine Geophysical Survey in the Northwest Atlantic Ocean Offshore New Jersey, May to August 2014 (RIN 0648-XD141)

Dear Ms. Harrison,

On behalf of groups listed below, we are requesting a 60-day extension to the public comment period for the National Marine Fisheries Service (NMFS) proposed Incidental Harassment Authorization for takes of marine mammals incidental to conducting a marine seismic survey in the northwest Atlantic Ocean off the New Jersey coast. We are also requesting that a public hearing be held in New Jersey prior to the conclusion of the comment period, so that those potentially affected by this activity can become better informed and given an opportunity to comment.

Any proposal to perform seismic surveys off the coasts of New Jersey and New York is a matter of significant public import. Seismic surveys may threaten significant harm to marine mammals, be they whales, dolphins, porpoises or seals. And, as NMFS is certainly aware, seismic testing is the first step towards offshore drilling. Accordingly, the public should be afforded the adequate time and opportunity to take a hard look at the proposed seismic survey.

In addition, the groups listed below require additional time to review the reports referenced in the proposed authorization, including a 2013 draft Environmental Assessment (EA) and a 2011 final Programmatic Environmental Impact Statement (PEIS), as well as to conduct background research into all aspects of the proposal, including the study purpose, goals, and implications for scientific understanding. Given the proposed seismic survey area is located within 15.5 miles of the Jersey Shore, the groups further intend to review the potential for nearshore impacts. Therefore, we the undersigned require a 60-day extension in order to conduct such a review.

We would welcome an opportunity to discuss this matter with you or your staff at your convenience. For further discussion, please contact Cindy Zipf at Clean Ocean Action at 732.872.0111 or zipf@cleanoceanaction.org.

Thank you for your consideration of our requests and we look forward to hearing from you.

Sincerely,

Cindy Zipf
Executive Director
Clean Ocean Action

Claire Douglass
Climate Campaign Director
Oceana

Richard Charter
Coastal Coordination Program
Senior Fellow
The Ocean Foundation

Michael Jasny
Director, Marine Mammal Protection
Natural Resources Defense Council

Miyoko Sakashita
Oceans Director, Senior Attorney
Center for Biological Diversity

Delice Calcote
Executive Director
Alaska Inter-Tribal Council

Rob Kramer
President
International Game Fish Association

Taffy Williams
Director / Board Member
Cetacean Society International
Whale and Dolphin Action League

John Weber
East Coast Regional Manager
Surfrider Foundation

Toni Zimmer
President
League of Women Voters of New Jersey

Tim Dillingham
Executive Director
American Littoral Society

Dede Shelton
Director of Operations/ Executive Director
Hands Across the Sand

Jeff Tittel
Director
New Jersey Sierra Club

Captain Jim Lovgren
Director
Fisherman's Dock Cooperative, Point Pleasant Beach, NJ

James Scarcella
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Natural Resources Protective Association

Richard Lee
Executive Director
Surfers' Environmental Alliance

Sr. Suzanne Golas, csjp
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Mary M. Hamilton
Executive Director
SandyHook SeaLife Foundation

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Scott Thompson
Paddleout.org

Sam Duncombe
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NJ Campaign Director
Clean Water Action

Sandy Batty
Executive Director
Association of NJ Environmental Commissions

Bill Feinberg
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Asbury Park Fishing Club

Britta Wenzel
Executive Director
Save Barnegat Bay

Ada Brunner
Concerned Citizen

Barbara Bennett
Concerned Citizen

Elizabeth S. Sorensen
Concerned Citizen

cc: Open letter
New Jersey Congressional Delegation
Governor Chris Christie

Princeton University

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ITP.Cody@noaa.gov

To: Jolie Harrison, National Marine Fisheries Service
From: Lincoln S. Hollister, Emeritus Professor and Senior Geologist, Princeton University
Subject: 0648-XD141
April 5, 2014

This is a comment on the "Draft Environmental Assessment of a Marine Geophysical Survey by the R/V Marcus G.*Langseth* in the Atlantic Ocean off New Jersey, June-July 2014."

Data from the survey will lead to understanding the effects of sea level change as recorded in sediment deposited on the continental margin of NJ. The survey will be done by a group of scientists, students, and technicians from three universities and will be supported by the National Science Foundation (NSF).

The letter from Clean Ocean Action, an environmental non government organization (eNGO), and signed by 24 other groups and individuals, asks for a 60-day extension in the public comment period in order to give the groups more time to review the science rationale and the environmental impacts of the proposed survey.

The requested delay is not warranted. The science has been reviewed by the incredibly rigorous peer review system of NSF. Furthermore, there are no scientists on the staffs of the eNGOs who have the expertise to properly evaluate the scientific basis of the proposed survey. The environmental impacts (or lack thereof) are explained in the documents, with references to the extensive bibliography. These documents have been reviewed by the national eNGOs for previous applications that planned to use the NSF-supported R/V Langseth. The national eNGOs don't need to start a new environmental review from scratch; they need to respect the data we have. As for local eNGOs, it is unreasonable to think that they can muster an independent review that can substitute for decades of study and observation on the effects of seismic surveys on marine life.

Based on the history of interaction between eNGOs and marine seismic surveys, it is clear that the purpose of the requested delay is to stop the proposed survey. This mirrors a strategy used by several of the signers of the letter. Stopping such a survey is particularly damaging, not just for basic understanding on which to build public policy, but also for academic groups. University-based science is severely set back by such delays. Students don't get the data they need to pursue their theses; professors don't get the publications needed to sustain their research programs. Most importantly, new data and ideas pertaining to the effects of sea level change will be lost.

The concern that oil and gas companies will somehow benefit from the survey and lead to oil and gas development off the NJ shore represents irresponsible paranoia, which is flamed by a couple of the signers of the letter.

I have had experience in dealing with marine seismic surveys and eNGOs. I was lead PI on a hugely successful seismic survey in the inland waterways of British Columbia. It was called ACCRETE and was done in 1994 with airguns 10 times more powerful than those to be used on the NJ project. We had observers on board and monitored the effects of the airguns on marine life. There were none. But, when we tried to do a similar project in 2005 (called Batholiths), which was based on discoveries we made in 1994, we were stopped by national eNGOs who conducted a campaign of disinformation that misled the local eNGOs. Political pressure from the local eNGOs led the Canadian federal government to deny permits for Batholiths. In getting Batholiths cancelled, the eNGOs ignored the observations from ACCRETE. They claimed we were a front for oil and gas, although there were no sediments under the ship track! They kept up their claim because they did not recognize the difference between sedimentary and igneous rocks, nor did they understand that oil and gas do not occur in igneous rocks. Nor did they accept that our data would be useless for oil and gas exploration.... no commercial use was ever made of the ACCRETE data. The small, local eNGOs were taken in by the dishonestly reported data. The loss to science because we could not get the data was immeasurable. The careers of students and young scientists were interrupted and some had to leave a career path in science.

If the proposed delay were granted it would mean the ceding of science and environmental review to organizations that do not have the science expertise to do the reviews. The result of delay would be to stop a project that will aid our efforts toward understanding the effects of sea level change.

Sincerely,

Lincoln S. Hollister
Professor Emeritus and Senior Geologist, Princeton University

dmandch@aol.com Apr 13

to ITP.Cody

I am strongly opposed to noise pollution in our oceans. I believe that new approaches to research need to be developed that will permit scientific mapping of the oceans without seismic events. Mariane animals are very sensitive to seismic noises. In fact a marine animals can lose its ability to function including mating, feeding and protecting itself without its hearing.

We have for too long taking the liberty of filling the oceans with noise. We need to change this philosophy. We should no longer provide incidental take to ocean noise activities. Marine animals, particularly those large mammals that rely so extensively on their should receive the highest level of protection.

Please deny this take permit.

Regards,
Drew Martin
500 Lake Ave. #102
Lake Worth, Fl. 33460

CORY A. BOOKER
NEW JERSEY

141
HART BUILDING
WASHINGTON, DC 20510-3007
(202) 224-3224

United States Senate

April 11, 2014

Dr. Kathryn D. Sullivan
Administrator
National Oceanic and Atmospheric Administration
1401 Constitution Avenue, NW, Room 5128
Washington, DC 20230

Dear Administrator Sullivan:

I write today in regards to the Lamont Doherty Earth Observatory's application for an Incidental Harassment Authorization which would allow the take of marine mammals by harassment to conduct a marine geophysical survey less than 16 miles off the coast of Long Beach Island, New Jersey.

I respectfully request a 60-day extension to the public comment period so that members of the public have sufficient time to review the proposed study and environmental assessment. In addition, I respectfully request that the National Marine Fisheries Service hold a public hearing in New Jersey so that members of the community who may be impacted by the proposed study have an opportunity to comment publically on the proposal.

I am deeply concerned that seismic surveys during the peak summer season just miles off of New Jersey's coast have the potential to cause significant harm not only to marine life and habitat, but to the coastal economy as well. Allowing for seismic surveys off the coast of New Jersey sets a dangerous precedent for future efforts to explore offshore for oil and gas, something I have strongly opposed in the Mid-Atlantic region, especially off of the New Jersey coast.

I appreciate your time and attention to this matter and look forward to your response. If you have any additional questions, please do not hesitate to contact me.

Sincerely,

Cory A. Booker
United States Senator

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Of Beach Access for Mobile Surf Fishing and
The Conservation of Coastal and Marine Resources since 1954

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United Four Wheel Drive Association
New Jersey Outdoor Alliance
Jersey Coast Anglers Association
Clean Ocean Action
Blue Ribbon Coalition

P.O. BOX 511
SEASIDE PARK, NJ 08752

www.NJBBA.org

May 15, 2014

Jolie Harrison, Supervisor
Incidental Take Program
Permits and Conservation Division
Office of ProtectedResources
National Marine FisheriesService 1315 East-West Highway
Silver Spring, MD 20910

Dear Jolie Harrison,
Subject 0648-XD141

At this time, we, the members of the New Jersey Beach Buggy Association oppose the use of Seismic Testing in the mapping of the under lying layers of the ocean floor off the coast of New Jersey. It is not because of the needed geological information that would be gathered, but because of the lack of planning of how this would affect the total ecological system of which the geological system is only a small part.

Even though surveys have been made off the coasts of Australia (the Northern Carnarvon Bain, Australian Northwest Shelf) and the Gulf of Mexico, no references have been given or found concerning the before and after observations on mammal, fish and plant life that can not avoid the repercussions from the impact of the sound waves.

If one refers to the *Sperm Whale Seismic Study in the Gulf of Mexico* prepared by Texas A&M University in 2008, only 17 sperm whales were studied. Even though through these 17 sperm whales some avoidance patterns were observed, no conclusive results could be established. Through statistical predictions a sampling size of n=75 should be used to establish any patterns.

One of the recommendations coming out of this report has called for a delay of the actual seismic testing for a number of years to allow for further data acquisition under controlled conditions of its affect on mammal, fish and plant life.

In a review entitled **A Review of the Impacts of Seismic Airgun Surveys on Marine Life** by Dr Lindy Weigart submitted in Feb of 2014 to the CBD Expert Workshop on Underwater Noise and its Impacts on Marine and Coastal Biodiversity, long term detriment to fish, mammal and invertebrates were discussed. Only a reference to short term study entailing a two month study (start time to written report) of the seismic testing showed no detrimental effects on bivalve mortality rate; this did not address any long term effects.

Until further studies, known or unknown, can be provided concerning the impact on the ecological system, the New Jersey Beach Buggy Association is opposed to the afore mentioned testing using the Seismic Method. We are also requesting a public hearing to be held to answer such questions as "Who be held economically liable for the future loss of the fisheries" and "Was there ever an environmental study performed for concerning other factors other than the geological information that is to be obtained".
Thank you for your time in this matter and in the hope that the seismic testing will be delayed until a full study and review can take place.

Respectfully,

Douglas A. Taylor
Douglas A. Taylor, Corresponding Secretary

Cc: Gov Christy, NJ Governor; Commissioner Bob Martin, NJDEP; US Senator Robert Menendez, NJ; US Senator Cory Booker, NJ

MARINE TRADES
ASSOCIATION OF NEW JERSEY

May 15, 2014

Via electronic mail set to ITP.Cody@noaa.gov
Ms. Jolie Harrison
Supervisor, Incidental Take Program
Permits and Conservation Division
Office of Protected Resources
National Marine Fisheries Services
1315 East-West Highway
Silver Spring, Maryland 20910

RE: Request for a rescheduling of the Takes of Marine Mammals Incidental to Specified Activities; Marine Geophysical Survey in the Northwest Atlantic Ocean Offshore New Jersey during the winter months of January and February, and no later than March.

Dear Ms. Harrison,

We are writing to you on behalf of the Marine Trades Association of New Jersey, a non-profit trade organization, representing over 300 marine related businesses, to state our objection to the proposed marine geophysical survey off the coast of New Jersey that is scheduled to begin on June 3.

This seismic testing is scheduled to occur during the peak of the recreational fishing season in New Jersey (June and July). As you may be aware, seismic surveying can disburse, injure or kill fish and marine mammals and puts at risk endangered species, such as the North Atlantic right whale. Approximately 50% of the boating population fishes, therefore the negative impacts of the study could be far reaching and have a deleterious effect on multiple industries, many of which are still reeling from the effects of Hurricane Sandy.

For these reasons, we respectfully object to the testing and ask that the project be cancelled. In the event, however, that the Administration chooses to sanction the geophysical survey, we urge you to require an alternative time period be implemented, such as the winter months of January and February, when the migration of spawning stocks that utilize the Shelf and Canyons offshore of the proposed site has concluded, and before those species begin their migration inshore. This would, hopefully, minimize impacts to our industry, our coastal fish and migratory marine mammals. Although the survey at that time of year will still have a negative impact, it is more likely to be less significant during that time.

Thank you for your consideration.

Sincerely,

Fred Brueggemann
President

Melissa Danko
Executive Director

cc: New Jersey Congressional Delegation
Governor Chris Christie
Rutgers University President Robert Barchi
Rutgers University SEBS Dean Robert Goodman
MTA/NJ Membership

Marcus Langseth Science Oversight Committee (MLSOC)
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Jolie Harrison, Supervisor
Incidental Take Program
Permits and Conservation Division,
Office of Protected Resources
National Marine Fisheries Service
1315 East-West Highway
Silver Spring, MD 20910
ITP.Cody@noaa.gov

May 15, 2014

Subject: *0648-XD141- Comment on "Takes of Marine Mammals Incidental to Specified Activities; Marine Geophysical Survey in the Northwest Atlantic Ocean Offshore New Jersey, May to August 2014"*

Dear Ms. Harrison:

The members of the Marcus Langseth Science Oversight Committee (MLSOC) are pleased to submit the following comments to the National Marine Fisheries Service about the application for an Incidental Harassment Authorization for the proposed 3D seismic program on the New Jersey Shelf to study sea-level rise. This 3D program uses the *R/V Marcus G Langseth*, a unique asset of the National Academic Fleet with its specially designed capabilities to conduct the proposed seismic program. MLSOC supports the NMFS commitment to science-based decisions in its regulatory process.

The MLSOC is a committee within the University National Oceanographic Laboratories System (UNOLS) and consists of a diverse group of professionals, including geophysicists, geologists, oceanographers, and marine engineers, who provide advice on the scientific operations of *R/V Langseth.* The committee's members have extensive experience in seismic operations around the world aboard *R/V Langseth*, and other seismic vessels, as well as knowledge and experience in mitigation and monitoring identified and/or required under the National Environmental Policy Act (NEPA), the Marine Mammal Protection Act (MMPA) and the Endangered Species Act (ESA). One role of the Committee is to advise both the National Science Foundation (NSF) and the ship operator Lamont Doherty Earth Observatory (LDEO) on safe, efficient, cost-effective, and scientifically compelling operations of *R/V Langseth*.

As a U.S. research vessel, *R/V Langseth* operates entirely within the U.S. regulatory process, and, when appropriate, international laws, required for understanding and mitigating the potential impacts of sound in the environment. NEPA requires proposed agency actions (in this case, NSF, which is proposing a seismic survey) to make the best effort to avoid adverse effects, minimize them, and mitigate them as part of assessing the environmental consequences of the project. The Environmental Assessment (EA), and the associated application for an Incidental Harassment Authorization (IHA) for this 3D seismic experiment on the NJ shelf lay out the program, its potential consequences, possible alternatives, the rationale for why the proposed action is the most efficient and safe program, and mitigation measures that would minimize any potential adverse impacts. Among the factors considered in developing the research plan are:

a. Minimum energy source size to accomplish scientific objectives
b. Mitigation and shut down procedures specific to species
c. Protected Species Visual Observers (PSVO) observations for a standard amount of time, generally 30 minutes prior to the start of the survey to clear a specified area around the vessel, and to monitor marine animal occurrence during seismic operations.
d. Startup of the energy source includes ramp-up procedures over a standard amount of time (generally 30 mins) that serves to alert animals of the activities and allows them to vacate the area if disturbed.
e. No start-up of the seismic source during poor visibility or at night unless at least one airgun has been operating.
f. PSVOs, independent biologists, have authority to shut down the seismic source when marine mammals or sea turtles are detected in or about to enter designated exclusion zones.
g. Passive Acoustic Monitoring (PAM) and infrared sensors during day and night to complement visual monitoring.
h. Additionally, the airguns would be shut down if a North Atlantic right whale were seen at any distance from the vessel.

On the NJ shelf cruise, the proponents propose to use a modest airgun array, much smaller that industry airgun arrays. This is possible because they are using two streamers only 3 km long. Industry streamers are typically 8 to 15 km length. The NJ cruise is part of the solution to innovative cruise planning for acquiring the necessary data for the scientific program with the minimum adverse impacts.

Seismic data are an essential and irreplaceable tool for scientific research in the oceans. Seismic methods are the only tool available for peering directly into the seafloor and acquiring the data necessary to advance understanding of the impact of climate change on the ocean's margins, plate tectonics, submarine landslides, and offshore faulting. Seismic data are also used to map nearshore and coastal changes from storms such as superstorm Sandy so that managers can identify areas of greatest risk to future erosion and coastal modification from these extreme events.

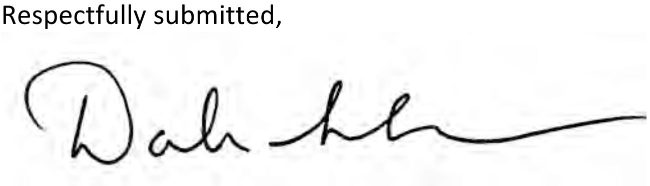
The NJ shelf program fits wholly within this framework and will provide invaluable data on sea level history by imaging former coastlines, rivers, and estuaries now buried beneath the sediments of the shelf. The proposed NJ shelf program uses an airgun array that is only about 10% of the size of the array typically used by industry for oil and gas exploration. Whereas oil and gas exploration requires larger seismic sources to image deep targets, the NJ shelf program is focused on shallow sediments where no oil or gas deposits occur.

If modest seismic programs such as that proposed for the NJ shelf using *R/V Langseth* are not permitted, the future of this unique national asset and the innovative research that it enables will be lost. The U.S. will have no way to investigate and study marine geologic features of critical interest to or potential geohazards along our coastlines, such as earthquakes, tsunamis, and landslides. Further, this means government officials will not be able to make informed polices to better protect its citizen, for example from earthquake or tsunami hazards, especially along populated coastline areas. If the R/V Langseth cannot operate in its own national waters to complete programs relevant to U.S. national interests, what role will science play in policies that safeguard public safety, resilience, and stability?

NSF and LDEO have followed the appropriate IHA process and have conformed with the associated requirements. Although NSF and LDEO consented, without precedent and for no scientific basis, the proposed project has been subjected to an additional 30 day public comment period (for a total of 60 days) under the MMPA IHA process. Based on the information and analysis provided by NSF and LDEO, the proposed activities meet the criteria established for issuance of an IHA. Therefore, the MLSOC urges NMFS to approve this application for an IHA.

R/V Langseth, and its predecessor, *R/V Ewing*, completed more than a decade's worth of academic/government seismic programs with the highest standards of mitigation and monitoring and without the dire, unfounded results purported by opponents of the activities (e.g., no marine mammal mass strandings). As a consequence of past activities, academic scientists have provided significant contributions to society through results which have enhanced our understanding of the Earth, Earth processes, and geohazards. Additionally, observations made by the PSVOs aboard seismic expeditions are contributing to better understanding of the distribution and behavior of marine mammals and sea turtles. We encourage NMFS – as a science based agency – to use science to make informed decisions, perform its regulatory duties, and issue IHAs in an appropriate and timely manner.

Respectfully submitted,



Dr. Dale Sawyer, Chair MLSOC
Rice University

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Paul Baker, Duke University
Nathan Bangs, University of Texas at Austin
Deborah Hutchinson, U.S. Geological Survey
William Lang, Resource Access International
David Scholl, University of Alaska
Alexander Shor, University of Hawaii
Maurice Tivey, Woods Hole Oceanographic Institution

Ex-officio:
Maya Tolstoy, Lamont-Doherty Earth Observatory
Suzanne Carbotte, Lamont-Doherty Earth Observatory

State of New Jersey

DEPARTMENT OF ENVIRONMENTAL PROTECTION
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CHRIS CHRISTIE
Governor

KIM GUADAGNO
Lt. Governor

BOB MARTIN
Commissioner

May 15, 2014

Jolie Harrison, Supervisor
Incidental Take Program
Permits and Conservation Division
Office of Protected Resources, National Marine Fisheries Service
1315 East-West Highway
Silver Spring, MD 20910

RE: Comments for Takes of Marine Mammals Incidental to Specified Activities; Marine Geophysical Survey in the Northwest Atlantic Ocean Offshore New Jersey, May to August 2014
RIN 0648-XD141

Dear Ms. Harrison:

The New Jersey Department of Environmental Protection (Department) respectfully submits the following comments for the above captioned notice, located at Federal Register, Volume 79, No. 68, April 9, 2014, which expires May 16, 2014. The Federal Notice is for an Incidental Harassment Authorization (IHA) to be issued by the National Marine Fisheries Service (NMFS).

Several species of sea turtles and four species of whale, as well as other marine mammals, frequent this region. New Jersey has numerous vessels operating marine mammal boat tours that operate predominately during the summer tourism season, which this study period overlaps. New Jersey's ecotourism is a burgeoning industry that has received positive attention from environmental advocacy groups, as well as national and local media outlets. Harassment of marine mammals and a reduction in sighting potential may have a negative impact on the economic viability of this industry. In addition, when the number of dead and dying dolphins increased in 2013 due to morbillivirus infections, the State of New Jersey via its Animal Health Diagnostic Laboratory within the Department of Agriculture began providing and funding laboratory services for pathology testing of marine mammals. This effort was conducted in coordination with the Marine Mammal Stranding Center, a not-for-profit entity that was not financially equipped to afford the increased amount of testing needed. Should the proposed seismic testing result in increased marine mammal strandings in New Jersey, the impact to state financial resources will be a burden both from on-site state response needed and from any state laboratory services provided. It is reasonably foreseeable that this project is likely to affect these species and have a direct negative impact on State resources.

The IHA notice also focuses on the study's impacts to marine mammals' habitat. The Department is mindful of potential effects to marine mammal habitat not only because of the study's impact to marine mammals' food source, but also for the potential impacts to an important resource to New Jersey's recreational and commercial fishing industry. The proposed area for seismic testing off the coast of NJ extends from Barnegat Ridge to the 35 fathom line and runs in a northwest to southeast direction intersecting fathom curves at a general perpendicular nature along its extent. The entire reach of the survey area is utilized by commercial and recreational fishermen from New Jersey and will detrimentally impact the marine harvest and economy of the State of New Jersey.

Based on NMFS data, New Jersey's fisheries, both commercial and recreational, are some of the most productive, highest grossing and employ more people than other states in the Mid-Atlantic and along the Atlantic Coast. The proposed time frame for the work, late May to August, is the time of peak abundance and fisheries activity off New Jersey. These activities will take place offshore from some of New Jersey's important fishing ports, including Barnegat Light, Atlantic City, and Point Pleasant. Based on the response of fish to high energy sound and the distance an impact is observable, this survey work may further preclude fisheries from a substantial area during peak operations key to the financial viability of our fisheries. Thus, the proposed survey would have a foreseeable effect on public access to and utilization of offshore areas, and would likely alter commercial and recreational fishing catch rates and patterns.

Data analysis of commercial and recreational landings from 1996 – 2013 indicate that this entire area is not only used by multiple commercial fisheries including gillnetters, otter trawl vessels, scallop boats, and long liners, but also an area heavily utilized by recreational fishermen. Both sectors in combination pursue over 35 species of fish in this area including but not limited to; albacore, bluefish, big eye tuna, Bluefin tuna, bonita, black sea bass, butter fish, cobia, cod, smooth dogfish, spiny dogfish, summer flounder, Atlantic menhaden, monkfish, red hake, skate, tilefish, swordfish, yellow fin tuna, and skipjack tuna. Considering just two of the several species harvested during 2013; summer flounder and black sea bass, May through August represents 20 percent of the commercial black sea bass harvest, and 22 percent of the commercial summer flounder harvest. This represents $250,000 worth of black sea bass and $1,360,000 of potential loss of summer flounder. This period generates 21% of commercial harvest revenue for New Jersey fishermen and represents 60 to 100% of the entire recreational season for the species listed above. Recreationally, 67% of the annual black sea bass are harvested during this period while 89% for summer flounder is represented during this time frame. Local businesses including restaurants, hotels, bait and tackle shops, and other coastal related trades are dependent on this time period generating income.

A portion of the proposed survey area is a recognized productive and historical fishing area known as "The Fingers" under NJDEP's Prime Fisheries Area Mapping. Contrary to the portrayal in the Draft Environmental Assessment in support of the IHA, areas beyond State waters are also heavily utilized by New Jersey's commercial and recreational fishing industry. Marine fish and fisheries are protected under the NJCMP, and public access to and use of natural resources are major components of the CZMA and the NJCMP. Based on previous studies examining seismic surveys and fisheries disturbances, it is reasonably foreseeable that the proposed surveys will have an impact from fisheries distribution, movement, migration and spawning perspectives that will lead to direct and indirect negative consequences to NJ's fishing industries. The Svein Løkkeborg, et al. study highlighted that "reduced catches on fishing grounds exposed to seismic survey activities have been demonstrated."[1] The conclusions reached by the Løkkeborg study are further supported by other recent studies concluding that catch rates reduced in the presence of seismic studies.[2]

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[1] Løkkeborg, S.; Ona, E.; Vold, A.; & Salthaug, A., 2012. Effects of Sounds from Seismic Air Guns on Fish Behavior and Catch Rates. Advances in Experimental Medicine and Biology, 730, 415-419.

[2] Fewtrell, J.L. & McCauley R.D., 2012, Impact of Air Gun Noise on Behavior of Marine Fish and Squid. Marine Pollution Bulletin, 64, 984-993.

According to NJ coastal policies, critical wildlife and endangered or threatened wildlife habitats are areas that serve an essential role in maintaining wildlife throughout their lifecycle. New Jersey's CZM rules discourage development that would affect critical wildlife habitats. Offshore waters serve as essential habitat for numerous fish and invertebrate species during various stages of their lifecycles. Studies have concluded that "evidence that noise exposure during larval development produces body malformations in marine invertebrates. Scallop larvae exposed to playbacks of seismic pulses showed significant developmental delays and 46% developed body abnormalities. Similar effects were observed in all independent samples exposed to noise while no malformations were found in the control groups."[3] A reduction in harvestable stock would result in further impacts to our commercial fisheries.

For the reasons stated above, the Department respectfully requests NMFS not issue an IHA for the proposed study because of the likely impact to New Jersey's resources, including marine mammals and marine mammal habitat.

Sincerely,

John Gray, Acting Director
Office of the Deputy Commissioner

Cc: Michele Siekerka, Deputy Commissioner
David Fanz, Assistant Director, Land Use Regulation
Marty Rosen, Manager, New Jersey Coastal Management Program
Brandon Muffley, Manager, Bureau of Marine Fisheries

---

[3] de Soto, N.; Delorme, N.; Atkins, J.; Howard, S.; Williams, J. & Johnson, M. 2013. Anthropogenic noise causes body malformations and delays development in marine larvae. Scientific Reports. 3. Article No. 2831.

Clean Ocean Action · The Ocean Foundation · Center for Biological Diversity
Hands Across the Sand · Save Barnegat Bay · Clean Water Action · CWA Local 1075 ·
Paddleout.org

May 16, 2014

Via electronic mail sent to ITP.Cody@noaa.gov
Ms. Jolie Harrison
Supervisor, Incidental Take Program
Permits and Conservation Division
Office of Protected Resources
National Marine Fisheries Service
1315 East-West Highway
Silver Spring, MD 20910

RE: Comments on the National Marine Fisheries Service Incidental Harassment Authorization for the Takes of Marine Mammals Incidental to Specified Activities; Marine Geophysical Survey in the Northwest Atlantic Ocean Offshore New Jersey, May to August 2014 (RIN 0648-XD141)

Dear Ms. Harrison:

On behalf of the undersigned organizations, Clean Ocean Action (COA) submits the following comments in response to the National Marine Fisheries Service (NMFS) request for comments for the proposed incidental harassment authorization (IHA) for the takes of marine mammals incidental to a marine geophysical survey in the Northwest Atlantic Ocean Offshore New Jersey, May to August 2014 (RIN 0648-XD141).[1]

Lamont-Doherty Earth Observatory (L-DEO), in collaboration with the National Science Foundation, Rutgers University, and the University of Texas, proposes to conduct a seismic vessel survey off the coast of New Jersey between May and August 2014 to study changes in sea level from 60 million years ago to present ("Proposed Project"). The Proposed Project includes the use of two four- or eight-airgun subarrays operating alternately, in conjunction with a multibeam echosounder, sub-bottom profiler, and acoustic Doppler current profiler. The nominal source levels of the airgun subarrays range from 246 to 253 decibels (dB) re: 1 µPa (peak-to-peak), and airguns would fire every 5.4 seconds, 24 hours a day, for a 30 day period set to commence on June 3, 2014. The area to be surveyed is a roughly rectangular region that

[1] 79 Fed. Reg. at 14780 (Monday, March 17, 2014) (hereafter "NMFS IHA").

encompasses approximately 230 square miles and is positioned between 15.5 and 52.8 miles of the coast of New Jersey.

NMFS issued its proposed IHA for takes of 690 marine mammals by harassment under section 101(a)(5)(D) of the Marine Mammal Protection Act (MMPA). The Proposed Project is subject to regulations under the National Environmental Policy Act (NEPA) and must also request a Section 7 Consultation under the Endangered Species Act (ESA)[2] and an Essential Fish Habitat assessment under the Magnuson-Stevens Fishery Conservation and Management Act.[3]

For the reasons detailed herein, the undersigned organizations request denial of the NMFS IHA on the grounds that the potential impacts to marine mammals are incompatible with the goals, mandates, and prohibitions of the MMPA. However, should NMFS determine that it will proceed with issuance of a final IHA, significant revision of the authorization and the completion of a full Environmental Impact Statement (EIS) would be necessary to remedy issues of incomplete information, inadequate assessment of impacts, and insufficient evaluation of alternatives and mitigation measures. Importantly, the Proposed Project should not be conducted during summer, which is the peak of marine mammal (and other marine species) activity off the New Jersey coast, as well as the height of tourism and fishing seasons. Moreover, NMFS would have to ensure that best available science and regulatory review are incorporated into the document, and require stronger mitigation measures and consider different times of year for the Proposed Project.

I. NMFS must ensure that its IHA complies with the MMPA.

The MMPA places a "moratorium on the taking" of marine mammals.[4] Any authorization to take marine mammals must result in the incidental take of only "small numbers of marine mammals of a species or population stock," and can have no more than a "negligible impact" on species and stocks. Furthermore, NMFS must provide for the monitoring and reporting of such takings and must prescribe methods and means of affecting the "least practicable adverse impact" on the species or stock and their habitat.[5]

A. Scientific evidence supports marine mammal harassment below the 160-dB Level B threshold

[2] Section 7 of the ESA (16 U.S.C. 1531 et seq.) outlines the procedures for Federal interagency cooperation to conserve federally-listed species and designated critical habitats.
[3] Public Law (P.L.) 94-265, as amended by the Magnuson-Stevens Fishery Conservation and Management Reauthorization Act (P.L. 109-479). EFH Guidelines at 50 CFR 600.05-600.930 outline the process to satisfy EFH consultation under Section 305(b)(2)-(4)) of the MSA.
[4] 16 U.S.C. § 1371(a).
[5] 16 U.S.C. § 1371(a)(5)(A) & (D).

The proposed IHA uses the single sound pressure level of 160 dB re 1 μPa (RMS) as a threshold for behavioral, sub-lethal take in all marine mammal species affected by the proposed survey.[6] This approach does not reflect the best available science, and the choice of threshold is not sufficiently conservative in several important respects. In fact, five of the world's leading biologists and bioacousticians working in this field recently characterized the 160-dB threshold as "overly simplified, scientifically outdated, and artificially rigid."[7] Therefore, the best available science indicates that NMFS must use a more conservative threshold.

Using a single sound pressure level of 160-dB for harassment represents a major step backward from recent programmatic authorizations. For Navy sonar activity, for example, NMFS has incorporated linear risk functions into its analysis, which endeavor to account for risk and individual variability and to reflect the potential for take at relatively low source levels.[8]

Furthermore, current scientific literature establishes that behavioral disruption can occur at substantially lower received levels for some marine mammal species, including these that will be impacted by the Proposed Project. For example, the startup of a seismic survey has been shown to cause endangered fin and humpback whales to stop vocalizing – a behavior essential to breeding and foraging.[9] Similarly, a low-frequency, high-amplitude fish shoal imaging device was recently found to silence humpback whales at a distance of up to 200 kilometers, where received levels ranged from 5 to 22 dB above ambient noise levels.[10] Groups of humpback whales in the wild have been observed to exhibit avoidance behaviors at a distance of two kilometers from a small airgun array; the received levels in these trials were 159 dB re: 1 μPa^2 peak-to-peak.[11] Blue whale behavioral changes in response to a small airgun array have also been monitored. Researchers tracked a blue whale traveling and vocalizing in the vicinity of a vessel firing a four-gun array with a source level of 215 dB re: 1 μPa^2 peak-to-peak and noted that at a distance of 10 kilometers from the vessel (where the received level was estimated to be 143 dB re: 1 μPa^2 peak-to-peak), the whale ceased vocalizations for an hour and changed

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[6] 79 Fed. Reg. at 14801.

[7] Clark, C., Mann, D., Miller, P., Nowacek, D., and Southall, B., Comments on Arctic Ocean Draft Environmental Impact Statement at 2 (Feb. 28, 2012); *see* 40 C.F.R. § 1502.22.

[8] *See, e.g.*, 74 Fed. Reg. 4844, 4844-4885 (Jan. 27, 2009).

[9] Clark, C.W., and Gagnon, G.C. 2006. Considering the temporal and spatial scales of noise exposures from seismic surveys on baleen whales. (IWC Sci. Comm. Doc. IWC/SC/58/E9); *see also* MacLeod, K., Simmonds, M.P., and Murray, E., Abundance of fin (*Balaenoptera physalus*) and sei whales (*B. Borealis*) amid oil exploration and development off northwest Scotland, *Journal of Cetacean Research and Management* 8: 247-254 (2006).

[10] Risch, D., Corkeron, P.J., Ellison, W.T., and van Parijs, S.M., Changes in humpback whale song occurrence in response to an acoustic source 200 km away, PLoS ONE 7(1): e29741. doi:10.1371/journal.pone.0029741 (2012).

[11] McCauley, R.D., Jenner, M.N., Jenner, C., McCabe, K.A., and Murdoch, J. 1998. The response of humpback whales (*Megaptera novaeangliae*) to offshore seismic survey: Preliminary results of observations above a working seismic vessel and experimental exposures. *Appea Journal*: 692-706.

course significantly.[12] The literature also shows that harbor porpoises are acutely sensitive to a range of anthropogenic sounds, including airguns. They have been observed to engage in avoidance responses 50 miles from a seismic airgun array, a result that is consistent with both captive and wild animal studies showing them abandoning habitat in response to pulsed sounds at very low received levels, well below 120 dB.[13] Cuvier's beaked whales exhibited alarming behavioral impacts when exposed to sonar at low received levels of 89-127dB re: 1 μPa.[14]

Although the proposed IHA NMFS cites many studies that show low-frequency sounds in general and seismic surveys in particular can have significant behavioral impacts to marine mammals well below 160 dB,[15] NMFS nonetheless irrationally continues to rely upon a Level B harassment threshold of 160 dB. NMFS should modify its threshold estimates, as they must be based on the best available science; this would in turn likely significantly increase the estimated number of marine mammal takes incidental to the Proposed Project.

B. NMFS's assertion of no Level A takes is not based on best available science

Although the NMFS IHA states that marine mammal harassment will be limited to Level B takes, evidence in the scientific literature has indicated that temporary threshold shifts (TTS) can occur in cetaceans at source levels lower than proposed for this survey. As NMFS itself cites, a recent study involved the exposure of a captive harbour porpoise to one airgun firing on three occasions at an average source level of 201 dB re: 1 μPa^2 peak-to-peak.[16] In addition to avoidance behavior exhibited by the animal during the trials, the researchers estimated through modeling that the onset of TTS that did not fully subside until *55 hours after exposure*.[17] Moreover, NMFS cannot rationally assume that other marine mammals will not incur injury at noise levels below those in the Proposed Project. The Lucke *et al.* study demonstrates that TTS can occur at different levels for different species of cetaceans. Moreover, controlled exposure trials in which harbor seals were exposed to small airguns firing for one hour at source levels ranging from 215 to 224 dB re: 1 μPa^2 peak-to-peak revealed

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[12] McDonald, M.A., Hildebrand, J.A., and Webb, S.C. 1995. Blue and fin whale observed on a seafloor array in the Northeast Pacific. *Journal of the Acoustical Society of America* **98**: 712-721.

[13] *See, e.g.*, Bain, D.E., and Williams, R., Long-range effects of airgun noise on marine mammals: responses as a function of received sound level and distance (2006) (IWC Sci. Comm. Doc. IWC/SC/58/E35).

[14] DeRuiter, S.L., Southall, B.L., Calambokidis, J., Zimmer, W.M.X., Sadykova, D., Falcone, E.A., Friedlaender, A.S., Joseph, J.E., Moretti, D., Schoor, G.S., Thomas, L., and Tyack, P.L. 2013. First Direct Measurements of behavioural responses by Cuvier's beaked whales to mid-frequency active sonar. *Biology Letters* **9**: 20130223 1 (2013).

[15] 79 Fed. Reg. at 14787.

[16] Lucke, Klaus, Siebert, U., Lepper, P. a, & Blanchet, M.-A. (2009). Temporary shift in masked hearing thresholds in a harbor porpoise (Phocoena phocoena) after exposure to seismic airgun stimuli. *The Journal of the Acoustical Society of America*, 125(6): 4060-70.

[17] Lucke, K., Siebert, U., Lepper, P.A., and Blanchet, M.-A. 2009. Temporary shift in masked hearing thresholds in a harbor porpoise (*Phocoena phocoena*) after exposure to seismic airgun stimuli. *Journal of the Acoustical Society of America* 125: 4060-4070. Emphasis added.

dramatic physiological and behavioral responses, including a fright response evidenced by significant drops in heart rate; decreased stomach temperatures indicating a cessation of feeding; and rapid swimming away from the noise source.[18] Thus, NMFS cannot assume that TTS and even permanent threshold shifts (PTS) would be unlikely for marine mammals in the area of this Proposed Project.

A number of other recent studies indicate that anthropogenic sound can induce PTS at lower levels than anticipated.[19] New data indicate that mid-frequency cetaceans have greater sensitivity to sounds within their best hearing range than was previously thought.[20] NMFS must also consider that even behavioral disturbance can amount to a Level A take if it interferes with essential life functions. For example, TTS can impair reproductive success and fitness that would constitute harm or Level A harassment. Beaked whales are sensitive to noise, and it is not necessarily the auditory damage that causes the injury. Sounds cause beaked whales to change their behavior, including panic response and rapid surfacing, which results in an injury similar to decompression sickness ("the bends").[21]

Given NMFS's decidedly non-conservative approach to estimating impacts thresholds for injury to marine mammals from the proposed survey, it is likely that many more marine mammals will be harmed than NMFS estimates. In light of the best available science, NMFS cannot rationally defend its conclusion that the proposed survey will not lead to any Level A impacts and will have no more than negligible impacts on these species or stocks. NMFS must take into account the best available science and set lower thresholds for level A take, which would lead to larger exclusion zones around the survey.

II. NOAA must prepare an EIS because there are significant environmental impacts from the Proposed Project

[18] Thompson, D., Sjoberg, M., Bryant, M.E., Lovell, P., and Bjorge, A. 1998. Behavioral and physiological responses of harbour (*Phoca vitulina*) and grey (*Halichoerus grypus*) seals to seismic surveys. Report to European Commission of BROMMAD Project. MAS2 C7940098.

[19] Kastak, D., Mulsow, J., Ghoul, A., and Reichmuth, C. 2008. Noise-induced permanent threshold shift in a harbor seal [abstract], *Journal of the Acoustical Society of America* **123**: 2986; Kujawa, S.G., and Liberman, M.C. 2009. Adding insult to injury: cochlear nerve degeneration after "temporary" noise-induced hearing loss, *Journal of Neuroscience* **29**: 14077-14085.

[20] See discussion in Wood, J., Southall, B.L. and Tollit, D.J. 2012. PG&E offshore 3-D Seismic Survey Project EIR – Marine Mammal Technical Draft Report. SMRU Ltd.; Marine Mammal Commission, Marine Mammals and Noise: A Sound Approach to Research Management, Report to Congress, at 46 (March 2007).

[21] Cox, T.M., Ragen, T.J., Read, A.J., Vos, E., Baird, R.W., Balcomb, K., Barlow, J., Caldwell, J., Cranford, T., Crum, L., D'Amico, A., D'Spain, G., Fernandez, A., Finneran, J., Gentry, R., Gerth, W., Gulland, F., Hildebrand, J., Houser, D., Hullar, T., Jepson, P.D., Ketten, D., MacLeod, C.D., Miller, P., Moore, S., Mountain, D.C., Palka, D., Ponganis, P., Rommel, S., Rowles, T., Taylor, B., Tyack, P., Wartzok, D., Gisiner, R., Mead, J., and Benner, L. 2006. Understanding the impacts of anthropogenic sound on beaked whales. *Journal of Cetacean Resource Management* **7**: 177-187.

For the reasons discussed below, we strongly urge NMFS to prepare an EIS for this project, which would include complete scientific substantiation for the project, a thorough analysis of all direct, indirect, and cumulative environmental impacts, and consideration of a full range of alternatives to the project. Moreover, to meet its NEPA obligations, the NEPA document must be made available for public review and comment.[22]

A. Purpose of NEPA and EA and trigger for an EIS

NEPA's fundamental purposes are to guarantee that: (1) agencies take a hard look at the environmental consequences of their actions before these actions occur; and (2) agencies make the relevant information available to the public so that it may also play a role in both the decision-making process and the implementation of that decision.[23] To assure transparency and thoroughness, agencies also must "to the fullest extent possible...[e]ncourage and facilitate public involvement" in decision-making.[24] Despite the fact that a draft Environmental Assessment (EA) was released in December 2013, the public was not offered an opportunity to comment on the Proposed Project until the issuance of the proposed IHA on March 17, 2014, less than three months before the study was scheduled to begin.

The purpose of an EA is to assist the agency in determining whether the project may significantly affect the environment and therefore require a full EIS.[25] An agency may avoid preparing a full EIS if the agency: (1) prepares an environmental assessment identifying and analyzing the action's environmental effects; and (2) makes a finding of no significant impact, which presents the agency's reasons for concluding that the action's environmental effects are not significant.[26] NEPA requires federal agencies to prepare an EIS for all "major federal actions significantly affecting the quality of the human environment."[27] A full EIS is required if "substantial questions are raised as to whether a project...may cause significant degradation of some human environmental factor."[28] To trigger this requirement, the plaintiff "need *not show*

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[22] *See, e.g. Anderson v. Evans*, 314 F.3d 1006, 1016 (9th Cir. 2002) ("the public must be given an opportunity to comment on draft EAs and EISs").
[23] See, e.g. 40 C.F.R. § 1500.1.
[24] 40 C.F.R. §1500.2(d
[25] 42 U.S.C. §4332(2)(C); 40C.F.R. §1508.9.
[26] 40 C.F.R. §§ 150l.4(b), (e); 1508.9; 1508.1.3.
[27] 42 U.S.C. § 4332(2)(C); see also 40 C.F.R. § 1501.4. The Act defines the "human environment" as including "the natural and physical environment and the relationship of people with that environment…This means that economic or social effects are not intended by themselves to require preparation of an environmental impact statement. When an environmental impact statement is prepared and economic or social and natural or physical environmental effects are interrelated, then the environmental impact statement will discuss all of these effects on the human environment." 40 C.F.R. § 1508.14.
[28] *Idaho Sporting Congress v. Thomas*, 137 F.3d 1146, 1149-50 (9th Cir. 1998).

that significant effects will *in fact* occur;" but rather, "raising substantial questions whether a project may have a significant environmental effect is sufficient."[29]

Whether an action may have "significant" impacts on the environment is determined by considering the "context" and "intensity" of the action.[30] "Context" means the significance of the project "must be analyzed in several contexts such as society as a whole (human, national), the affected region, the affected interests, and the locality."[31] Intensity of the action is determined by considering the following ten factors: (1) impacts that may be both beneficial and adverse. A significant effect may exist even if the Federal agency believes that on balance the effect will be beneficial; (2) the degree to which the proposed action affects public health or safety; (3) unique characteristics of the geographic area such as proximity to ecologically critical areas; (4) the degree to which the effects on the quality of the human environment are likely to be highly controversial; (5) the degree to which the possible effects on the human environment are highly uncertain or involve unique or unknown risks; (6) the degree to which the action may establish a precedent for future actions with significant effects or represents a decision in principle about a future consideration; (7) whether the action is related to other actions with individually insignificant but cumulatively significant impacts; (8) the degree to which the action may adversely affect districts, sites, highways, structures, or objects listed in or eligible for listing in the National Register of Historic Places or may cause loss or destruction of significant scientific, cultural, or historical resources; (9) the degree to which the action may adversely affect an endangered or threatened species or its habitat that has been determined to be critical under the federal Endangered Species Act; (10) whether the action threatens a violation of Federal, State, or local law or requirements imposed for the protection of the environment.[32] The presence of one or more significant effects can trigger the need for a full EIS.[33] Based on the nature of potential impacts to marine life from the Proposed Project and the incomplete analysis of such impacts in the EA (discussed further below), a full EIS must be prepared for this study.

B. Availability of new information subsequent to the finalization of the PEIS in 2011 precludes NMFS's reliance on this prior NEPA analysis.

It is inadequate for NMFS to rely on any prior NEPA analysis because there is significant new information about the impacts of seismic surveys on marine mammals and fish. New, relevant

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[29] *Id*. (emphases in original).
[30] 40 C.F.R. § 1508.27.
[31] Id. § 1508.27(a).
[32] 40 C.F.R. § 1508.27(b)(1)-(10).
[33] S*ee, e.g. Nat'l Parks & Conserv. Ass'n. v. Babbitt*, 241 F.3d 722, 731 (9th Cir. 2001) (either of two significance factors considered by the court "may be sufficient to require preparation of an EIS in appropriate circumstances"); *Anderson v. Evans*, 350 F.3d 815, 835 (9th Cir. 2003) (presence of one or more factors can necessitate preparation of a full EIS).

information on marine mammals, specifically North Atlantic right whales and bottlenose dolphins, is discussed herein in Section IV. Additionally, while tiering to a broader EIS may be useful in complying with NEPA, it does not eliminate the need to conduct a thorough analysis of the impacts of the site-specific actions.[34]

C. Cumulative actions and effects have not been adequately evaluated.

In conducting a NEPA review, federal agencies must look at cumulative actions and effects. Cumulative actions are those that "have cumulatively significant impacts and should therefore be discussed in the same impact statement."[35] Similar actions include those that have "common timing or geography."[36] Cumulative impacts are those that result when combined with past, present, and reasonably foreseeable future actions on the resources of the area.[37]

Here, there are numerous activities in the region that will harm the same marine mammals and environment that must be analyzed in a cumulative impacts analysis. The Proposed Project has made only limited consideration of the cumulative impacts of this project in conjunction with other current and/or proposed anthropogenic noise-producing activities in the region. The Draft EA used by NMFS in drafting its IHA devotes only two sentences to the proposed Geologic and Geophysical (G&G) seismic airgun and other related seabed test drilling activities being considered by the Bureau of Ocean Energy Management (BOEM) for the mid- and south-Atlantic OCS Planning areas, which is also out for public review and comment at this time. Cumulative impacts from shipping activities are only addressed in terms of increased vessel traffic, and the additive effects of more noise in the area and a greater potential for ship strikes are not considered. Marine mammal disease is also a concern, particularly for bottlenose dolphins affected in 2013 by *morbillivirus*. The Draft EA only assesses the potential for the Proposed Project to "contribute to the development or continuation of a morbillivirus outbreak"[38] in bottlenose dolphins, but fails to consider the cumulative harmful effects of the Proposed Project on the population in light of the recent morbillivirus outbreak.

Such assessments are significant components of an analysis of potential impacts to marine life from the additional set of noise sources considered in the Proposed Project, and must be assessed in the NMFS IHA.

D. Potential impacts from sound-producing sources other than seismic airguns were not evaluated.

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[34] 40 C.F.R. § 1502.20.
[35] 40 CFR § 1508.25(a)(2).
[36] Id. at § 1508.25(a)(3).
[37] 40 C.F.R. §§ 1502.16, 1508.7, 1508.8, 1508.25(a)(2).
[38] Draft Environmental Assessment (Dec. 2013, rev. April 2014) at 43.

Neither the NMFS IHA nor the EA upon which it relies have offered any meaningful evaluation of the potential impacts that other sound-producing sources used in the Proposed Project may have on marine species. Of particular concern, the NMFS IHA indicates that a high-frequency Kongsberg EM 122 multibeam echosounder will operate concurrently with airgun operations. The multibeam echosounder produces sound in the 10.5 to 13.0 kHz frequency range, which is within the optimal hearing spectrum for many odontocete and pinniped species that may occur in the study area. A 12-kHz multibeam echosounder system operated by an Exxon survey vessel off the coast of Madagascar was implicated by an independent scientific review panel (ISRP) in the mass-stranding of approximately 100 melon-headed whales (*Peponocephala electra*) in 2008.[39] The report of the ISRP stated, "all other possible factors considered were determined by the ISRP to be unlikely causes for the initial behavioral response."[40]

Furthermore, a 2002 seismic expedition in the Gulf of California, also lead by L-DEO, employed a similar multibeam sonar system with a center frequency of 15.5 kHz and source levels of 237 dB. Beaked whale strandings observed in the area of the survey in September 2002 may have been linked to the use of this technology – a federal judge responded by ordering the ship to cease operations.[41]

Based on the correlation between these previous stranding events and the use of multibeam sonar technology, it is imperative that NMFS fully assess the potential for this source to impact marine mammals both on its own and in concert with seismic airgun blasts.

E. The analysis of alternatives in the EA was incomplete.

The "heart" of the NEPA process is an agency's duty to consider "alternatives to the proposed action" and to "study, develop, and describe appropriate alternatives to recommended courses of action in any proposal which involves unresolved conflicts concerning alternative uses of available resources."[42] The CEQ regulations require NMFS to "rigorously explore and objectively evaluate all reasonable alternatives, and for alternatives which were eliminated

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[39] Southall, B.L., Rowles, T., Gulland, F., Baird, R. W., and Jepson, P.D. 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.

[40] Id.

[41] Cox, T.M., Ragen, T.J., Read, A.J., Vos, E., Baird, R.W., Balcomb, K., Barlow, J., Caldwell, J., Cranford, T., Crum, L., D'Amico, A., D'Spain, G., Fernandez, A., Finneran, J., Gentry, R., Gerth, W., Gulland, F., Hildebrand, J., Houser, D., Hullar, T., Jepson, P.D., Ketten, D., MacLeod, C.D., Miller, P., Moore, S., Mountain, D.C., Palka, D., Ponganis, P., Rommel, S., Rowles, T., Taylor, B., Tyack, P., Wartzok, D., Gisiner, R., Mead, J., and Benner, L. 2006. Understanding the impacts of anthropogenic sound on beaked whales. *Journal of Cetacean Resource Management* **7**: 177-187.

[42] 42 U.S.C. §§ 4332(2)(C)(iii), 4332(2)(E).

from detailed study, briefly discuss the reasons for their having been eliminated."[43] "A 'viable but unexamined alternative renders [the] environmental impact statement inadequate.'"[44]

The EA does not devote sufficient evaluation of the No Action alternative, in which researchers conducting the study would not proceed with the Proposed Project but would instead rely on core samples previously conducted in the same area to evaluate historical changes in sea level rise. We also urge NMFS to consider alternative times of year for the Proposed Project and evaluate when the potential for impact to marine life would be at its lowest. Should it be determined that the Proposed Project must continue as planned for the summer of 2014, we urge NMFS to consider alternatives with stronger mitigation measures including larger exclusion zones and lower sound thresholds, avoidance of areas that are high value habitat to marine mammals, suspension of activities in low light and night conditions, use of the fewest surveys and duplicate surveys as possible, and other methods to detect marine mammals beyond visual observation and acoustic monitoring.

III. NMFS must take best available science and the precautionary principle into account.

Several experts in marine mammal bioacoustics have underscored our extremely limited understanding of the potential auditory and behavioral impacts to marine mammals from the use of seismic airguns and other sound-producing technologies. Darlene R. Ketten, a marine biologist and neuro-anatomist at the Woods Hole Oceanographic Institution, has written, "[a]t this time we have insufficient data to accurately predetermine the underwater acoustic impact for anthropogenic sources."[45] Other published scientists have noted, "[g]iven the current state of knowledge…the risk of seismic sources causing hearing damage to marine mammals cannot be dismissed as negligible."[46] Scientists have also commented on the variability in how a seismic source could affect a marine mammal based on the orientation of the source relative to the animal, which is not considered in the Proposed Project. A 2004 review paper on the effects of seismic surveys on marine mammals stated, "[m]arine mammals will be distributed in a variety of positions relative to a seismic array and the signal they receive may have a complicated and variable nature."[47] A study of the environmental implications of marine seismic surveys conducted in Australia published in 2000 concluded, "[i]t was believed slight differences in the orientations of receivers to each array, alignments and depths of array components and of functioning air guns within each array contributed to the measured

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[43] 40 C.F.R. § 1502.14(a).
[44] *Muckleshoot Indian Tribe v. U.S. Forest Serv.*, 177 F.3d 800, 814 (9th Cir. 1999) (quoting *Citizens for a Better Henderson v. Hodel*, 768 F.2d 1051, 1057 (9th Cir. 1985)).
[45] Ketten, D.R. Marine Mammal Auditory Systems: A Summary of Audiometric and Anatomical Data and Implications for Underwater Acoustic Impacts. Polarforschung, 72. Jahrgung, Nr. 2/3, pp. 79-92.
[46] Gordon, J.C.D., Gillespie, D., Potter, J., Frantzis, A., Simmonds, M.P., Swift, R., and Thompson, D. 2004. A Review of the Effects of Seismic Survey on Marine Mammals. *Marine Technology Society Journal* **37**: 14-32.
[47] Id.

differences. Again this exemplified the difficulty of predicting the received air gun level for a specific air gun array."[48]

Because of this high degree of uncertainty in our understanding of impacts to marine mammals from airgun sources, compounded by the variability in the level of impact based on the position of the source relative to a marine mammal, NMFS should be precautionary in its assessment of incidental takes. One of the Principles in the 2010 Final Recommendations of the Interagency Ocean Policy Task Force report urges the use of best available science and the precautionary approach: "Decisions affecting the ocean…should be informed by and consistent with the best available science. Decision-making will also be guided by a precautionary approach as reflected in the Rio Declaration of 1992."[49] Responsible application of the precautionary principle to the NMFS IHA would reasonably have led to the denial of marine mammal takes incidental to the Proposed Project.

IV. Important species information was not incorporated into NMFS's analysis.

Of particular concern is that a 2013 peer-reviewed study demonstrating North Atlantic right whale presence off the New Jersey coast year-round, particularly in the spring and summer months, does not appear to have been incorporated into the NMFS IHA. Furthermore, factors that may compound the number of bottlenose dolphin takes, including the recent population debilitation by *morbillivirus* and the time and area overlaps between the Proposed Project and calving, do not appear to have been taken into account. Inclusion of this information is critical to ensuring that the NMFS IHA is based on the best available science and considers external factors in its take estimates.

A. The presence, abundance, and potential impacts to North Atlantic right whales in the survey area were not adequately evaluated.

With respect to the critically endangered North Atlantic right whale (*Eubalaena glacialis*), NMFS fails to take into account the best available science on population size, cumulative effects, or species presence in the survey area. NOAA estimates that the western population of the North Atlantic right whale contains only about 400 individuals.[50] Because of this critically low population level, NMFS has stated that "no mortality or serious injury for this stock can be

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[48] McCauley, R.D., Fewtrell, J., Duncan, A.J., Jenner, C., Jenner, M-N., Penrose, J.P., Prince, R.I.T., Adhitya, A., Murdoch, J., and McCabe, K. 2000. Marine seismic surveys – A study of environmental implications. *Appea Journal* 692-708.

[49] The White House Council on Environmental Quality. Final Recommendations Of The Interagency Ocean Policy Principle 15 of the Rio Declaration 1992 reads, "in order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall be not used as a reason for postponing cost-effective measures to prevent environmental degradation."

[50] http://www.nmfs.noaa.gov/pr/species/mammals/cetaceans/rightwhale_northatlantic.htm.

considered insignificant."[51] The NMFS IHA authorizes the Level B take of three (3) individual right whales; however, given the low population level and NMFS's own prior statements, take of even one individual would constitute more than a negligible impact and would therefore violate the MMPA.

The NMFS IHA does not cite specific research papers or information on right whales that may give the reader an indication of NMFS reached its decision on the number of authorized takes. For example, in the Behavioral Disturbance section, subsection Baleen Whales, the following whale species are mentioned: gray, bowhead, humpback, blue, sei, fin, and minke.[52] The North Atlantic right whale, arguably the most important marine mammal species in this group of 26 marine mammals authorized for takings due to its strategic status, is not even mentioned in this section. As such, the NMFS IHA provides no analysis of specific right whale impacts from the Proposed Project, other than to authorize three Level B takes. It is unclear whether the variety of other baseline stressors facing right whales in the region, including ship strikes and fishing gear entanglement, were accounted for in the calculation of takes. Nevertheless, it is essential that NMFS consider the cumulative effects of the Proposed Project in addition to these pre-existing stressors.

The peer-reviewed, Whitt *et al.* 2013 paper, "North Atlantic right whale distribution and seasonal occurrence in nearshore waters off New Jersey, USA, and implications for management," should have been considered by NMFS in its evaluation of potential right whale impacts. This study involved the use of passive acoustic monitoring at several locations off the New Jersey coast over the course of two years and found that "North Atlantic right whales are present off New Jersey throughout the year and not only during 'typical' migratory periods."[53] The numbers of up-call detections per day were highest from March through June, which indicates that right whales communicate extensively during this time of year off the New Jersey coast.[54] Furthermore, skim-feeding behavior observed off Barnegat Bay indicated that right whale feeding grounds may extend beyond the generally understood primary feeding areas further north, leading the authors to conclude that the "sightings and acoustic data from the present study also suggest that the nearshore waters of New Jersey may serve habitat functions other than migration for this species."[55] If NMFS has not included this study in its assessment of right whale takes, then the three takes authorized may be a significant underestimation.

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[51] NMFS. 2012. Marine Mammal Stock Assessment Reports (SARs) by Species/Stock; North Atlantic Right Whale (*Eubalaena glacialis*): Western Atlantic Stock. http://www.nmfs.noaa.gov/pr/pdfs/sars/ao2012whnr-w.pdf.
[52] 79 Fed. Reg. at 14787-14788.
[53] Whitt, A.D., Dudzinski, K., and Laliberte, J.R. 2013. North Atlantic right whale distribution and seasonal occurrence in nearshore waters off New Jersey, USA, and implications for management. *Endangered Species* Research 20: 59-69.
[54] Id.
[55] Id.

B. The NMFS IHA does not appear to account for external factors potentially affecting the area bottlenose dolphin population.

Common bottlenose dolphins (*Tursiops truncatus*) are commonly observed in New Jersey coastal waters during the summer months, and have been sighted as far north as Barnegat Light.[56] The Proposed Project authorizes takes of 279 pelagic bottlenose dolphins, the highest number of all the marine mammal species evaluated.[57] This high number of takes is troublesome for two reasons. Firstly, according to Robert Schoelkopf, founding director of the Marine Mammal Stranding Center in Brigantine, NJ, the calving season for bottlenose dolphins in the New Jersey coastal region typically runs from May through June.[58] The Proposed Project would subject newborn calves to intense levels of noise; these individuals are limited in their ability to flee the ensonified area due to their dependence on their mothers and small size, and are possibly also more susceptible to hearing damage than adult dolphins. The Proposed Project does not account for the overlap of the survey period with the bottlenose dolphin calving period, nor does it evaluate the potential heightened sensitivity of bottlenose dolphin calves to anthropogenic noise.

Furthermore, the MMSC recorded 151 bottlenose dolphin strandings in 2013 alone, compared to 19 strandings in 2012. This high number of strandings prompted NOAA to declare an Unusual Mortality Event for bottlenose dolphins along the Atlantic coast from early July 2013 through the present. Investigations led by NOAA have tentatively identified *morbillivirus* as the most probable cause of the strandings.[59] Mr. Schoelkopf has expressed concern about the impact that the Proposed Project could have on the local bottlenose dolphin population: "They've already taken a pretty good beating, death-rate wise. To have the testing conducted during the birthing period could be even more traumatizing to the entire population. If we're looking at a normal death rate on animals because of entanglement and fishing gear, shark bites, [and] pneumonia, then the sonic explosions could be totally devastating to anything that swims underwater."[60] The stranding data indicate that the local bottlenose dolphin population has been compromised by the *morbillivirus* outbreak of 2013, and the Proposed Project puts this population and its numbers under further, unnecessary stress.

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[56] Robert Schoelkopf, pers. comm.
[57] 79 Fed. Reg. at 14802 (Table 5).
[58] Robert Schoelkopf, pers. comm.
[59] http://www.nmfs.noaa.gov/pr/health/mmume/midatldolphins2013.html.
[60] http://thesandpaper.villagesoup.com/p/environmental-organizations-against-proposed-seismic-testing-off-barnegat-bay/1158487.

V. NMFS's determination that only "negligible" impacts to marine mammals will occur is reckless and not scientifically defensible.

The Proposed Project acknowledges the scarcity of data throughout the discussion of potential impacts to marine life, and yet irrationally characterizes impacts to marine life as "negligible." Examples from the text of the Proposed Project that are particularly noteworthy include:

- "We expect that the masking effects of pulsed sounds…on marine mammal calls and other natural sounds will be limited, although there are very few specific data on this."[61]
- "The sound criteria used to estimate how many marine mammals might be disturbed to some biologically-important degree by a seismic program are based primarily on behavioral observations of a few species…for many species there are no data on responses to marine seismic surveys."[62]
- "There is little systematic information available about reactions of toothed whales to noise pulses."[63]
- "[T]here has been no specific documentation of temporary threshold shift let alone permanent hearing damage (i.e., permanent threshold shift), in free-ranging marine mammals exposed to sequences of airgun pulses during realistic field conditions."[64]
- "The available data do not allow identification of a specific exposure level above which non-auditory effects can be expected…or any meaningful quantitative predictions of the numbers (if any) of marine mammals that might be affected in those ways."[65]

Based on the extremely limited amount of real-world data upon which to base its conclusions regarding potential impacts to marine life, how can NMFS comfortably state that the impacts to marine mammals are all expected to be "negligible" and fall within the Level B Harassment classification? As stated previously, in the absence of robust data that points to a low likelihood of impacts, the NMFS IHA should rely on a more conservative, precautionary approach.

VI. The NMFS IHA contains several references to location, project, or species information that is incorrect.

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[61] 79 Fed. Reg. at 14785.
[62] 79 Fed. Reg. at 14787.
[63] 79 Fed. Reg. at 14788.
[64] 79 Fed. Reg. at 14789.
[65] 79 Fed. Reg. at 14791.

The Proposed Project contains several references to information that is incorrect, leading the reader to conclude that "cut and paste" from previously issued NMFS IHAs was employed in the drafting of this document. Examples include:

- "It is considerably less likely that PTS would occur during the proposed seismic survey in Cook Inlet."[66] Cook Inlet is in Alaska. NMFS should ensure that local conditions in the study area have been accounted for in its analysis.
- "Additionally, no beaked whale species occur in the proposed seismic survey area."[67] The Proposed Project states that six beaked whale species are listed as potentially occurring in the proposed seismic survey area; these include Blainville's beaked whale, Cuvier's beaked whale, Gervais' beaked whale, Sowerby's beaked whale, True's beaked whale, and northern bottlenose whale.[68] NMFS should ensure that assessments of potential impacts to these beaked whale species have been completed.
- "…[M]arine mammals might experience stress responses at received levels lower than those necessary to trigger onset TTS. Based on empirical studies of the time required to recover from stress responses…NMFS also assumes that stress responses could persist beyond the time interval required for animals to recover from TTS and might result in pathological and pre-pathological states that would be as significant as behavioral responses to TTS. However, as stated previously in this document, the source levels of the drillships are not loud enough to induce PTS or likely even TTS" (p. 14791). There are no drillships in this proposed study. NMFS should ensure that a complete evaluation of the potential for sources proposed for use in this study to induce TTS or PTS.

How can the assessment of impacts to marine life be accepted as comprehensive, given the apparent lack of close scrutiny that went into drafting it? We urge NMFS to remove such erroneous references from the IHA and ensure that other instances of incorrect information do not exist within the document.

VII. Conclusion

For the reasons detailed above, the undersigned organizations request denial of the NMFS IHA. The Proposed Project threatens serious harm to numerous species of marine mammals and is therefore contrary to the goals, mandates, and prohibitions of the MMPA.

However, should NMFS determine that it will proceed with issuance of a final IHA, significant revision of the authorization and the completion of a full EIS are necessary to remedy issues of

[66] 79 Fed. Reg. at 14790.
[67] 79 Fed. Reg. at 14791.
[68] 79 Fed. Reg. at 14783 (Table 1).

incomplete information, inadequate assessment of impacts, and insufficient evaluation of alternatives and mitigation measures. Importantly, the Proposed Project must not be allowed to be conducted during summer, which is the peak of marine mammal (and other marine species) activity off the New Jersey coast, as well as the height of tourism and fishing seasons. NMFS would also have to ensure that best available science and regulatory review are incorporated into the document, and require stronger mitigation measures and consider different times of year for the Proposed Project.

Sincerely,

Cindy Zipf Executive Director Clean Ocean Action	Cassandra Ornell Staff Scientist Clean Ocean Action
Richard Charter Senior Fellow Coastal Coordination Program The Ocean Foundation	Miyoko Sakashita Oceans Director, Senior Attorney Center for Biological Diversity
Dede Shelton Director of Operations Hands Across the Sand	Britta Wenzel Executive Director Save Barnegat Bay
David Pringle NJ Campaign Director Clean Water Action	Thomas Fagan Executive Board/Treasurer CWA Local 1075
Scott S. Thompson General Director paddleout.org	

Appendix H

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
NORTHEAST REGION
55 Great Republic Drive
Gloucester, MA 01930-2276

JUN 18 2014

Mr. Bauke (Bob) Houtman,
Integrated Programs Sections Head
Division of Ocean Sciences
National Science Foundation
4201 Wilson, Blvd, Room 725
Arlington, VA 22230

ATTN: Ms. Holly Smith

Dear Mr. Houteman:

Columbia's Lamont-Doherty Earth Observatory (LDEO), with funding from the National Science Foundation (NSF), proposes to conduct a high energy, 3-D seismic survey using the R/V *Marcus G Langseth* offshore of the Atlantic coast of New Jersey in June and July 2014 to study the arrangement of sediments deposited during times of changing global sea level from roughly 60 million years ago to the present. The R/V *Langseth* would deploy an air gun array of either 700 in^2 or 1400 in^2 in total discharge volume in water depths ranging from 30 to 745 meters. The receiving system for the returning acoustic signals would consist of four 3000 meter hydrophone streamers. No anchoring of the vessel or placement of equipment on the sea floor would be anticipated during the survey.

We have reviewed the draft Environmental Assessment (DEA) of the Marine Geophysical Survey by the R/V *Langseth* in the Atlantic Ocean off New Jersey and the accompanying Determination of No Adverse Effect on Essential Fish Habitat prepared by the National Science Foundation (NSF). The DEA dated December 2013 is tiered off a 2011 Final Programmatic Environmental Impact Statement (FPEIS)/Overseas Environmental Impact Statement (OEIS) for Marine Seismic Research.

In accordance with the Magnuson-Stevens Fishery Conservation and Management Act (MSA), essential fish habitat (EFH) has been identified and described in the Exclusive Economic Zone portions of the study area by the New England, Mid-Atlantic, and South Atlantic Fishery Management Councils and us. The MSA specifies consultation with us is required for federal actions which may adversely affect EFH. As the federal action agency for this matter, the NSF has determined that the seismic study is expected to have insignificant impacts on fish, EFH and Habitat Areas of Particular Concern.

The EFH Final Rule defines an adverse effect on EFH as "any impact which reduces the quality and/or quantity of essential fish habitat." The rule further states:

> Adverse effects may include direct or indirect physical, chemical, or biological alterations of the waters or substrate and loss of, or injury to, benthic organisms, prey species and their habitat, and other ecosystem components, if such

> modifications reduce the quality and/or quantity of EFH. Adverse effects to EFH may result from actions occurring within EFH or outside of EFH and may include site-specific or habitat-wide impacts, including individual, cumulative, or synergistic consequences of actions. (50 CFR 600.810)

We have reviewed the analysis and proposed mitigation measures contained in the DEA prepared for this action, as well as FPEIS/OEIS. Upon considering the design and nature of this survey, it appears that some level of adverse effect to EFH may occur. However, because much of the research available to date on the adverse effects of seismic survey methods on aquatic resources has been focused on marine mammals and there is little information available on the effects of these activities on fish and benthic organisms, we have no specific EFH conservation recommendations to provide pursuant to Section 305(b) (2) of the Magnuson-Stevens Act at this time. Further EFH consultation on this matter by the NSF is not necessary unless future modifications to the survey are proposed and such actions may result in adverse impacts to EFH.

Additional research and monitoring is needed to gain a better understanding of the potential effects these activities may have on EFH, federally managed species, their prey and other NOAA trust resources, and should be a component of future NSF funded seismic survey activities. This will aid in the development of site and project specific EFH conservation recommendations for future projects as appropriate.

Be advised that separate correspondence will be provided by our Office of Protected Resources regarding their evaluation of the Incidental Harassment Authorization request and the Section 7 of the Endangered Species Act consultation for this action. For additional information on the status of these evaluations please contact Jeannine Cody at (301) 427-8401 or jeannine.cody@noaa.gov.

If you have any questions or need additional information, please do not hesitate to contact Karen Greene at 732 872-3023 or karen.greene@noaa.gov .

Sincerely,

Louis A. Chiarella
Assistant Regional Administrator
Habitat Conservation Division

cc:
F/SER, David.Dale@noaa.gov
F/GAR, Karen.Greene@noaa.gov
F/HC, Terra.Lederhouse@noaa.gov
F/PR, Jeanne Cody@noaa.gov

Appendix I

Smith, Holly E.

From:	Hassell, Kevin <Kevin.Hassell@dep.nj.gov>
Sent:	Tuesday, May 20, 2014 2:26 PM
To:	Smith, Holly E.; kerry.kehoe@noaa.gov; Blanco, Caroline M; David Kaiser - NOAA Federal; Gregory Mountain (gmtn@rci.rutgers.edu); margaret.davidson@noaa.gov
Cc:	Glynnis Roberts - NOAA Affiliate; Randall Schneider - NOAA Federal; Gray, John; Fanz, Dave; Siekerka, Michele; Rosen, Martin; Kopkash, Ginger; Jackie Rolleri - NOAA Federal (jackie.rolleri@noaa.gov)
Subject:	NSF funded seismic suvey
Attachments:	NSFRutgersSeismic.pdf

To Whom It May Concern:

Please find attached an electronic copy of the federal consistency notice of intent to review letter submitted on May 16, 2014 by the New Jersey Coastal Management Program, within the N.J. Department of Environmental Protection, with respect to the proposed National Science Foundation funded 3-d Seismic survey offshore New Jersey.

Kevin Hassell
Environmental Specialist 3
NJ Department of Environmental Protection
Division of Coastal and Land Use Management
401 East State St, 7W
Mail Code 401-07C, PO Box 420
Trenton, NJ 08625-0420
609-984-7897
Kevin.Hassell@dep.state.nj.us

COASTAL MANAGEMENT PROGRAM

State of New Jersey
DEPARTMENT OF ENVIRONMENTAL PROTECTION
LAND USE MANAGEMENT
P.O. Box 420, 401 East State Street
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CHRIS CHRISTIE
Governor

KIM GUADAGNO
Lt. Governor

BOB MARTIN
Commissioner

May 16, 2014

Ms. Margaret Davidson
Acting Director
Office of Ocean and Coastal Resource Management
NOAA Ocean Service
1305 East-West Highway
SSMC4 N/ORM3 Rm. 11211
Silver Spring, MD 20910

RE: Federal Funding by National Science Foundation to Rutgers University, for conducting 3-D seismic surveys in the Atlantic Ocean

Dear Ms. Davidson:

The New Jersey Coastal Management Program (NJCMP), within the New Jersey Department of Environmental Protection, is notifying the Office of Ocean and Coastal Resource Management (OCRM), the National Science Foundation (NSF), and Rutgers University (Applicant) of its intent to review the above-referenced activity (project) for consistency with the enforceable policies of the NJCMP. Since the activity discussed below is an unlisted activity under the NJCMP, the NJCMP is providing this notice to discuss: the NJCMP's authority under applicable Federal Coastal Zone Management Act (CZMA) rules; the timely submission of this request; and facts supporting the need for a consistency determination. NJCMP believes that the proposed seismic surveys will have both direct and indirect reasonably foreseeable effects on the uses and resources of New Jersey's coastal zone relating to commercial fishing, recreational fishing and boating; marine fish, sea turtles and marine mammals; and, shipwrecks and historic and archaeological resources.

1.0 - Project Background

On March 17, 2014, the National Marine Fisheries Service (NFMS) published a Federal Register Notice (79 FR 14779, March 17, 2014) announcing the proposed issuance of an Incidental Harassment Authorization to the Lamont Doherty Earth Observatory in collaboration with the National Science Foundation (NSF) to take marine mammals by harassment incidental to conducting a marine geophysical (seismic) survey in the northwest Atlantic Ocean from May through August 2014. The project involves conducting high-energy, 3-dimensional (3–D) seismic surveys on the R/V Langseth in the northwest Atlantic Ocean approximately 25 to 85 kilometers (km) (15.5 to 52.8 miles (mi)) off the New Jersey coast for approximately 32 days from June 3 to July 9, 2014. The proposed study (e.g., equipment testing, startup, line changes, repeat coverage of any areas, and equipment recovery) would include approximately 720 hours of airgun operations. The proposed survey would cover approximately 4,900 km (3,045 mi) of transect lines within a 12 by 50 km (7.5 by 31 mi) area. Each transect line would have a spacing interval of 150 m (492 ft) in two 6-m (19.7-ft) wide race-track patterns. The operation of high energy surveys for approximately 30 contiguous days may have a profound impact on New Jersey's fisheries.

On April 22, 2014, a conference call was held between NJCMP, OCRM and NSF staff to discuss the proposed activity. During that conference call, it was determined that Rutgers University will be the recipient of the NSF funding as the Principal Investigator for the scientific research related to the surveys that require the proposed incidental harassment authorization. On May 7, 2014 another conference call was held between NJCMP, OCRM, and NSF to discuss alternate arrangements to assuage the NJCMP's concerns over potential impacts to New Jersey's resources. On this call, OCRM also provided NJCMP with the details necessary to submit this request. While the conference call was beneficial to lay the foundation for an alternative resolution to this matter, the NJCMP made clear that the State of New Jersey would pursue this request since a final resolution was not agreed upon and the NJCMP is required to timely submit this request.

2.0 – Timely Submission of this Request

As discussed on the May 7, 2014 conference call, OCRM informed NJCMP that a threshold matter to resolve is the NJCMP's "timely submission" of this request. NJCMP requested clarification on the definition of timely submission and OCRM directed NJCMP to evaluate the applicability of several sources of information: Federal Executive Order (EO) 12372 (1982); and other intergovernmental agreements.

EO 12372 (1982) does not apply to this NJCMP request. Section 1 states the purpose of the EO 12372 (1982) is to "provide opportunities for consultation by elected officials of those State and local governments...directly affected by, proposed Federal financial assistance or direct Federal development." Section 4 further states that the Office of Management and Budget (OMB) will maintain a list of official state entities to review and coordinate Federal financial assistance or direct Federal development. A review of OMB's published state entities reveals that New Jersey is not listed with a coordinating entity. OMB's publication states that "States that are not listed on this page have chosen not to participate in the intergovernmental review process." http://www.whitehouse.gov/omb/grants_spoc. Since New Jersey is not a party to this agreement, EO 12372 (1982) is inapplicable to this request.

NJCMP conducted a survey among several New Jersey Department of Environmental Protection (NJDEP) programs to ascertain the applicability of other intergovernmental agreements. The conclusion reached is that agreements exists primarily between the NJDEP and U.S. Environmental Protection Agency (USEPA), typically in the form of our Performance Partnership Agreements (PPAs) for various delegated, authorized, or assumed programs. These PPAs do not specify or define what timely submission is for NJDEP requests to USEPA. Because no other agreements are dispositive on this issue, the NJCMP cannot define timely submission based on other intergovernmental agreements.

Since EO 12372 (1982) and other intergovernmental agreements are inapplicable to determining timely submission, the NJCMP believes a reasonable standard is appropriate in defining timely submission. The NJCMP has reasonably submitted this request in a timely fashion primarily because the NJCMP has made good faith efforts to work with NSF to modify the study to alleviate the NJCMP's concerns over the potential impacts to New Jersey's resources. From March 2014 to the May 7, 2014 conference call, the NJCMP conducted the following activities: researched the potential impacts of the proposed activities with NJDEP experts; conferred with stakeholders including the environmental, marine mammal, and recreational and commercial fishing advocates; and worked with NSF on alternative study arrangements. Within 9 calendar days from the last conference call with NJCMP, NSF, and OCRM, the NJCMP is submitting this request. The NJCMP believes that based on the NJCMP's diligence in organizing information and working with interested parties, the NJCMP has demonstrated a timely submission for this request.

3.0 - Applicable Authority to Request Federal Consistency

Under Section 307(c)(1)(A) of the CZMA at 16 USC 1456(c)(1)(A), each Federal agency activity within or outside the coastal zone that affects any land or water use or natural resource of the coastal zone shall be carried out in a manner which is consistent, to the maximum extent practicable, with the enforceable policies of the approved State Coastal Management Programs. Subpart C of the Federal Consistency Regulations at 15 CFR 930 address consistency for Federal Agency Activities. Under the Federal Consistency Regulations at 15 CFR 930.31(c), Federal actions that include any federal agency activity functions performed by or on behalf of a federal agency in exercise of its statutory responsibilities may be subject to the federal consistency requirements and to the regulations promulgated by the National Oceanic and Atmospheric Administration (NOAA) that implement that statutory provision. In addition, any assistance provided under a federal program to a State or local government or any related public entity through grant or contractual arrangements, loans, subsidies, guarantees, insurance, or other form of financial aid may also be subject to the federal consistency requirements.

The NJCMP believes that the proposed project may reasonably be expected to affect the uses and resources of New Jersey's coastal zone. 15 CFR § 930.33(c) states that Federal agency activities outside of the coastal zone are subject to Federal Agency review to determine whether they affect any coastal use or resource. 15 CFR § 930.33(d) states that

Federal agencies shall broadly construe the effects test to provide State agencies with consistency determinations, while 15 CFR § 930.34(c) further clarifies that State agency notification is neither a substitute for, nor does it eliminate Federal agency responsibility to comply with the consistency requirement, and provide State agencies with consistency determinations. The NJCMP believes that NSF, as a Federal Agency in ownership of the research vessel R/V Langseth conducting the work and with Lamont Doherty Earth Observatory acting on NSF's behalf in operation of its vessel, is subject to Subpart C of the federal consistency regulations and therefore, NSF should have provided a consistency determination to the NJCMP.

In addition, Rutgers University, as a recipient of the NSF funding to conduct the research, and subject to concurrence by OCRM with this determination, under Section 307(d)- Federal Assistance and its implementing regulations, is required, as the Applicant, to prepare and submit to the NJCMP a consistency certification analyzing the consistency of the proposed project with the enforceable policies of the NJCMP based on reasonably foreseeable effects on New Jersey's coastal uses and resources. Reasonably foreseeable effects are discussed in Section 4 of this request.

A "foreseeable effect" pursuant to 15 CFR 930.11(g) includes "both direct effects which result from the activity and occur at the same time and place as the activity, and indirect (cumulative and secondary) effects which result from the activity and are later in time or farther removed in distance, but are still reasonably foreseeable." In accordance with this definition, the proposed seismic survey has reasonably foreseeable effects on the uses and resources of New Jersey's coastal zone. Based on information available to the NJCMP, the NJCMP believes that the proposed survey would have reasonably foreseeable direct effects on New Jersey's coastal zone since the study area is directly used by New Jersey's commercial and recreational fishermen. Further, for the reasons described below, the NJCMP believes that the proposed seismic surveys will have both direct and indirect reasonably foreseeable effects on the uses and resources of New Jersey's coastal zone relating to commercial fishing, recreational fishing and boating; marine fish, sea turtles and marine mammals; and, shipwrecks and historic and archaeological resources.

4.0 - Foreseeable effects on Coastal Uses and Resources

The regulatory standard for OCRM's approval of the NJCMP request is that the proposed activity has reasonably foreseeable effects on uses or resources of the State's coastal zone pursuant to 15 CFR 930.95(d). Based on the initial information provided by the applicant, the NJCMP concludes that the activity satisfies this requirement.

Although federal assistance for research activities beyond New Jersey's coastal zone is not specifically listed under New Jersey's Federal Consistency jurisdiction, the proposed testing does represent an unlisted activity requiring federal assistance that the NJCMP believes may have a reasonably foreseeable effect on uses or resources of New Jersey's coastal zone. In such cases, the regulations implementing the CZMA require OCRM's approval of the NJCMP's request to review the activity pursuant to 15 CFR § 930.95(d). If OCRM grants review approval, the CZMA and its implementing regulations delay the

NSF from approving assistance for the activity until either the NJCMP concurs with a consistency certification or the NJCMP review period expires, whichever occurs first. If OCRM denies the NJCMP's request for review, the NSF may proceed to authorize the activity without NJCMP concurrence pursuant to 15 CFR § 930.54(c).

4.1 - Reasonably Foreseeable Effects to Commercial Fishing, Recreational Fishing, and Boating

The proposed area for seismic testing off the coast of NJ extends from Barnegat Ridge to the 35 fathom line and runs in a northwest to southeast direction intersecting fathom curves at a general perpendicular nature along it's extent. The entire reach of the survey area is utilized by commercial and recreational fishermen from New Jersey and will detrimentally impact the marine harvest and economy of the State of New Jersey.
A portion of the proposed survey area is a recognized productive and historical fishing area known as "The Fingers" under NJDEP's Prime Fisheries Area Mapping. Contrary to the portrayal in the Draft Environmental Assessment in support of the IHA, areas beyond State waters are also heavily utilized by New Jersey's commercial and recreational fishing industry. Marine fish and fisheries are protected under the NJCMP, and public access to and use of natural resources are major components of the CZMA and the NJCMP. Based on previous studies examining seismic surveys and fisheries disturbances, it is reasonably foreseeable that the proposed surveys will have an impact from fisheries distribution, movement, migration and spawning perspectives that will lead to direct and indirect negative consequences to NJ's fishing industries. Svein Løkkeborg, et al.) highlighted that "reduced catches on fishing grounds exposed to seismic survey activities have been demonstrated."[1] The conclusions reached by the Løkkeborg study are further supported by other recent studies concluding that catch rates reduced in the presence of seismic studies.[2]

Based on NMFS data, New Jersey's fisheries, both commercial and recreational, are some of the most productive, highest grossing and employ more people than other states in the Mid-Atlantic and along the Atlantic Coast. The proposed time frame for the work, late May to August, is the time of peak abundance and fisheries activity off New Jersey. These activities will take place offshore from some of New Jersey's important fishing ports, including Barnegat Light, Atlantic City, and Point Pleasant. Based on the response of fish to high energy sound and the distance an impact is observable, this survey work may further preclude fisheries from a substantial area during peak operations key to the financial viability of our fisheries. Thus, the proposed survey would have a foreseeable effect on public access to and utilization of offshore areas, and would likely alter commercial and recreational fishing catch rates and patterns.

Data analysis of commercial and recreational landings from 1996 – 2013 indicate that this entire area is not only used by multiple commercial fisheries including gillnetters,

[1] Løkkeborg, S.; Ona, E.; Vold, A.; & Salthaug, A., 2012. Effects of Sounds from Seismic Air Guns on Fish Behavior and Catch Rates. Advances in Experimental Medicine and Biology, 730, 415-419.
[2] Fewtrell, J.L. & McCauley R.D., 2012, Impact of Air Gun Noise on Behavior of Marine Fish and Squid. Marine Pollution Bulletin, 64, 984-993.

otter trawl vessels, scallop boats, and long liners, but also an area heavily utilized by recreational fishermen. Both sectors in combination pursue over 35 species of fish in this area including but not limited to; albacore, bluefish, big eye tuna, Bluefin tuna, bonita, black sea bass, butter fish, cobia, cod, smooth dogfish, spiny dogfish, summer flounder, Atlantic menhaden, monkfish, red hake, skate, tilefish, swordfish, yellow fin tuna, and skipjack tuna. Considering just two of the several species harvested during 2013; summer flounder and black sea bass, May through August represents 20 percent of the commercial black sea bass harvest, and 22 percent of the commercial summer flounder harvest. This represents $250,000 worth of black sea bass and $1,360,000 of potential loss of summer flounder. This period generates 21% of commercial harvest revenue for New Jersey fishermen and represents 60 to 100% of the entire recreational season for the species listed above. Recreationally, 67% of the annual black sea bass are harvested during this period while 89% for summer flounder is represented during this time frame. Local businesses including restaurants, hotels, bait and tackle shops, and other coastal related trades are dependent on this time period generating income.

Offshore waters also serve as essential habitat for invertebrate species during various stages of their lifecycles. Studies have provided "evidence that noise exposure during larval development produces body malformations in marine invertebrates. Scallop larvae exposed to playbacks of seismic pulses showed significant developmental delays and 46% developed body abnormalities. Similar effects were observed in all independent samples exposed to noise while no malformations were found in the control groups."[3] A reduction in harvestable stock would result in further impacts to our commercial fisheries.

Consequently, the NJCMP has concluded that there are reasonably foreseeable effects on New Jersey's commercial fishing industry and recreational boating and fishing industries, which are based in ports, marinas and other upland facilities located throughout New Jersey's coastal zone.

4.2 - Reasonably Foreseeable Effects to Marine Mammals and Sea Turtles

According to NJ coastal policies, critical wildlife and endangered or threatened wildlife habitats are areas that serve an essential role in maintaining wildlife throughout their lifecycle. New Jersey's CZM rules discourage development that would affect critical wildlife habitats.

Several species of sea turtles and four species of whale, as well as other marine mammals, frequent this region. New Jersey has numerous vessels operating marine mammal boat tours that operate predominately during the summer tourism season, which this study period overlaps. New Jersey's ecotourism is a burgeoning industry that has received positive attention from environmental advocacy groups, as well as national and local media outlets. Harassment of marine mammals and a reduction in sighting potential

[3] de Soto, N.; Delorme, N.; Atkins, J.; Howard, S.; Williams, J. & Johnson, M. 2013. Anthropogenic noise causes body malformations and delays development in marine larvae. Scientific Reports. 3. Article No. 2831.

may have a negative impact on the economic viability of this industry. In addition, when the number of dead and dying dolphins increased in 2013 due to infections, the State of New Jersey via its Animal Health Diagnostic Laboratory within the Department of Agriculture began providing and funding laboratory services for pathology testing of marine mammals. The increased mortality was largely due to morbillivirus infections. This effort has been conducted in coordination with the Marine Mammal Stranding Center, a not-for-profit entity that was not financially equipped to afford the increased amount of testing needed. Should the proposed seismic testing result in increased marine mammal strandings in New Jersey, the impact to state financial resources will be felt both from any on-site state response needed and from any state laboratory services provided. It is reasonably foreseeable that this project is likely to affect these species and have a direct negative impact on State resources.

4.3 - Reasonably Foreseeable Effects to Shipwrecks and Historic and Archaeological Resources.

Shipwrecks and artificial reefs are recognized by the NJCMP as special areas. Under the CZM rules, this special area includes all permanently submerged or abandoned remains of vessels, and other features including, among other things, artificial reefs, anchors, quarry rocks or lost cargo, that serve as a special marine habitat or are historic and cultural resources. These offshore features are the frequent destination of New Jersey's recreational fishermen, as well as the state's sports divers. The proposed project is reasonably likely to affect the accessibility of shipwrecks and historic and archaeological resources during the survey period.

5.0 - Conclusion

The federal agency activities and federal assistance that are the subject of the application to the NMFS for an IHA are reasonably likely to also affect the land and water uses and natural resources of New Jersey's coastal zone and thus the activities are subject to the consistency review requirements of Section 307(a) and Section 307(d) of the CZMA. By this letter, and pursuant to the regulations implementing the CZMA at 15 CFR § 930.33(c) and 15 CFR § 930.95(d), the NJCMP requests that OCRM concur with our assessment that NSF is responsible to provide New Jersey with a consistency determination and also approve review of this proposed activity based on federal assistance to a public institution. In addition, by this letter, the NJCMP is informing the Applicant (Rutgers) of its right to submit to OCRM within 15 days from the Applicant's receipt of this letter, comments on New Jersey's request to review this activity.

If you have any questions concerning this letter, please contact John Gray at (609) 292-6877.

Sincerely,

Virginia KopKash
Assistant Commissioner
Land Use Management

CC List:

David Kaiser, NOAA
Kerry Kehoe
Randall Schneider, NOAA
Glynnis Roberts, NOAA
Holly Smith, NSF
Dr. Gregory Mountain, Rutgers University, Applicant
Michele Siekerka, NJDEP, Deputy Commissioner
David Fanz, NJDEP, Land Use Management
John Gray, NJDEP, Office of Permit Coordination and Environmental Review

Appendix J

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SERVICE
OFFICE OF OCEAN AND COASTAL RESOURCE MANAGEMENT
Silver Spring, Maryland 20910

MAY 2 2 2014

Ms. Holly Smith
National Science Foundation
4201 Wilson Blvd., Room 725
Arlington, VA 22230

Re: Federal Consistency Review of Federal Funding by the National Science Foundation to Rutgers University for Conducting Seismic Surveys in the Atlantic Ocean

Dear Ms. Smith:

By a letter dated May 16, 2014, and received on May 20, 2014, the State of New Jersey has announced its intent to review the proposed marine geophysical survey by Rutgers University aboard the R/V Marcus G. Langseth in the Atlantic Ocean in the federal waters offshore of New Jersey during the period June-July 2014.

OCRM has notified the state that it will review the state's request to determine whether the activity is subject to the review requirements for Federal Financial Assistance to State and Local Governments under 15 C.F.R. part 930, subpart F of the Coastal Zone Management Act (CZMA) Federal Consistency regulations.

In reviewing the state's request, OCRM will need to determine who the applicant is for the award by the National Science Foundation to support the survey; who is/are the recipient[s]; and who is/are the principal investigator[s] for this project. Thank you for your May 21, 2014, email providing documents stating that Rutgers University is a grant applicant and principal investigator and that Lamont-Doherty Earth Observatory was dropped from the application. However, we also need to understand the respective roles of the University of Texas and Lamont-Doherty Earth Observatory's remaining role, if any, and any other institutions participating in this project. Of particular interest is an explanation of the connection between the Rutgers University project and the need for Lamont-Doherty Earth Observatory to obtain an Incidental Harassment Authorization from the National Marine Fisheries Service under the Marine Mammal Protection Act. By this letter, OCRM is requesting that the National Science Foundation provide information that is pertinent to answering these questions.

If it is determined that the activity is subject to the subpart F requirements, OCRM will determine if the request has been made by the state in a timely manner and, if so, whether the state has shown that there are reasonably foreseeable effects to coastal uses or resources of the state that would result from the activity.

If it is determined that the activity is not subject to the subpart F requirements, the National Science Foundation as the funding agency for this project would need to determine whether to submit to New Jersey a CZMA consistency determination or a negative determination under 15 C.F.R. part 930, subpart C.

Please contact Mr. Kerry Kehoe at 301-563-1151; Kerry.Kehoe@noaa.gov with any questions that you may have in regards to OCRM's review.

Sincerely,

Paul Scholz
Acting Director

Appendix K

NATIONAL SCIENCE FOUNDATION
4201 WILSON BOULEVARD
ARLINGTON, VIRGINIA 22230

May 29, 2014

Paul Scholz, Acting Director
Office of Ocean and Coastal Resource Management
National Ocean Service
National Oceanic and Atmospheric Administration
Silver Spring, Maryland 20910

Re: Federal Consistency Review of Federal Funding by the National Science Foundation to Rutgers University for Conducting Seismic Surveys in the Atlantic Ocean

Dear Mr. Scholz:

I am in receipt of your letter dated May 22, 2014, in which you request information related to the proposed marine geophysical survey by Rutgers, the State University of New Jersey (Rutgers) offshore of New Jersey scheduled for early this summer. Below is a summary of the proposed project, and a description of the roles of the Principal Investigators (PIs), the National Science Foundation (NSF), and the operator of the research vessel *Marcus G. Langseth (R/V Langseth)*, Columbia University's Lamont-Doherty Earth Observatory (LDEO). In addition, included are some relevant facts concerning the interactions between the State of New Jersey's Department of Environmental Protection (NJDEP), the National Oceanic and Atmospheric Administration's Office of Ocean and Coastal Resource Management (OCRM), and NSF. On behalf of NSF, I sincerely hope that the information provided during our several conversations with your staff and in this letter will assist you in your review of NJDEP's request to determine whether the proposed project is subject to the review requirements for Federal Financial Assistance to State and Local Governments under 15 C.F.R. part 930, Subpart F of the Coastal Zone Management Act (CZMA) Federal Consistency regulations.

I. Description of Proposed Project

NSF received a collaborative proposal from the PIs, Drs. G. Mountain (Rutgers) and C. Fulthorpe, J. Austin, and M. Nedimovic (University of Texas at Austin's Institute for Geophysics

(UTIG)) to collect data essential to Earth processes (*see* Attachment 1). The purpose of the proposed project 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 kilometer 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 PIs worked collaboratively to prepare and submit the single research proposal to NSF for funding consideration; while each institution submitted a separate proposal, the content of each proposal is the same and together they constitute one proposed project. In fact, they are connected in the NSF EJacket system and referred to as one, single proposed project.

II. The Principal Investigators

The proposal received by NSF was a collaborative effort submitted by Drs. G. Mountain C. Fulthorpe, J. Austin, and M. Nedimovic to collect data essential to Earth processes. Dr. Mountain of Rutgers is, however, the scientific lead for the proposed project, making Rutgers the lead institution for the proposed project and Dr. Mountain the lead PI. Dr. Mountain has been the key proponent of the proposed collaborative research activities and survey design. He has been involved in previous research efforts in the survey area, including previous seismic surveys in 2002, 1998, 1996, and 1990. As the lead PI, he will serve as the integrator of the research activities, coordinating various components of the efforts by other scientists involved in the project. To support the proposed project, Dr. Mountain submitted a "Ship Time Request" to use the R/V *Langseth* through the University-National Oceanographic Laboratory System (UNOLS) and is positioned to participate on the cruise as Chief Scientist.

Although Rutgers is the lead institution for the proposed project, UTIG is a collaborating institution. Drs. Fulthorpe, Austin, and Nedimovic of UTIG are collaborators on the proposed project with Dr. Mountain. While all scientists will participate collaboratively on various components of the single proposal and have important independent roles in ensuring the project's success, Dr. Mountain remains the lead PI for the entire research effort.

III. <u>The Funding Stream</u>

A. Research Funding

As discussed above, the proposed project is one, single, project. The monetary support provided by NSF, however, is divided into two funding streams: (1) Rutgers; and, (2) UTIG. Although the original collaborative proposal received by NSF included research funding requests for Rutgers, UTIG, and LDEO, LDEO will not receive research funding. Based on NSF science priorities and current budgetary constraints, the cognizant NSF Program Officer negotiated the proposal budget and, as a result, funding sought for an LDEO researcher will not be provided. Additionally, subsequent to the original proposal submission, but prior to the budget negotiation, Dr. Nedimovic accepted a position at UTIG; thus, he was added to the UTIG budget and, therefore, funding for his research role would be through UTIG. Consequently, funding for the proposed research activities would only go to Rutgers and UTIG. These two funding streams are reflected in the grant letters for the proposed collaborative research effort (*see* Attachments 2 and 3).

B. Funding of Ship Operations

Pursuant to a five year Cooperative Agreement (CA), originally awarded in 2012, LDEO receives funds to operate the R/V *Langseth* (*see* Attachment 4). This funding is to allow LDEO to act as the vessel operator so that a platform is available to NSF-funded researchers for conducting marine scientific research. With regard to the proposed project, the lead PI (Dr. Mountain of Rutgers) requested ship time on the R/V *Langseth* because it is the only vessel in the U.S. Academic Fleet that is capable of supporting the research. Therefore, the operation of the R/V *Langseth* should be viewed as incidental to the proposed research. Use of the R/V *Langseth* to facilitate the lead PI in carrying out the proposed project has been scheduled for approximately 30 days during the June/early July 2014 timeframe.

IV. <u>Subpart F is the Appropriate Provision of the CZMA Regulations Applicable to the Proposed Project.</u>

As described above, the proposed project is led by Rutgers. It is a Rutgers led project regardless of the participation by UTIG and the logistical support by LDEO. Accordingly, the proposed project is one in which there is federal assistance by NSF to a state governmental entity, Rutgers. Therefore, any consistency review appropriately falls under Subpart F of the CZMA's implementing regulations.

A threshold requirement for requesting consistency review under Subpart F of the regulations is a finding of timeliness. With regard to the proposed project, however, NJDEP's request was made approximately three and one-half months after the proposed project was released to the public for review and comment and, thus, it is untimely. Specifically, NSF posted its Draft Environmental Assessment on its website on February 3, 2014, requesting public review and comment during a 30 day public comment period, ending on March 3, 2014. NJDEP elected not to comment on NSF's Draft Environmental Assessment, which was prepared pursuant to the National Environmental Policy Act (NEPA), during this public comment period. The second public notice of the proposed project came in the form of a Federal Register notice issued by the National Marine Fisheries Service (NMFS) announcing its intent to issue an Incidental Harassment Authorization (IHA) pursuant to the Marine Mammal Protection Act (MMPA) for the proposed project. This Federal Register notice was published on March 17, 2014. In response to a request to extend the public comment period on the IHA, NMFS issued a second notice in the Federal Register extending the comment period by 30 days. This notice was published on April 9, 2014.

In addition to the formal public notices of the proposed project published on the NSF website and in the Federal Register, NSF, OCRM and NJDEP engaged in informal conversations regarding the proposed project. These informal conversations began when NSF contacted OCRM in late March to discuss CZMA implications regarding the proposed project. That conversation was held on April 1, 2014. On April 14, 2014, OCRM left a voicemail message for NSF staff notifying them that the NJDEP informally contacted OCRM on April 11, 2014 expressing an interest in the project. After receiving the news from OCRM, NSF immediately contacted OCRM and suggested holding a joint teleconference with NJDEP and OCRM to discuss NJDEP interest in the proposed project. OCRM arranged a teleconference with NJDEP and NSF on April 22, 2014, to discuss applicability of the CZMA. In preparation for the April 22nd teleconference, OCRM sent an email to both NSF and NJDEP dated April 15, 2014 (*see* Attachment 5) requesting advanced information. Specifically, OCRM asked: (1) NSF to identify which academic institutions would receive NSF funding; and, (2) NJDEP to identify any enforceable policies that may be relevant to the proposed activities. NSF provided the funding information in advance of the teleconference as requested (*see* Attachment 6); NJDEP, however, did not respond to OCRM's request to identify relevant enforceable policies that may apply to the proposed project. The teleconference went forward on April 22nd, during which the majority of the discussion was devoted to identifying which CZMA Subpart applied to the proposed project. Despite repeated requests for NJDEP to identify which enforceable policies it believed were implicated, no response was given.

Following the April 22nd teleconference with NJDEP, NSF staff held numerous discussions separately with OCRM and NJDEP staff to try to identify NJDEP's concerns with the proposed project and learn of any relevant enforceable policies NJDEP believed applied. On May 7th, another teleconference was held with OCRM, NJDEP, and NSF staff to again discuss NJDEP's concerns, however, NJDEP again failed to identify any enforceable policies it believed were implicated; only vague requests for delaying the project and employing non-specific mitigation measures were made. When NSF asked NJDEP staff to provide specifics regarding these requests, however, none were provided. NJDEP did submit comments to NMFS pursuant to the MMPA IHA public comment period on May 15, 2014. On May 20th, despite NSF's repeated and good-faith efforts to respond to NJDEP's concerns, NJDEP sent an email to NSF staff with an attachment of a letter sent by NJDEP, via U.S. Post, from Virginia KopKash, Assistant Commissioner DEP to Margaret Davidson, Acting Director OCRM requesting review of the project under Subparts C and F of the regulations implementing CZMA, with a carbon copy to NSF. The letter, however, also fails to formally identify the relevant enforceable policies of concern to NJDEP. In sum, NJDEP waited three and one-half months to bring its request to OCRM to review the proposed project under Subpart F of the CZMA's implementing regulations. Further, NJDEP waited until the very end of the lengthy environmental compliance process to make their formal request to review the proposed project; the proposed survey sail date of June 3, 2014, was clearly published in the NSF Draft Environmental Assessment available on the NSF website on February 3rd, and also in the NMFS IHA Federal Register notice on March 17th.

V. Consistency Review Under Subpart C, Likewise, Is Untimely.

In its letter to OCRM, NJDEP claims that it is seeking consistency review under Subpart C of NSF's funding of LDEO's ship operations. As previously noted, however, funding for R/V *Langseth* ship operations is provided to LDEO through a five year CA, which was originally established in 2012. Thus, the opportunity to request a consistency review of the use of the R/V *Langseth* for ship operations in support of marine scientific research closed years ago.

VI. NSF's Requirement that LDEO Obtain an IHA

As part of routine operational process, NSF has traditionally required LDEO, as the ship operator, to submit IHA requests pursuant to the MMPA when marine seismic research activities are to be carried out with the R/V *Langseth* as the research platform. As the vessel operator, LDEO is in a strong position to ensure that all necessary permits, authorizations, and clearances required for proposed research activities to go to sea (including international vessel clearances and IHAs) are obtained before the vessel leaves dock. In addition, when the vessel operator is held responsible for preparing and submitting the necessary permits and authorizations, there is consistency with document quality and content. Further, as the vessel operator, LDEO is not only responsible for obtaining the IHA, but also for obtaining any Protected Species Observers required by the IHA and providing the necessary equipment for them to carry out their role on the ship.

VII. Conclusion

I hope that the information provided above will assist your office in its review of NJDEP's request for consistency review. If you need any additional information or would like to discuss the information already provided, please do not hesitate to contact me either by email or by phone at 703-292-7713. Thank you in advance for your attention to this matter.

Sincerely,

Holly E Smith

Holly E. Smith
Environmental Compliance Officer

Attachments:

(1) Research Proposal: Collaborative Research: Community-Based 3D Imaging That Ties Clinoform Geometry to Facies Successions and Neogene Sea-Level Change
(2) Grant Letter to Rutgers for Collaborative Research: Community-Based 3D Imaging That Ties Clinoform Geometry to Facies Successions and Neogene Sea-Level Change
(3) Grant Letter to UTIG for Collaborative Research: Community-Based 3D Imaging That Ties Clinoform Geometry to Facies Successions and Neogene Sea-Level Change
(4) 2012 Cooperative Agreement to LDEO for R/V *Langseth* Ship Operations
(5) Email dated April 15, 2014 from OCRM to NJDEP and NSF
(6) Email dated April 21, 2014 from NSF to OCRM and NJDEP

Corrected : 08/22/2012

COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

PROGRAM ANNOUNCEMENT/SOLICITATION NO./CLOSING DATE/if not in response to a program announcement/solicitation enter NSF 11-1

PD 98-1620 | 08/15/12

FOR CONSIDERATION BY NSF ORGANIZATION UNIT(S) (Indicate the most specific unit known, i.e. program, division, etc.)

OCE - MARINE GEOLOGY AND GEOPHYSICS

FOR NSF USE ONLY

NSF PROPOSAL NUMBER

1260237

DATE RECEIVED	NUMBER OF COPIES	DIVISION ASSIGNED	FUND CODE	DUNS# (Data Universal Numbering System)	FILE LOCATION
08/15/2012	2	06040000 OCE	1620	(b) (4) [redacted]	09/04/2012 4:50pm

EMPLOYER IDENTIFICATION NUMBER (EIN) OR TAXPAYER IDENTIFICATION NUMBER (TIN)
(b) (4) [redacted]

SHOW PREVIOUS AWARD NO. IF THIS IS
☐ A RENEWAL
☐ AN ACCOMPLISHMENT-BASED RENEWAL

IS THIS PROPOSAL BEING SUBMITTED TO ANOTHER FEDERAL AGENCY? YES ☐ NO ☒ IF YES, LIST ACRONYM(S)

NAME OF ORGANIZATION TO WHICH AWARD SHOULD BE MADE
Rutgers University New Brunswick

AWARDEE ORGANIZATION CODE (IF KNOWN)
0026294000

ADDRESS OF AWARDEE ORGANIZATION, INCLUDING 9 DIGIT ZIP CODE
Rutgers University New Brunswick
3 Rutgers Plaza
New Brunswick, N.J. 089018559

NAME OF PRIMARY PLACE OF PERF
Department of Earth and Planetary Sciences

ADDRESS OF PRIMARY PLACE OF PERF, INCLUDING 9 DIGIT ZIP CODE
Department of Earth and Planetary Sciences
610 Taylor Rd.
Piscataway ,NJ ,088548066 ,US.

IS AWARDEE ORGANIZATION (Check All That Apply) (See GPG II.C For Definitions)
☐ SMALL BUSINESS ☐ FOR-PROFIT ORGANIZATION ☐ MINORITY BUSINESS ☐ WOMAN-OWNED BUSINESS
☐ IF THIS IS A PRELIMINARY PROPOSAL THEN CHECK HERE

TITLE OF PROPOSED PROJECT **Collaborative Research: Community-Based 3D Imaging That Ties Clinoform Geometry to Facies Successions and Neogene Sea-Level Change**

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE
$ 789,819	24 months	05/01/13	

CHECK APPROPRIATE BOX(ES) IF THIS PROPOSAL INCLUDES ANY OF THE ITEMS LISTED BELOW
☐ BEGINNING INVESTIGATOR (GPG I.G.2)
☐ DISCLOSURE OF LOBBYING ACTIVITIES (GPG II.C.1.e)
☐ PROPRIETARY & PRIVILEGED INFORMATION (GPG I.D, II.C.1.d)
☐ HISTORIC PLACES (GPG II.C.2.j)
☐ EAGER* (GPG II.D.2) ☐ RAPID** (GPG II.D.1)
☐ VERTEBRATE ANIMALS (GPG II.D.6) IACUC App. Date ________
PHS Animal Welfare Assurance Number ________
☐ HUMAN SUBJECTS (GPG II.D.7) Human Subjects Assurance Number ________
Exemption Subsection ________ or IRB App. Date ________
☐ INTERNATIONAL COOPERATIVE ACTIVITIES: COUNTRY/COUNTRIES INVOLVED (GPG II.C.2.j)
☐ HIGH RESOLUTION GRAPHICS/OTHER GRAPHICS WHERE EXACT COLOR REPRESENTATION IS REQUIRED FOR PROPER INTERPRETATION (GPG I.G.1)

PI/PD DEPARTMENT
Earth and Planetary Sciences

PI/PD FAX NUMBER
732-445-2044

PI/PD POSTAL ADDRESS
610 Taylor Rd.
Wright Lab
Piscataway, NJ 08854
United States

NAMES (TYPED)	High Degree	Yr of Degree	Telephone Number	Electronic Mail Address
PI/PD NAME Gregory S Mountain	PhD	(b) (6) [redacted]	732-445-0817	gmtn@rci.rutgers.edu
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				

Electronic Signature

CERTIFICATION PAGE

Certification for Authorized Organizational Representative or Individual Applicant:

By signing and submitting this proposal, the Authorized Organizational Representative or Individual Applicant is: (1) certifying that statements made herein are true and complete to the best of his/her knowledge; and (2) agreeing to accept the obligation to comply with NSF award terms and conditions if an award is made as a result of this application. Further, the applicant is hereby providing certifications regarding debarment and suspension, drug-free workplace, lobbying activities (see below), responsible conduct of research, nondiscrimination, and flood hazard insurance (when applicable) as set forth in the NSF Proposal & Award Policies & Procedures Guide, Part I: the Grant Proposal Guide (GPG) (NSF 11-1). Willful provision of false information in this application and its supporting documents or in reports required under an ensuing award is a criminal offense (U. S. Code, Title 18, Section 1001).

Conflict of Interest Certification

In addition, if the applicant institution employs more than fifty persons, by electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative of the applicant institution is certifying that the institution has implemented a written and enforced conflict of interest policy that is consistent with the provisions of the NSF Proposal & Award Policies & Procedures Guide, Part II, Award & Administration Guide (AAG) Chapter IV.A; that to the best of his/her knowledge, all financial disclosures required by that conflict of interest policy have been made; and that all identified conflicts of interest will have been satisfactorily managed, reduced or eliminated prior to the institution's expenditure of any funds under the award, in accordance with the institution's conflict of interest policy. Conflicts which cannot be satisfactorily managed, reduced or eliminated must be disclosed to NSF.

Drug Free Work Place Certification

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant is providing the Drug Free Work Place Certification contained in Exhibit II-3 of the Grant Proposal Guide.

Debarment and Suspension Certification

(If answer "yes", please provide explanation.)

Is the organization or its principals presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Federal department or agency? Yes ☐ No ☒

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant is providing the Debarment and Suspension Certification contained in Exhibit II-4 of the Grant Proposal Guide.

Certification Regarding Lobbying

The following certification is required for an award of a Federal contract, grant, or cooperative agreement exceeding $100,000 and for an award of a Federal loan or a commitment providing for the United States to insure or guarantee a loan exceeding $150,000.

Certification for Contracts, Grants, Loans and Cooperative Agreements

The undersigned certifies, to the best of his or her knowledge and belief, that:

(1) No federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, "Disclosure of Lobbying Activities," in accordance with its instructions.

(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by section 1352, Title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

Certification Regarding Nondiscrimination

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative is providing the Certification Regarding Nondiscrimination contained in Exhibit II-6 of the Grant Proposal Guide.

Certification Regarding Flood Hazard Insurance

Two sections of the National Flood Insurance Act of 1968 (42 USC §4012a and §4106) bar Federal agencies from giving financial assistance for acquisition or construction purposes in any area identified by the Federal Emergency Management Agency (FEMA) as having special flood hazards unless the:

(1) community in which that area is located participates in the national flood insurance program; and
(2) building (and any related equipment) is covered by adequate flood insurance.

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant located in FEMA-designated special flood hazard areas is certifying that adequate flood insurance has been or will be obtained in the following situations:

(1) for NSF grants for the construction of a building or facility, regardless of the dollar amount of the grant; and
(2) for other NSF Grants when more than $25,000 has been budgeted in the proposal for repair, alteration or improvement (construction) of a building or facility.

Certification Regarding Responsible Conduct of Research (RCR)
(This certification is not applicable to proposals for conferences, symposia, and workshops.)

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative of the applicant institution is certifying that, in accordance with the NSF Proposal & Award Policies & Procedures Guide, Part II, Award & Administration Guide (AAG) Chapter IV.B., the institution has a plan in place to provide appropriate training and oversight in the responsible and ethical conduct of research to undergraduates, graduate students and postdoctoral researchers who will be supported by NSF to conduct research.
The undersigned shall require that the language of this certification be included in any award documents for all subawards at all tiers.

AUTHORIZED ORGANIZATIONAL REPRESENTATIVE		SIGNATURE	DATE
NAME Emmeline Crowley		Electronic Signature	Aug 15 2012 10:43AM
TELEPHONE NUMBER 848-932-4027	ELECTRONIC MAIL ADDRESS Emily.Crowley@Rutgers.edu		FAX NUMBER 732-932-0162

* EAGER - EArly-concept Grants for Exploratory Research
** RAPID - Grants for Rapid Response Research

COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

PROGRAM ANNOUNCEMENT/SOLICITATION NO./CLOSING DATE/if not in response to a program announcement/solicitation enter NSF 11-1	FOR NSF USE ONLY
PD 98-1620 08/15/12	NSF PROPOSAL NUMBER
FOR CONSIDERATION BY NSF ORGANIZATION UNIT(S) (Indicate the most specific unit known, i.e. program, division, etc.) OCE - MARINE GEOLOGY AND GEOPHYSICS	**1259135**

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EMPLOYER IDENTIFICATION NUMBER (EIN) OR TAXPAYER IDENTIFICATION NUMBER (TIN)	SHOW PREVIOUS AWARD NO. IF THIS IS	IS THIS PROPOSAL BEING SUBMITTED TO ANOTHER FEDERAL AGENCY?
(b) (4) [redacted]	☐ A RENEWAL ☐ AN ACCOMPLISHMENT-BASED RENEWAL	YES ☐ NO ☒ IF YES, LIST ACRONYM(S)

NAME OF ORGANIZATION TO WHICH AWARD SHOULD BE MADE	ADDRESS OF AWARDEE ORGANIZATION, INCLUDING 9 DIGIT ZIP CODE
University of Texas at Austin	Austin, TX 787121532 US
AWARDEE ORGANIZATION CODE (IF KNOWN) 0036582000	

NAME OF PRIMARY PLACE OF PERF	ADDRESS OF PRIMARY PLACE OF PERF, INCLUDING 9 DIGIT ZIP CODE
University of Texas at Austin Institute for Geophysics	University of Texas at Austin Institute for Geophysics 10100 Burnet Road, ROC/Bldg. 196 Austin ,TX ,787584445 ,US.

IS AWARDEE ORGANIZATION (Check All That Apply) (See GPG II.C For Definitions) ☐ SMALL BUSINESS ☐ FOR-PROFIT ORGANIZATION ☐ MINORITY BUSINESS ☐ WOMAN-OWNED BUSINESS ☐ IF THIS IS A PRELIMINARY PROPOSAL THEN CHECK HERE

TITLE OF PROPOSED PROJECT **Collaborative Research: Community-Based 3D Imaging that Ties Clinoform Geometry to Facies Successions and Neogene Sea-Level Change**

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE
$ 194,431	24 months	05/01/13	

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- ☐ PROPRIETARY & PRIVILEGED INFORMATION (GPG I.D, II.C.1.d)
- ☐ HISTORIC PLACES (GPG II.C.2.j)
- ☐ EAGER* (GPG II.D.2) ☐ RAPID** (GPG II.D.1)
- ☐ VERTEBRATE ANIMALS (GPG II.D.6) IACUC App. Date ____ PHS Animal Welfare Assurance Number ____
- ☐ HUMAN SUBJECTS (GPG II.D.7) Human Subjects Assurance Number ____ Exemption Subsection ____ or IRB App. Date ____
- ☐ INTERNATIONAL COOPERATIVE ACTIVITIES: COUNTRY/COUNTRIES INVOLVED (GPG II.C.2.j) ____
- ☐ HIGH RESOLUTION GRAPHICS/OTHER GRAPHICS WHERE EXACT COLOR REPRESENTATION IS REQUIRED FOR PROPER INTERPRETATION (GPG I.G.1)

PI/PD DEPARTMENT	PI/PD POSTAL ADDRESS
Institute for Geophysics	10100 Burnet Rd., ROC/Bldg. 196 J.J. Pickle Research Campus (R2200) Austin, TX 787584445 United States
PI/PD FAX NUMBER 512-471-0999	

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PI/PD NAME Craig S Fulthorpe	PhD	(b) (6) [redacted]	512-471-0459	craig@ig.utexas.edu
CO-PI/PD James A Austin, Jr.	PhD		512-471-0450	jamie@ig.utexas.edu
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				

Electronic Signature

CERTIFICATION PAGE

Certification for Authorized Organizational Representative or Individual Applicant:

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(If answer "yes", please provide explanation.)

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(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, "Disclosure of Lobbying Activities," in accordance with its instructions.

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AUTHORIZED ORGANIZATIONAL REPRESENTATIVE	SIGNATURE	DATE
NAME Barbara D Reyes	Electronic Signature	Aug 13 2012 11:15AM

TELEPHONE NUMBER	ELECTRONIC MAIL ADDRESS	FAX NUMBER
512-471-6289	barbarareyes@austin.utexas.edu	512-471-6564

* EAGER - EArly-concept Grants for Exploratory Research
** RAPID - Grants for Rapid Response Research

Corrected : 08/22/2012

COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

PROGRAM ANNOUNCEMENT/SOLICITATION NO./CLOSING DATE/if not in response to a program announcement/solicitation enter NSF 11-1		FOR NSF USE ONLY
PD 98-1620	08/15/12	NSF PROPOSAL NUMBER
FOR CONSIDERATION BY NSF ORGANIZATION UNIT(S) (Indicate the most specific unit known, i.e. program, division, etc.)		1259487
OCE - MARINE GEOLOGY AND GEOPHYSICS		

DATE RECEIVED	NUMBER OF COPIES	DIVISION ASSIGNED	FUND CODE	DUNS# (Data Universal Numbering System)	FILE LOCATION
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IS AWARDEE ORGANIZATION (Check All That Apply) (See GPG II.C For Definitions) ☐ SMALL BUSINESS ☐ FOR-PROFIT ORGANIZATION ☐ MINORITY BUSINESS ☐ WOMAN-OWNED BUSINESS ☐ IF THIS IS A PRELIMINARY PROPOSAL THEN CHECK HERE

TITLE OF PROPOSED PROJECT **Collaborative Research: Community-Based 3D Imaging That Ties Clinoform Geometry to Facies Successions and Neogene Sea-Level Change**

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE
$ 99,419	24 months	05/01/13	

CHECK APPROPRIATE BOX(ES) IF THIS PROPOSAL INCLUDES ANY OF THE ITEMS LISTED BELOW

- ☐ BEGINNING INVESTIGATOR (GPG I.G.2)
- ☐ DISCLOSURE OF LOBBYING ACTIVITIES (GPG II.C.1.e)
- ☒ PROPRIETARY & PRIVILEGED INFORMATION (GPG I.D, II.C.1.d)
- ☐ HISTORIC PLACES (GPG II.C.2.j)
- ☐ EAGER* (GPG II.D.2) ☐ RAPID** (GPG II.D.1)
- ☐ VERTEBRATE ANIMALS (GPG II.D.6) IACUC App. Date ________ PHS Animal Welfare Assurance Number ________
- ☐ HUMAN SUBJECTS (GPG II.D.7) Human Subjects Assurance Number ________ Exemption Subsection ____ or IRB App. Date ____
- ☐ INTERNATIONAL COOPERATIVE ACTIVITIES: COUNTRY/COUNTRIES INVOLVED (GPG II.C.2.j) ________
- ☐ HIGH RESOLUTION GRAPHICS/OTHER GRAPHICS WHERE EXACT COLOR REPRESENTATION IS REQUIRED FOR PROPER INTERPRETATION (GPG I.G.1)

PI/PD DEPARTMENT	PI/PD POSTAL ADDRESS
Seismology, Geology & Tectonophysics	Lamont-Doherty Earth Observatory P.O. Box 1000 Palisades, NY 109648000 United States
PI/PD FAX NUMBER 845-365-8150	

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CO-PI/PD				
CO-PI/PD				
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AUTHORIZED ORGANIZATIONAL REPRESENTATIVE		SIGNATURE	DATE
NAME Maribel Respo		Electronic Signature	Aug 14 2012 11:46AM
TELEPHONE NUMBER 845-365-8829	ELECTRONIC MAIL ADDRESS mrespo@admin.ldeo.columbia.edu		FAX NUMBER 845-365-8112

* EAGER - EArly-concept Grants for Exploratory Research
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PROJECT SUMMARY

For the general benefit of a broad user community of scientists, educators and students, the Co-Principal Investigators propose to coordinate the use of R/V *Marcus Langseth* to acquire a 3D seismic volume encompassing the three IODP Expedition 313 drillsites on the inner-middle shelf of the New Jersey (NJ) continental margin. Exp313, the latest chapter in the multi-decade Mid-Atlantic Transect, represents the community's best opportunity to link excellently sampled/logged late Paleogene-Neogene prograding clinoforms to state-of- the-art 3D images. The primary goal of this proposal is to constrain the complex forcing functions tying evolution and preservation of the margin stratigraphic record to base-level changes. These processes include eustasy, climatic and paleooceanographic variations, tectonism, compaction and rates of sediment supply. Exp313 borehole data will provide lithostratigraphy, geochronology and paleobathymetry. Geomorphology revealed by coherency in horizontal (travel-time) slices within the volume (among other 3D imaging tools) will identify diagnostic features such as river systems, shorelines, delta channels, sediment failure scars, etc., none of which can be resolved in existing 2D seismic data to the degree required to map shifting shallow-water depositional settings in the vicinity of clinoform rollovers. Embracing a community-based strategy, the co-PIs will manage planning, acquisition and data processing up to the point of an interpretable 3D volume. This will entail a pre-cruise planning workshop, hands-on training for young scientists at sea, and rapid turn-around of the data by a commercial processor. Data will be made available to the engaged scientific community to use as the foundation of follow-on, PI- driven proposals that improve understanding of factors shaping the NJ margin in particular, and that imprint the sedimentary record at continental margins in general. The scientific parties of several ocean drilling expeditions and outcrop specialists of shallow-water systems are two groups certain to want to compare their research experience with the ground-truth these data will provide.

Intellectual Merit

The NJ margin has for decades been recognized as among the best siliciclastic passive margins for elucidating the timing/amplitude of eustatic change during the "Ice House" period of Earth history, when glacioeustatic changes shaped continental margin sediment sections around the world. A transect strategy adopted by the international scientific ocean drilling community has been used to study this interval at shallow-water settings offshore NJ, New Zealand and the Bahamas that were dominated by prograding clinoforms. 3D seismic imaging is now a viable tool for the research community, ready to be applied to the NJ margin to put these sampled records in a spatially accurate, stratigraphically meaningful context. Such imagery will allow researchers to map sequences around Exp313 sites with a resolution and confidence previously unattainable, and to analyze their spatial/temporal evolution. Long-awaited objectives include: 1) establishing the impact of known Ice House base-level changes on the stratigraphic record; 2) providing greater understanding of the response of nearshore environments to changes in elevation of global sea level (with special relevance to the current relentless rise), and 3) determining the amplitudes/timing of global sea-level changes during the mid-Cenozoic, which should help humanity put anthropogenic base-level change in a proper long-term context.

Broader Impacts

The community will be engaged in 3 ways. 1) A pre-cruise workshop will review the scientific payoff that 3D seismic-core-log integration can provide, and enable attendees to help shape acquisition and data processing details that optimize this goal; 2) 12 bunks aboard *Langseth* will be reserved for student/post-doc/young scientist volunteers to acquaint each with 3D acquisition and the myriad activities that comprise a research cruise; and 3) a post-cruise workshop will identify community-based avenues for analysis/interpretation of the processed 3D volume and integration with Exp313 results. The 3D images will very likely become an integral part of IODP outreach. Lamont-Doherty Earth Observatory and the University of Texas Institute for Geophysics have collaborative NSF grants to archive marine seismic data collected with NSF support. The raw field data will be delivered to the LDEO facility immediately after acquisition, and a fully processed 3D data 'volume' will be sent to the UTIG facility ~5 months after that, with the expectation that these data will become a showcase for how such sub-seafloor imaging can inform the understanding of stratigraphic evolution at continental margins.

TABLE OF CONTENTS

For font size and page formatting specifications, see GPG section II.B.2.

*Proposers may select any numbering mechanism for the proposal. The entire proposal however, must be paginated. Complete both columns only if the proposal is numbered consecutively.

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Appendix Items:

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PROJECT DESCRIPTION

Collaborative Research: Community-Based 3D Imaging that Ties Clinoform Geometry to Facies Successions and Neogene Sea-Level Change

PROLOGUE

This resubmission has benefited from constructive input by 8 mail reviewers, a panel summary, and NSF feedback (fall 2011). In response, we amplify three issues: 1) 3D imaging will detect nearshore features (e.g., meandering rivers, estuary complexes, lagoons/barrier islands, incised shelf valleys, etc.) that can be tied to IODP Exp313 sites M27-M29; mapping these features and associated facies, which developed during a time of known glacioeustatic variation, is a key both to understanding the evolution of siliciclastic systems and quantifying eustatic changes preserved in clinoformal architecture; 2) the proposed 3D survey area is 50% larger than in our initial submission, with no increase in survey time (34 days), as a result of revised estimates of in-fill shooting and downtime based on well-known histories of weather, currents, ship traffic and marine mammal activity in the proposed study region offshore New Jersey (NJ); and 3) a robust collaboration with the aligned GeoPRISMS community, including at-sea participation and pre- and post-data acquisition workshops; all activities are designed to help educators, young investigators and students understand the value of calibrating models of stratigraphic facies successions, as well as to engage them in theoretical and hands-on learning experiences with 3D seismic acquisition/processing. The goal throughout this project will be to optimize community use of the proposed product - a 3D data volume tied to continuously cored/logged/dated siliciclastic clinoforms that evolved at a stable passive margin during a time of independently measured glacioeustatic change.

INTRODUCTION

Shoreline movements and linked shifts in nearshore processes have important societal consequences. As discussion of global warming grows from speculation to more widespread acceptance (Inter-governmental Panel on Climate Change, 1995; 2001; 2007), impacts at the land-sea divide are gaining media attention. Nonetheless, journalists, policy makers, and even earth scientists often fail to grasp that while links exist among warming, melting ice and rising sea levels, actual effects on shoreline position locally vary widely. Shoreline positions are controlled by many factors, only one of which is global sea level. For example, in Scandinavia (rising due to glacial rebound) and Venice, Italy (subsiding due to sediment compaction), shorelines are moving in opposite directions despite the current rise in global sea-level of ~3mm/yr (projections point to an increase of ≥8 mm/yr by 2100; Rahmstorf et al., 2007). Other drivers include sediment supply and wave/storm-influenced sediment dispersal/compaction, plus regional influences: lithospheric cooling, isostatic/flexural loading, and dynamic topography within the asthenosphere. On old passive margins (e.g., NJ), regional effects are small and perhaps impossible to measure, but all contribute to the complexity of assessing eustatic change through geologic time.

Preserved shallow-water sediments are divided into facies successions bounded by regional unconformities (e.g., Sloss, 1963). The difficulty of mapping these "sequences" (Vail et al., 1977) in true 3D, and deconvolving factors that generate them, have long hindered all but broad interpretations regarding their relationships to eustatic change (e.g., Haq et al., 1987). Because of the importance of coarse-grained sand bodies as reservoirs, oil companies have sought ways to anticipate distributions of sequences based on seismic data alone, often without investing in costly geologic sampling. They focus on intervals/settings that offer the highest economic returns, most recently in structurally complex deep-water settings, leaving behind less productive, Neogene shelf clinoform settings. They also generally withhold their high-quality seismic data and predictive techniques from public disclosure. The international research community shares many of the same scientific interests, but relies less on high-quality seismic data and more on samples from scientific ocean drilling to link the preserved stratigraphic record with eustasy (COSOD II, 1987; Watkins and Mountain, 1990; JOIDES, 1992; Fulthorpe et al., 2008). Such efforts have focused on assembling a global compilation of co-registered analyses of paleo-water depths, sediment compaction/age, and thermal/isostatic/flexural subsidence in shallow-water basins along continental edges. Gathering these drilling-based data has been challenging, and accompanying industry-grade seismic data remain generally unavailable. Our goal here is to augment recently drilled and logged NJ shelf successions

PROJECT DESCRIPTION

with superb 3D seismic images to provide the interested academic community an improved understanding of the factors shaping the global sedimentary record at passive margins, including the long-term history of eustatic change. Because continental margins contain the archive from which much of the world's oil and gas is extracted, and along which ~10% of humanity lives, knowledge of the interaction of this sediment record with ongoing base-level changes serves highly relevant societal interests.

BACKGROUND

The Transect Drilling Strategy

ODP/IODP-related workshops (refs. above) and more than two decades of community-based discussions have concluded that a global set of borehole transects across multiple passive margins is required to deconvolve eustatic signals from those of local processes (Christie-Blick et al., 1990; Kominz and Pekar, 2001). Only this strategy can confirm global synchroneity of sequence boundaries and document stratigraphic responses in diverse tectonic/depositional settings. To yield a reliable measure of eustatic change between two sequences, drilling must sample an intervening sequence boundary in at least three locations: 1) the youngest topset sediments of the older sequence, close to the seaward increase in gradient (the clinoform "rollover"/paleo-shelf edge); 2) the oldest bottomset sediments of the younger sequence at the seaward toe of that same clinoform; and 3) farther seaward along the same surface, where complications of reworking are diminished and age control optimal (Fulthorpe et al., 2008). Using this approach, lateral variations in facies, paleo-water depth and age can be traced along key surfaces. With proper accounting for total subsidence, reliable elevations/dimensions of sequences at their time of deposition can be estimated to distinguish local transgressive/regressive cycles (e.g., Scandinavia vs. Venice) from eustatic changes (e.g., Steckler et al, 1999).

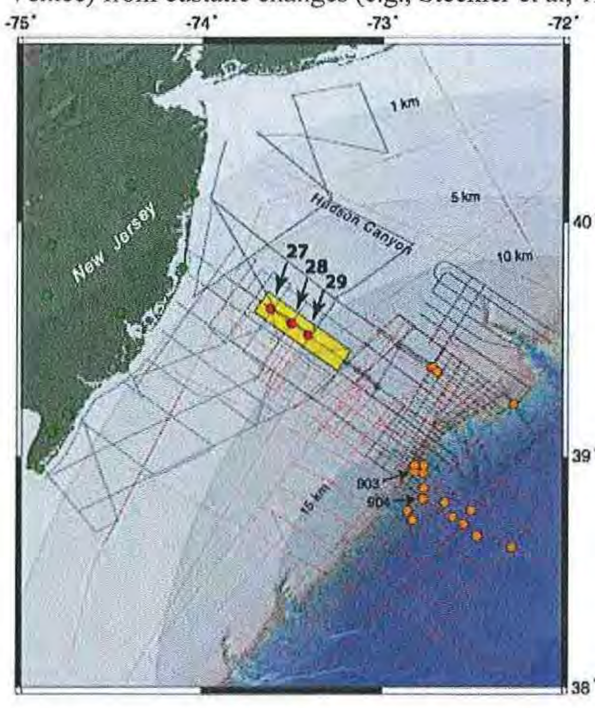

Figure 1. Proposed 12 x 50 km 3D seismic volume (yellow rectangle) encompassing Exp313 Sites 27-29 (red circles) embedded within grids of deep-penetration, reconnaissance (dashed red lines) and higher-resolution (solid gray lines) 2D MCS profiles. Previous studies have tied these grids to scientific ocean drilling wells on the outer shelf, slope and rise (orange circles). Onshore wells (green circles) provide updip equivalents to offshore stratigraphic units (see details in the text). Depths to basement are indicated (muted gray colors/contours).

IODP Expeditions 313 and 317 (NJ and offshore New Zealand, respectively) have followed this strategy, drilling dip-oriented transects imaged by grids of 2D MCS profiles (Mountain, Proust, McInroy et al., 2010; Fulthorpe, Hoyanagi, Blum et al., 2011). This proposal builds on the successful drilling of the first of these, termed the "Mid-Atlantic Transect" (MAT), by seeking to fill a critical gap in seismic correlation. Exp313 samples provide age/paleo-water depth/facies variations within and between sequences imaged by existing grids of 2D MCS data (Fig. 1). The 3D volume we propose to collect will provide accurately rendered, high-resolution "seismic geomorphology" linking depositional/erosional processes driving shoreline movements to known mid-Neogene base-level changes.

Evolution of the "Mid-Atlantic Transect" (MAT)

The NJ margin has long been recognized as a leading candidate for the study of eustatic change and its impact on the sediment record because of: 1) smooth thermal subsidence since Triassic-Early Jurassic rifting (Watts and Steckler, 1979); 2) substantial sediment supply since the mid-Oligocene (Poag, 1985), when high-latitude glaciations provide an independent measure of eustatic forcing (Miller et al., 1998;

PROJECT DESCRIPTION

Zachos et al., 2001; Pekar et al., 2002; Pekar and Christie-Blick, 2008); 3) optimal geochronologic control as a result of a mid-latitude setting; and 4) accessibility/wealth of supporting information (Fig. 1).

In support of the transect drilling approach, multiple 2D MCS grids have been collected since 1990 to locate potential drill sites (Fig. 1). The first was a reconnaissance grid of 120-channel, 1350 in.^{3} air-gun array profiles across shelf wells spot-cored by the U.S. Geological Survey and industry (Hathaway et al., 1976; Scholle, 1977; Libby-French, 1984). Roughly two dozen unconformity bounded, post-Eocene sequences across the shelf/upper slope were traced areally using these data. ODP Leg 150, restricted to the slope/rise, recovered sediments documenting 22 early Eocene-middle Pleistocene ("Ice House") seismic surfaces (Mountain, Miller, Blum, et al., 1994; Miller et al., 1996). In most cases, seismic sequence boundaries matched to Leg 150 boreholes showed little/no time missing across them. Coarse-grained deposits that fined upwards from the bases of many sequences were interpreted as sediments transported basinward during sea-level lowstands. The scientific community understood that Leg 150 samples were from paleo-water depths too deep to yield insight into eustatic amplitudes and their role in shaping facies successions, but shelf drilling required was not at that time deemed safe.

To attempt to remedy the need for shallow-water control, Coastal Plain drilling was begun to complement the deep-water data (Miller et al., 1994). Oligocene – mid-Miocene sequence boundaries onshore (Fig. 1) were found to correlate well with $\delta^{18}O$ increases derived from deep-ocean sampling, confirming that they formed during times of most rapid global sea-level falls (Fig. 2). Furthermore, sequence ages compared well with the Haq et al. (1987) eustatic chart (see also Miller et al., 1996, 1998).

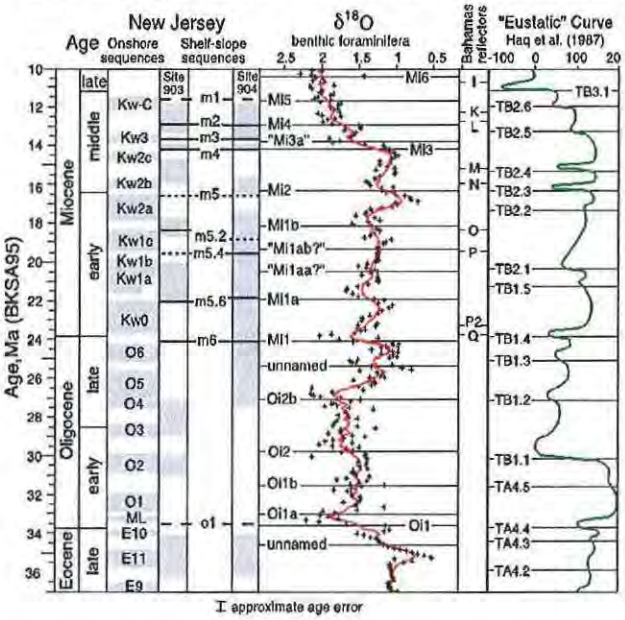

Figure 2. Correlation chart of the NJ margin, late Eocene-late middle Miocene. Onshore sequences (19 total, gray=recovered, white=hiatus) were sampled at 6 sites. Shelf sequence boundaries (10 total, o1-m1) were defined in MCS profiles (see Fig. 1) and traced to the slope. Depositional sequences at ODP slope sites 903/904 (gray=recovered, white=hiatus; Fig 1) are tied to the magnetic reversal time scale (Berggren et al, 1995) and the global $\delta^{18}O$ curve. Ice volume increases are inferred from $\delta^{18}O$-matched hiatuses in the updip/onshore record and slope sequence boundaries. A global sea level curve inferred from coastal onlap and other means (Haq et al., 1987) is at far right. While these correlations appear robust, the critical missing piece for understanding the evolution of the siliciclastic sedimentary record during a time of known eustatic change is spatial correlation of 3D seismic images (crucial for identifying/tracking shorelines and related shallow-water features) with well-sampled drillsites, such as Sites 27-29 (Fig. 1).

The Coastal Plain effort showed that: 1) sequence boundary ages could be determined to better than ±0.5 myr, thereby providing the chronologic control needed to track eustasy for the past 42 myr (Miller et al., 1996, 1998); 2) stratal surfaces are the primary cause of margin seismic reflections (Mountain, Miller, Blum, et al., 1994); 3) middle Eocene-Miocene sequence boundaries correlate with globally recognized $\delta^{18}O$ increases, linking their formation to glacioeustatic falls (Miller et al., 1996, 1998); 4) through correlation with Leg 166 (Bahamas) drilling, siliciclastic and carbonate margins yield correlatable and in some cases comparable records of inferred sea-level change (Miller et al., 1998; Eberli, Swart, and Malone, et al., 1997); and 5) several amplitude estimates of ~20-85 m for my-duration sea-level variations exist that agree with estimates based on $\delta^{18}O$ changes (Kominz et al., 1998, 2003).

Nonetheless, onshore/slope drilling on the NJ margin cannot alone constrain late Paleogene-Neogene eustasy. Onshore wells are too far updip to recover lowstand sediments and, without seismic profiles, they lack the complementary sequence architecture needed to understand facies distributions within clinoform packages. Furthermore, neither onshore nor deep-water drilling can sample paleo-shelves/clinoform rollovers that are among the most sensitive features to post-Oligocene sea-level change. The full range of known/expected "Ice House" sea-level variations cannot be addressed without drilling on the shelf.

To prepare for shelf drilling, 2D MCS profiles across the shelf/uppermost slope were collected (Fig. 1; Austin et al., 1996). These featured two aspects required for safety: high-resolution (shallowly-towed, short-offset GI gun/streamer geometry, 12.5 m shot spacing, 1 ms sampling, ~5 m vertical resolution) and dense spacing (150 m) around locations of proposed drill sites. Such data quality and density were deemed necessary to avoid drilling into pockets of shallow, pressurized gas. These data increased the resolution and number of mappable sequences (Fulthorpe et al., 1999, 2000; Fulthorpe and Austin, 2008). Unfortunately, because the *JOIDES Resolution* generally employs open-hole drilling, ODP denied all proposed sites except two that "twinned" the COST B-2 stratigraphic test well, to ensure the absence of gas (Scholle, 1977). Consequently, ODP Leg 174A drilled Sites 1071 and 1072 on the outer shelf ~.75 and 3.5 km from B-2 (Fig. 1; Austin, Christie-Blick, Malone, et al., 1998). Loose sands and drill-ship heave resulted in limited recovery to the extent that bounding surfaces could not be sampled/dated with the desired precision. Nonetheless, observed prograding clinoformal seismic sequences were confirmed as being bracketed by unconformities that formed during sea-level falls. Other contributions included: 1) water depths during late-middle Miocene-Pleistocene lowstands were close to zero ~100 km seaward of the modern shoreline; 2) inferred fluvial incisions (restricted to topsets) suggest that ambient sea-level never fell below rollovers; and 3) benthic forams indicate that maximum highstand water depths were ~50-100 m, constraining sea-level amplitudes once the effects of accumulation, compaction and loading are taken into account.

Leg 174A results also showed that a drilling platform immune to heave and a drill rig with closed-circulation were needed to provide both the flexibility in site selection and high core recovery required to meet long-standing MAT objectives. This suggested that drilling beneath the inner shelf, where ~30 m water depths permitted use of a self-propelled jack-up rig ("mission-specific platform") planted on the seafloor, was essential. To serve safety constraints, a second 2D MCS grid was completed landward of previous surveys, again with ~5 m vertical resolution and narrow line spacing (Fig. 1; Monteverde et al, 2008). Sites were selected following the transect strategy; imaging focused on early Neogene clinoforms on the inner-middle shelf.

IODP Expedition 313 – Neogene Clinoforms Continuously Cored and Logged

Exp313 drilled/logged 3 sites, (M)27-29, in 35 of water 45-65 km offshore NJ in 2009 (Figs. 1 and 3; Mountain, Proust, McInroy et al., 2010). Goals were to: 1) identify surfaces representing late Paleogene-Neogene base-level changes and compare their ages with sea-level variations implied by the $\delta^{18}O$ glacioeustatic global proxy (Fig. 2); 2) estimate corresponding amplitudes/rates/mechanisms of sea-level change during this "Icehouse" time; and 3) evaluate/improve models predicting lithofacies successions, depositional environments and seismic architecture in response to such sea-level changes and other processes that imprint the shallow-water record. Exp313 collected 1311 m of very good-excellent quality cores with 80% recovery. The deepest hole penetrated 757 mbsf to upper Eocene sediments. Slim-line logs included spectral gamma ray, resistivity, magnetic susceptibility, sonic and acoustic televiewer. Porewater chemistry profiles were generated; uncontaminated sediments were also frozen for microbiologic studies.

Downhole logs, multi-sensor track measurements of unsplit cores, and physical properties of discrete samples, aided by vertical seismic profile measurements at each site, provided core-log-seismic ties with preliminary depth uncertainties of ±5 m or less (Mountain, Proust, McInroy et al., 2010). Excellent synthetic seismograms provide support for core-log-seismic correlation within specific intervals (Mountain and Monteverde., in review). Studies by the Exp313 Scientific Party (over 2 dozen papers representing scientific results are due for submission to *Geosphere* by Aug 4, 2012) link strata to 16 seismically mapped (Figs. 1, 4) regional surfaces/unconformities. The three sites sampled topsets, foresets and toesets of multiple stacked clinoforms. Litho- and biofacies have been correlated along key seismic surfaces to yield mutually consistent depositional histories, although, as will be described, nagging

PROJECT DESCRIPTION

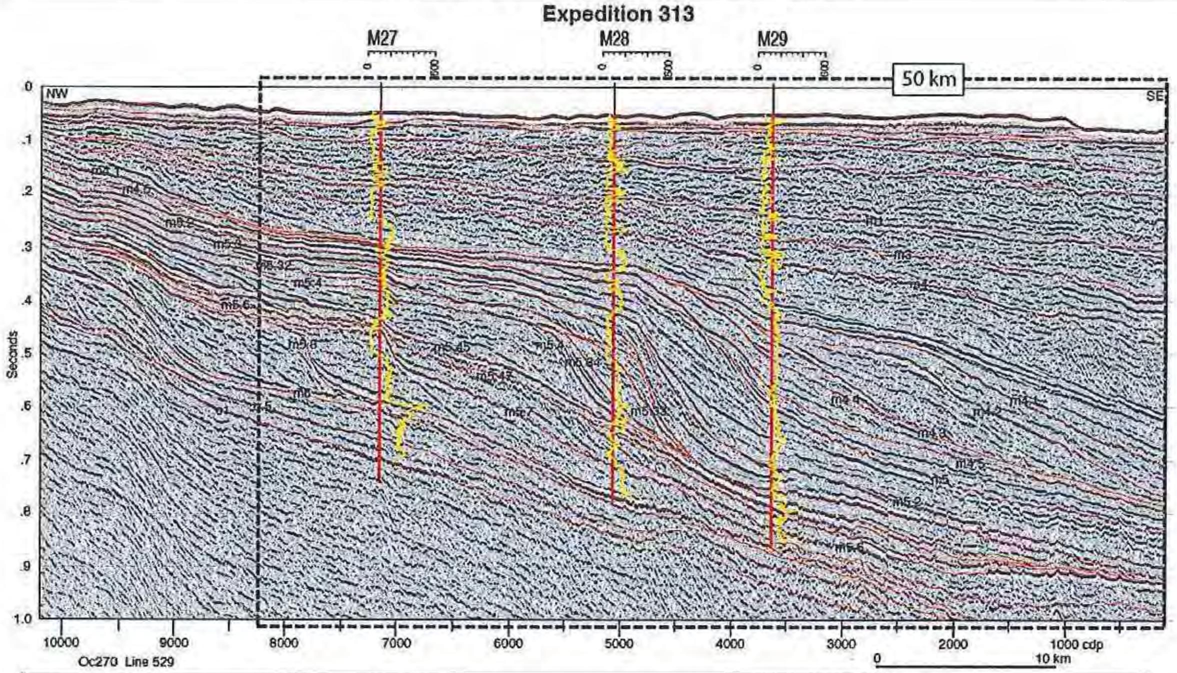

Figure 3. Oc270 line 529 through Exp313 sites M27-29 and the area we propose for a 12x50 km 3D seismic volume (dotted rectangle is the long dimension of that survey; Fig. 1). Gamma ray logs, converted to travel-time with velocities developed for Exp313, are shown in yellow. Early Oligocene - mid-Miocene sequences o1 to m4.1 have been continuously cored/logged and correlated across an existing 2D grid of seismic data on the inner shelf (Monteverde et al., 2008; Figs. 1, 4). As good as the resulting correlations appear to be, ambiguities fundamental to understanding the link between sea-level change and sequence evolution, notably the recognition of diagnostic shorelines and related shallow-water features (fluvial incisions, point bars, estuary complexes, etc.), remain and will not be fully resolved without 3D imaging encompassing these drill sites.

uncertainties remain that cannot be resolved with existing seismic coverage. Excellent paleontologic zonations (based on coccolithophores, dinocysts, diatoms and limited planktonic foraminifera), plus Sr-isotopic ages, are revealing a nearly continuous record of 0.5-2 myr sea-level cycles in the 22-12 Ma interval. Older and younger strata outside this age range have also been sampled, but were not present at all sites. Facies and benthic foram assemblages implying paleo-water depth changes of 60-80 m have been found in topset beds within transgressive-regressive cycles. Initial 2-D backstripping suggests that these paleobathymetric changes are the result of eustatic variations of ~1/2 this magnitude (Mountain and Steckler, 2011; Steckler et al, in review). Ongoing shorebased studies, involving correlation/backstripping of additional surfaces to recover original geometries, should improve eustatic amplitude estimates within the targeted time interval.

However, despite Exp313 successes, made possible by excellent core recovery with ties to logs and mapped sequences (Mountain, Proust, McInroy et al., 2010), uncertainties regarding sequence evolution and relationships with eustatic change remain: 1) If topset strata become subaerially exposed during lowstands, why are no shoreline features, and so few incised valleys, recognized on existing 2D seismic data in the Exp313 region (Fig. 4)? 2) What is the source of debris flow deposits found in Exp313 cores seaward of clinoform rollovers, during what stage(s) of the sea-level cycle are they likely to have formed, and why is there no seismic geomorphologic evidence of sediment transport from either up-dip or along-strike sources on the 2D data? 3) How are prograding Oligocene - mid-Miocene clinoforms influenced by initiation of the globally important mid-Miocene climate transition? Despite progress in sampling these clinoforms, one key element, encompassing spatial imaging, is missing. The clinoform rollover (i.e., paleo-shelf edge) is the key imaging location, because landward shoreline trajectories shift, and the growth and development of incisions in response to sea-level change can be observed seismically. Drilling calibrates those trajectories, but <u>only</u> spatial imaging can both recognize and document them through time.

PROJECT DESCRIPTION

We must know more about detailed processes and depositional environments at/near rollovers, especially volumes/timing of sediment bypass to clinoform slopes. Lateral variability along shorelines is also crucially important, so we must document changes in processes/depositional environments in both dip and strike directions, to the extent that resources allow.

In summary, the "MAT" has been a long-term effort, culminating in Exp313, involving repeated 2D seismics at a range of frequencies to carry out iterative drillsite targeting (using successive sampling technologies) to address the Neogene geologic history at an old passive margin. One crucial piece remains – to integrate calibrated shallow-water facies with 3D images of architecture/geomorphology.

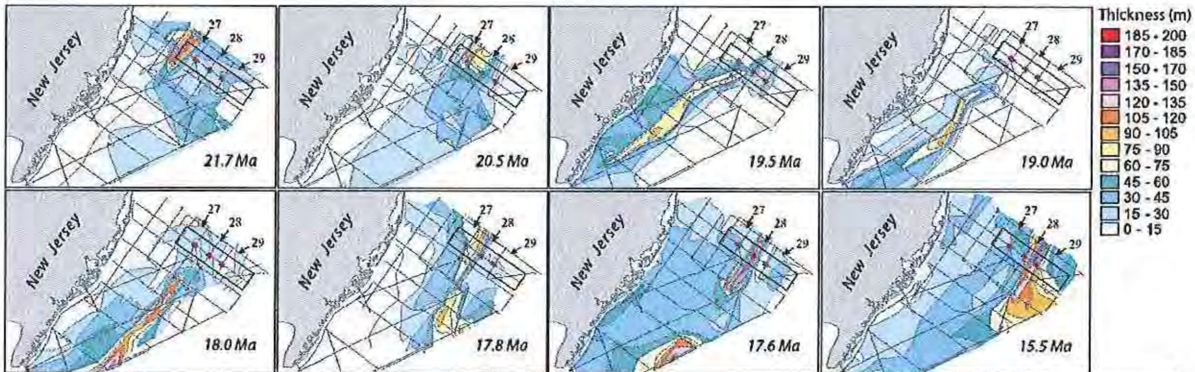

Figure 4. *Isopachs of 8 early to middle Miocene sequences offshore NJ (legend at right; after Monteverde et al., 2008; basal age of sequences from Browning et al., in review). The proposed 12 x 50 km 3D MCS volume encompassing Exp313 Sites M27-M29 (red circles) is outlined in black. Seismic sequences have been identified using 2D MCS profiles (Figs. 1, 3), tied to ODP drill sites on the outer shelf and slope (see Fig. 1), and correlated to hiatuses in ODP onshore wells (Figs. 1, 2). Note seaward progradation of Miocene sediments through time, plus progression from a northern sediment buildup (21.7 Ma), followed by a southern buildup (18.0 Ma), then returning to a northern buildup (15.5 Ma) suggesting both time-varying sources of sediment and margin-parallel redistribution. This complex evolution challenges the reliability of understanding sequence development using only sparse, primarily dip-oriented 2D profiles. The proposed 3D volume will image stratal features within both the thickest parts of some sequences and along the thinner perimeters of others.*

RESEARCH GOALS of the PROPOSED WORK

Provide Community Access to a Calibrated (by Exp 313 Drilling) 3D Seismic Volume

Integration of 3D images with Exp313 drilling results will couple the highest quality cores from this passive margin with unparalleled definition of seismic facies character and spatial geometry where they are needed, near rollovers/paleo-shelf edges most sensitive to changes in base-level during the Ice House. Such an integration will advance sea-level science, while providing unprecedented insights into impacts of migrating shorelines during rising sea level, such as we are experiencing today (see Broader Impacts). Future breakthroughs in the marine geosciences will rely on spatial imaging of the subsurface that can only be achieved with 3D technology. Since its appearance in the early 1970's (Walton, 1972), commercial 3D surveying has grown at such a rate that by 1999 it had eclipsed 2D profiling in terms of worldwide dollar value of acquisition (Liner, 1999). However, despite clear science advantages, its use by academia has followed slowly due to high costs of acquisition and processing.

NSF addressed this issue by convening the 2010 workshop *Challenges and Opportunities in Academic Marine Seismology* (http://www.steveholbrook.com/mlsoc/workshop_report.pdf) to encourage the academic research community to explore ways of increasing access to 3D data. A major recommendation comprised three parts: 1) generate "community" 3D surveys using the *Langseth*, the first academic 3D seismic vessel, 2) hire private companies to process 3D data to an initial interpretable volume within 6 months post-cruise, and 3) release 3D volumes for general use in follow-on, PI-driven interpretation projects. Our proposal follows this model, while being driven by MAT's enduring scientific goals.

Capitalize on the Fundamental Advantages of 3D Seismic Data

The power of 3D seismic volumes is their ability to elucidate both sedimentary processes and paleoenvironments, through assessments of "seismic geomorphology". Sedimentary basin fill is inherently 3D at all spatial scales. Traditional 2D surveys can document basin-scale (tens of km) three-dimensionality, but cannot differentiate km-scale (and less) morphologies, e.g., estuary complexes, shelf channels, upper slope canyons, etc., that are keys to defining shallow-water processes and paleoenvironments, which in turn can be used to determine shifting shoreline positions through time and hence constrain paleo-sea level changes. Individual profiles may image such features, but mapping them between profiles kilometers apart is possible only in a generalized fashion (see Fig. 4). Whereas commercial 3D data can meet academic research needs on some margins, such data are lacking off NJ.

A common misconception exists that 2D and 3D reflection data differ only in image presentation, i.e., that 2D surveying produces a cross section, while 3D surveying produces a volume. In truth, what can be extracted from 3D data far exceeds this conspicuous dimensional component. 2D images are also fundamentally hampered by "cylindrical ambiguity" and "viewpoint limitation". Cylindrical ambiguity means that 2D data lack information necessary to establish cross-profile positioning; there is no way to know true locations of reflections that "appear" to lie beneath the survey track, but which originate from somewhere to one (either) side of the profile plane. Viewpoint limitation means that only reflecting surfaces facing the profile plane can be imaged; all others, including those directly below with even modest cross-profile dips, remain invisible. Maximum reflector dips beneath the inner NJ shelf are small (<8°; Figs. 3, 4), so cross-profile mis-positioning of reflections is not as large as in geologic areas with more steeply dipping features. However, for the two-way travel time range of highest interest (0-0.8 s; Fig. 3), and the corresponding average velocity range (1.6-1.8 km/s), the expected maximum cross-profile mis-positioning of events on existing profiles is 35-100 m, which is as large or larger than incised valleys and related shoreline-related features we hope to observe. 3D acquisition and processing will virtually eliminate these problems.

Another challenge using 2D data for stratigraphic interpretations is caused by streamer cable side-drift/feathering (Renick, 1974; Levin, 1983). During 2D acquisition, cross-currents cause average feathering of ~10° (Yilmaz, 2001). As a result, 2D profiling becomes a limited-swath 3D survey to one side of profile track. Processing such marine survey data using standard 2D imaging procedures (as has been done to the present) creates spurious discontinuities/wipeouts in reflection events (Nedimovic et al., 2003). Currents offshore NJ vary in both strength and direction (Butman et al., 2003), so they must have caused 5-10° streamer feathering when existing 2D data were collected (Fig. 3); this is confirmed by records of visual sightings of tail buoys. Such feathering has detracted from reflection event continuity in all 2D profiles offshore NJ. Unfortunately, past feathering effects cannot be corrected because streamer navigation was not utilized during all of those 2D surveys.

Exploit the Unique Tools Associated with 3D Imaging

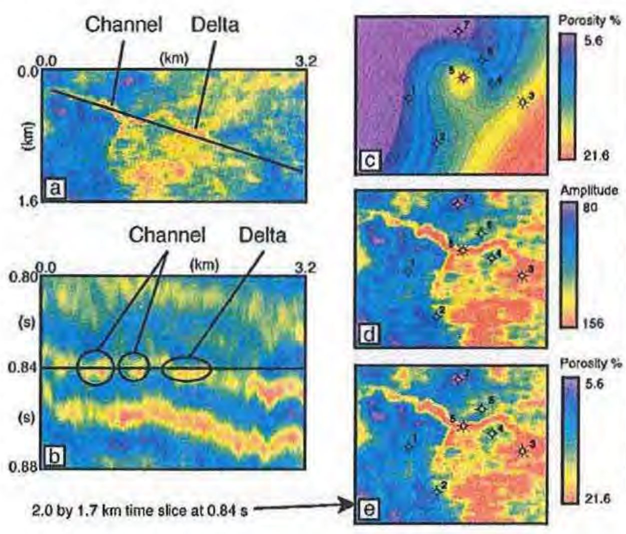

Figure 5. (a, b) Channel systems (from the Gulf of Mexico) in 2D and 3D and (c, d, e) integrating seismic and well data to extract porosity. a-b: While a map view (a) of an amplitude slice at 840 ms two-way travel-time provides a clear image of a channel and (associated) delta, little can be inferred about this system from a cross-sectional image (b) carefully chosen to cross the channel twice and the delta once. (c): Gridded porosity map at the reservoir level (840 ms, see a), based upon samples from 7 drilled holes. (d): Time slice at the same level as in (c). Note the level of detail of sratigraphic features. (e): Seismic-guided porosity map formed by integrating seismic and well data. If 3D seismic data had been collected before drilling, 5 dry holes (1, 2, 4, 6, 7) would not have been drilled. Figure adapted from Liner (1999).

PROJECT DESCRIPTION

The growing use of 3D seismic techniques has led to significant advances in stratigraphic studies. Small but important "process" features like incised channels, difficult to document using 2D data, stand out in maps derived using 3D data (Figs. 5, 6). However, stratigraphic interpretation benefits not only from a 3D view of the subsurface, but also from the ability to extract quantities called "seismic attributes" from 3D volumes. Both pre-stack and post-stack attributes will be needed from the proposed 3D volume to extract the maximum information for ongoing stratigraphic interpretations of the NJ margin.

Post-stack seismic attributes result from image manipulation (Liner, 1999; Fig. 5). For NJ, the most useful post-stack attributes are instantaneous amplitude, phase, frequency and Q (1/attenuation). When applied to 3D volumes, these attributes can be powerful indicators of lithologic variations, event continuity, fracturing and absorption. The most useful 2D attributes for delineating channels are coherency, edge detection, directional gradient (e.g., "curvature", Fig. 6) and shaded relief.

While 3D surveys provide more accurate and useful information than 2D seismic imaging (Fig. 5c-e), the most complete geologic information is extracted by combining 3D images with drilling/logging. Such a combined approach allows for detailed analysis of geometry, lithology, porosity, fluid saturation and anisotropy of buried sediments and associated depositional/erosional systems (e.g., complex fluvial channel systems; Fig. 6) and their geometric relationships with Neogene rollovers sampled by Exp313.

An excellent example of the value of 3D data is provided by ongoing research into the upper Oligocene-Recent clinoformal stratigraphy of the Northern Carnarvon Basin (NCB), Australian Northwest Shelf (NWS) (Liu et al., 2011; Sanchez et al., 2012a, b). Middle Miocene-Pliocene siliciclastic sediments represent a long-lived (~8 my) break in otherwise carbonate-dominated shelf sedimentation. Available commercial 3D volumes have enabled a profound new interpretation of these prograding siliciclastics as 27 shelf-/shelf-edge delta lobes (Fig. 7). Only through true 3D mapping has it been possible to correlate individual clinoform sets with these lobate, complex deltaic morphologies. Long-term (cumulative) progradation of this delta system and subsequent backstepping correlate with long-term sea-level fall and rise during the late middle-late Miocene. This observed siliciclastic influx correlates with other coeval increases in siliciclastic sediment supply worldwide, including offshore NJ and a prospective depocenter in the Gulf of Mexico (see text below).

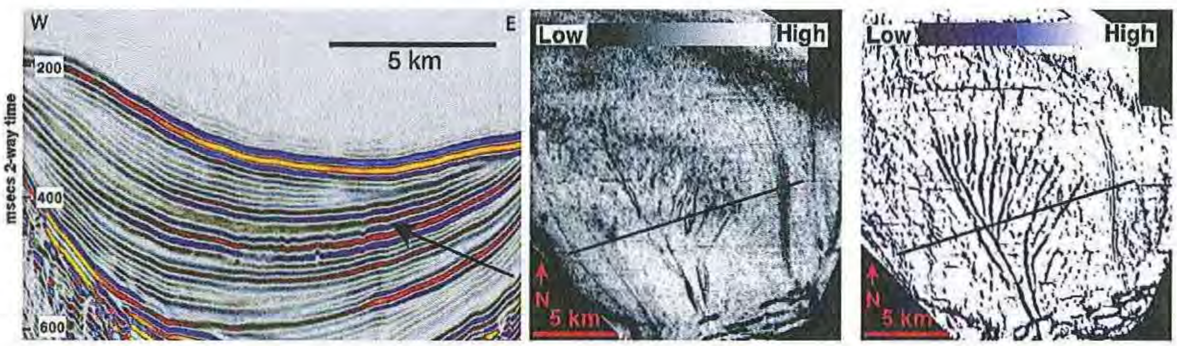

Figure 6. Visualization and interpretation of paleo-channels in 2D (left) and 3D (center, right) seismic data. Left: Strike-oriented 2D seismic reflection profile from the Gulf of Mexico showing subtle undulations in one imaged stratal horizon (indicated by the black arrow) which are produced by slope channels. However, this could not be confirmed using the 2D representation by itself. Center/right: Seismic attribute (travel-time) slices produced along the same horizon extracted from a conventional 3D volume, the center view showing "coherence" and the right view highlighting "most-negative curvature". Identifying complex channel features and tracking them spatially is straightforward using the 3D volume, but challenging if not impossible to achieve using 2D control alone, even if the 2D grid is dense, as is true for some of the grids on the NJ margin (Figs. 1, 4). From Lozano and Marfurt, 2008.

In addition, 3D mapping in the NCB has yielded important insights into the relationships between clinoformal sequence boundaries and sea-level change, particularly: 1) complex spatial acoustic evidence of karst topography (indicative of shelf exposure) along some horizons, and 2) step-like, vertical offsets up

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to 65 m high, downward toward the basin on the outer paleo-shelves (near rollovers) of two early-middle Miocene sequence boundaries. These have been interpreted as rarely preserved examples of wave-cut terraces or sea cliffs (Liu et al., 2011). All of these features represent direct evidence of paleo-sea level and shoreline location, which can only be interpreted with 3D data.

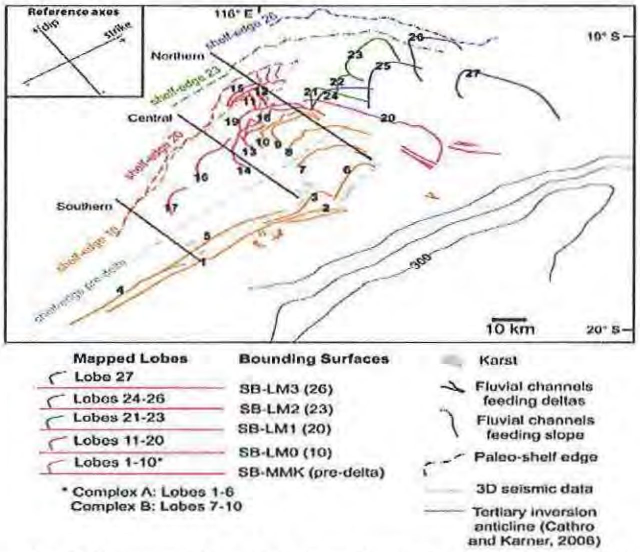

Figure 7. Delta lobes and positions of paleo-shelf edges at the ends of deltaic progradation pulses in the Northern Carnarvon Basin (NCB), Australian Northwest Shelf (NWS; Sanchez et al., 2012 a, b). The outline of each lobe corresponds to the rollover of the upper bounding unconformity of the mapped clino-form set representing that lobe. Interpreted fluvial channels within the siliciclastic interval are shown in colors correlative with their pre-sumed associated delta lobe. Interpreted karst features, indicative of paleo-shelf exposure (i.e., sea-level low stand), also underlie lobes 1-6. This interpretation of clinoform sets as a spatially complex set of prograding delta lobes was only possible through mapping within a 3D seismic volume (outline of the volume shown in the figure, thin grey line).

Tie 3D Volume to Exp 313 Results to Resolve Ambiguities of Neogene Stratigraphic Evolution

Seismic morphologies similar to those of the NWS, containing imprints of changing sea level and other factors that control shallow-water sedimentary processes, are present on the NJ margin (Fulthorpe and Austin, 1998; Nordfjord et al., 2005). The 3D MCS volume we propose to collect will focus on resolving the origin of such features critical to understanding the relationships between sea-level change and sequence development. In particular, we will focus on shallow-water features near and at paleo-shorelines: fluvial channels, point bars and estuary complexes (Nordfjord et al., 2005). MCS line 529 (Fig. 3) runs through the center of our proposed survey area and ties the three Exp313 sites. Below, we use that image to frame three working hypotheses that can be tested by combining a 3D volume with Exp313 results. These hypotheses/related goals agree with components of the Eastern North American Margin (ENAM) component of the GeoPRISMS Draft Implementation Plan (http://www.geoprisms.org/enam.html).

1) What are the spatial/temporal relationships between sea-level low stands and areas of paleo-shelf exposure adjacent to/landward of clinoform rollovers? Linked hypothesis: low stand paleo-shelf exposure has increased since the Oligocene, probably in response to increasing eustatic amplitudes (Fig. 2), resulting in an increasing number of fluvial incisions both up-section and seaward across the NJ margin.

Seismic sequences, when first defined, were classified according to the nature of their basal boundaries (Mitchum et al., 1977). While terminology has since been refined, a fundamental observation remains valid: some sequences begin with valleys cut into the top of the underlying sequence, while others have no such incisions, and begin instead with apparently conformable deposition onto beds of the preexisting shelf/uppermost slope. The former incised, "Type 1", sequence boundaries have been inferred to indicate a larger and/or more rapid fall in base-level than the latter, "Type 2", boundaries. Judging from existing 2D MCS data off NJ (Fig. 1), incised valleys appear to be scarce in paleo-shelf strata landward of rollovers, suggesting that Type 2 boundaries dominate the early Miocene within the proposed survey area (Fig. 3). Similarly, a lack of lobate low stand fans seaward of clinoform toes (Figs. 3, 4; see below) supports the hypothesis that Type 1 systems are minor to nonexistent in this lower Miocene section. Nonetheless, there is seismic evidence (at ~cdp 4000, between m5 and m4.5, Fig. 3) of a shelf-edge delta and erosional truncation of foresets, suggesting base level at m5 time was very close to, if not below, the elevation of adjacent topsets. In addition, landward of all Exp313 sites (Fig. 1), isolated incisions ~100 m wide and 5-10 m deep are observed seismically, but none can be connected with existing data coverage (Fig. 4;

Monteverde et al., 2008). Possible explanations include: 1) incised valleys are well-preserved/present, but existing 2D profiles do not cross them (unlikely); 2) such valleys were removed by ravinement during transgressions (possible, but unlikely due to the lack of core-based evidence for accompanying hiatuses between sequences in Exp313 samples); or 3) such valleys are present, but too small/widely spaced to be resolved by existing 2D coverage (very likely). This third possibility is supported by interpretations of dense, ultra-high resolution single-channel (2D/3D CHIRP geophysical profiles) of the NJ shelf 60 km to the southeast, which confirm that complex dendritic, incised fluvial systems formed during the latest Pleistocene (Davies et al., 1992; Duncan et al., 2001; Nordfjord et al., 2005). Incised valleys are crucial paleo-water depth indicators at sequence boundaries, independent of benthic foraminiferal successions. We are confident that if incised valleys exist within lower Miocene sediments around Exp313 sites, and seaward toward correlative rollovers, they will be detected using 3D images along with related morphologic enhancement techniques (Figs. 5, 6). Mapping these incisions will constrain shoreline positions through time, improve estimates of eustatic amplitudes, and enable sequence architecture/seismic geomorphologic techniques to predict facies distributions calibrated by Exp313.

While pre-middle Miocene shelf exposure near Exp313 sites is difficult to detect with existing 2D data, this is not true of younger intervals sampled by Exp313 above reflector m4.1 (Fig. 3). Spot coring at irregular surfaces corresponding to sequence boundaries m1, m3 and m4 at sites M27 and M29 recovered shallow water sands, and in several cases ~1 m of paleosol (Mountain, Proust, McInroy, et al., 2010). These surfaces can be traced seismically to clinoforms on the mid-shelf 25 km seaward of M29, but the proposed 3D imaging will not extend seaward to those younger clinoforms. Nonetheless, several hundred meters of largely discontinuous reflectors above m4.1 (Fig. 3) are virtually certain to be resolved with 3D techniques to a degree rarely seen, providing seismic expression of nearshore and coastal plain facies tied to Exp313 cores and logs.

Using the proposed 3D volume, seismic evidence for paleo-shelf exposures and proximity of fluvial sources to paleo-shelf edges/rollovers can be mapped, along with shelf/uppermost slope delta architecture (if it exists; Fig. 7), within any of the eight sequences constrained by Exp 313 results (Fig. 3). Community-based efforts can then document any enhanced fluvial contributions to observed clinoform progradation during a known time interval of long-term eustatic fall and increasing glacioeustatic amplitudes. Seismic attribute analyses, e.g., coherence displays (Fig. 6, center), offer exciting opportunities to locate/map incised valleys/canyons at sequence boundaries, to calibrate sand distribution in shallow shelf intervals/topsets, clinoform front/toe and basinal settings, and to investigate facies-dependent bedding characteristics calibrated by Exp 313. The higher fold and improved source to be used for the proposed 3D survey (see below) will also provide enhanced multiple suppression and thereby produce sharper definition of sequence boundaries (e.g., Fig. 4), a task that is especially challenging along the mid-Atlantic shelf because of highly reflective and parallel layering of interbedded muds and sands in the Neogene section (e.g., Austin, Christie-Blick et al., 1998)

2) What are the mechanisms of sediment transport seaward of clinoform rollovers, and how do they fit into the sequence stratigraphic model? Linked hypothesis: During shelf progradation, the evolution of clinoform front morphology is a complex response to changes in gradient, sediment source geometry (point- vs. line-source), and basinward redeposition by sediment gravity flows/turbidity currents.

Despite the lack of seismic evidence for inner-shelf incisions along the tops of Oligocene-middle Miocene sequences (Fig. 4), mass-transport deposits on slopes were encountered by Exp313 (Fig. 8). The classic model of siliciclastic sequence development includes submarine fans seaward of clinoform toes (Van Wagoner et al., 1988; Posamentier and Vail, 1988), presumed to represent sediment by-pass/basinward transport of mostly coarse-grained material during times of rapid sea-level fall. However, there is little evidence of such lobate depocenters in Oligocene-Miocene sections beneath the NJ shelf (Figs. 3, 4; Greenlee et al., 1992; Poulsen et al., 1998). In their place beneath the inner shelf there are well-defined deposits less than a few km seaward of rollovers that accumulated as units 10's-100's of m thick on ~2° clinoform slope gradients (Fig. 3). All pinch out landward and thin seaward, where most become seismically indistinguishable from underlying strong reflectors at slope toes. Each extends for 10's of km along-strike. These sediments have been termed "slope apron deposits"; Exp313 results have shown that they comprise glauconitic sands and mature quartz grains up to gravel size, all presumably shed from edges of adjacent clinoform tops (Fig. 8). The Exp313 team is using both litho- and seismic stratigraphic features of several of these deposits where they occur within a single sequence. The goal is to identify criteria that divide them into separate depositional units, but because they represent rapidly deposited, reworked material, such subdivisions will be difficult or impossible to establish with the existing 2D data. We will also be able to determine how slope apron deposition relates to timing of eustatic change(s), a goal at the heart of understanding clinoform evolution. A 3D volume is required to do this work.

In addition to resolving internal structures of slope aprons, the 3D volume will also detect failure scars/transport lanes that directed mass flows basinward (Fig. 8). The volume will also document spatial/temporal connections to shelf-crossing incised valleys immediately landward of rollovers. One important objective is to determine the degree to which observed incised features served as conduits for sediment originating landward of the rollover, as opposed to more local slope redistributions, such as headward erosion, gravitational creep, slumping and/or debris flow mechanisms, all of which originated seaward of rollovers. Ties between continuously sampled cores and 3D images make this possible.

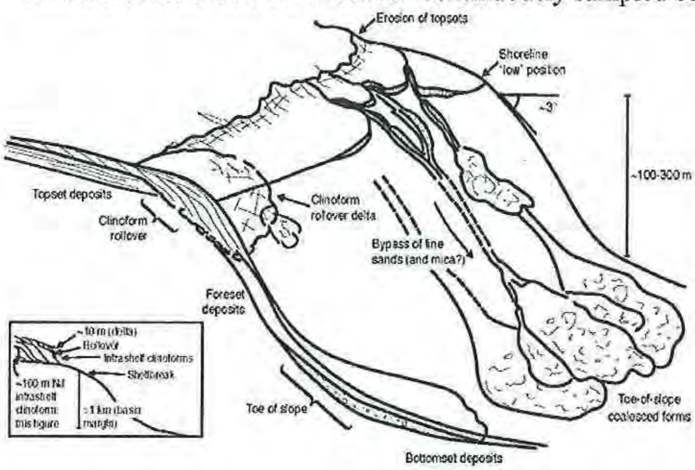

Figure 8. Conceptual model developed during Exp313 to explain regular occurrences of poorly sorted, stratified, glauconite-rich coarse sand/gravels in cores taken near the tops of clinoform slopes. Multiple channels and/or regressive shorefaces at clinoform rollovers are presumed to erode into/entrain older topset deposits. These sediments are remobilized and transported down the clinoform slope as debris flows and turbidity currents to form aprons close to the toe of slope (Mountain, Proust, McInroy et al., 2010). The 3D volume will vastly improve images of clinoform rollovers, where these sediment movements take place in response to base-level changes.

Research on sediment transport pathways using 2D data has been unable to provide definitive models of shelf/slope/basin connectivity on this or any continental margin. In the sequence stratigraphic model, fans and laterally extensive onlap depend on stable point sources of sediment (e.g., Karner and Driscoll, 1997). But even middle-late Miocene sequence boundaries that display evidence of paleo-shelf exposure are not associated with lobate lowstand accumulations basinward of clinoform toes, based on available 2D profiles (e.g., Fulthorpe et al., 2000). Perhaps such deposits were instead transported farther basinward to the continental rise and/or laterally along the margin, as probably occurred in the Miocene on Australia's NWS (Cathro et al., 2003). Lowstand fans are also absent in paleo-shelf settings of the Canterbury Basin, New Zealand, where influences of along-strike currents are unequivocal (Lu et al., 2003; Lu and Fulthorpe, 2004). Morphologic elements of paleo-slope incisions, i.e., canyons and rills, on the mid-Atlantic and other margins remain unclear with available (2D) seismic control. Pleistocene and modern canyons are large (up to 300 m deep and 2-5 km wide), closely spaced (2-10 km), and the Hudson and Delaware canyons off the east coast of the U.S. are clearly linked to river systems that have retreated westward during the Holocene sea-level rise. In contrast, middle-late Miocene canyons are both less deeply incised and less common and do not appear to be directly linked to paleo-shelf incisions, suggesting that they are not directly related to fluvial sources (Fulthorpe et al., 1999; Fulthorpe et al., 2000). Fulthorpe et al. (1999) have advanced the hypothesis that observed paleo-shelf-edge linearity results from along-strike sediment transport by waves and currents, which mutes the influence of individual fluvial point sources to form a line-source of sediment delivery to clinoform fronts (see also Fulthorpe and Austin, 2008). Individual fluvial sources apparently did not deliver sufficient sediment to overcome along-strike forcing to produce lobate depocenters (see Fig. 7), even though some fluvial incisions appear similar in width and depth to the Pleistocene Hudson and Delaware shelf channels (Fulthorpe et al., 1999). Shelf and slope incisions cannot be observed on the NCB/NWS, despite 3D imaging (Fig. 7). A lack of prominent point sources on the Miocene NJ margin (Fulthorpe et al., 1999; Pekar et al., 2003) may account for differences between NJ sequences and the standard sequence model (e.g., presence of slope aprons and absence of lobate fans). However, none of these inferences can be confirmed using only the available 2D seismic control. The only way that process-based links between sediment sources and observed/sampled NJ Oligocene-Miocene clinoforms can be established, and their relationship to sea-level cycles defined, is by 3D imaging encompassing Exp313 sites (Figs. 3-4).

Similarly, canyons cut into clinoform slopes do not appear to be linked to those incising more gently dipping surfaces basinward of clinoform toes, suggesting that different submarine erosional processes may be associated with observed changes in gradient. This may result from different "regime variables" controlling sedimentation patterns (Swift and Thorne, 1991; Fulthorpe et al., 2000). Along the modern shelf edge offshore NJ, incisions up to 140 m deep can occur even on low gradients basinward of clinoform toes, most likely due to fluid escape processes (Dugan and Flemings, 2000). 3D imaging along clinoform slopes in this project can test for this process of slope failure in the early - mid-Miocene.

3) What was the sedimentary process response to the global mid-Miocene climatic (and tectonic) transition? Linked hypothesis: Changes in the rate of sediment input to the NJ margin during the mid-Miocene, as evidenced by mapping clinoforms bracketed by sequence boundaries, are linked to globally significant changes in the relative intensity of margin erosion.

Many continental margins reveal mid-Miocene influxes of siliciclastic sediments (Molnar, 2004). In addition to NJ (Poag and Sevon, 1989; Pazzaglia and Brandon, 1996; Steckler et al., 1999), other well-constrained examples of this pattern include the Gulf of Mexico (Galloway et al., 2000; Galloway, 2008), Canterbury Basin (Lu et al., 2005), NCB (Cathro et al., 2003; Sanchez et al., 2012a, b), the Angola margin (Lavier et al., 2001), and the Maltese Islands margin (John et al., 2003). Age estimates for this influx range from 15-12 Ma. The NCB case (Fig. 7) is striking, because the observed siliciclastic increase occurred at a preexisting carbonate margin. In the Canterbury Basin, the mid-Miocene sediment increase is not linked to known tectonism in the proximal Southern Alps; the only notable increase in sedimentation rate that coincides with tectonism is much later, during a well-defined period of increasing convergence rates at the Alpine Fault (Lu et al., 2005). This global pattern of mid-Miocene sediment influxes has been linked to global cooling following the mid-Miocene $\delta^{18}O$ peak. One possible mechanism is that the post - mid-Miocene global sea-level fall may have led to increased shelf erosion everywhere. However, reconstructed paleobathymetric profiles on the NJ margin suggest that the amount of sediment required for the observed progradation, estimated as a 20-fold increase in flux, exceeds that available from paleo-shelf erosion alone (Steckler et al., 1999). Other proposed mechanisms include changes in precipitation and in the amplitude/frequency of late Cenozoic climate change (Molnar, 2001; 2004).

However, climate may not have been the only driver of mid-Miocene sediment influx. Tectonic uplift of the hinterland may also have contributed (Poag and Sevon, 1989; Pazzaglia and Brandon, 1996). Potter and Szatmari (2009) have united climatic and tectonic mechanisms for Miocene sedimentation by hypothesizing a global increase in middle-late Miocene tectonic activity driven by accelerated upwelling at two "superplumes" below the Pacific and Africa plates, which may also have produced far-field uplift of passive margins such as NJ. In their scenario, tectonic activity drove the coeval climatic transitions, through opening/closing key gateways and changing the oceanic circulation to trigger global cooling. The same Appalachian uplift that provided sediment to NJ has also been proposed as the origin of voluminous mid-Miocene sediments in the deep Gulf of Mexico (Jackson et al, 2011). These sediments were delivered by the paleo-Tennessee River, which discharged into the northeastern Gulf prior to its capture by the Mississippi (Galloway et al., 2000; Galloway, 2008). In spite of the large volumes of sandy sediment delivered to the Gulf basin, coeval updip slope canyons have not been identified, in marked contrast to the Pleistocene depositional episode (Galloway et al., 2000; Galloway, 2008). These Gulf of Mexico Miocene sediments are now targets of intensive hydrocarbon exploration, so understanding processes of middle Miocene sediment delivery from shelf to basin is economically as well as academically important.

The middle-late Miocene was a critical period in which climatic/tectonic processes combined to influence sedimentation globally. One of the long-term goals off NJ is to evaluate sedimentary response to these Miocene changes that influenced hinterland capability to provide sediment to the margin. Our proposed 3D survey will target initiation of the mid-Miocene sediment influx by imaging the transition between steep, slowly prograding Oligocene to mid-Miocene clinoforms drilled during Exp313 (Fig. 3), to more gently dipping, but more rapidly progradating features deposited later in the Miocene. Seismic geomorphology derived using the 3D volume will allow us to map temporal changes in shelf channel geometrical parameters (e.g., width, depth, sinuosity, gradient) to deduce changing sediment transport capacities from the hinterland through time, while slope morphologies, including the presence/absence of incised valley/canyons, will provide insights into processes involved in sediment bypassing to deep water (Fig. 8). In addition, correlation with the well-dated mid-Miocene sequences in the Gulf of Mexico, sourced from the same hinterland, will enable the timing of the influx in each basin to be compared.

WORK PLAN

Early-middle Miocene sequences clearly vary along-strike (Fig. 4), but a 3D volume long enough (perhaps ~100 km) to image all mapped variability is cost prohibitive. Instead, we propose to collect a 50 (dip) x 12 (strike) km volume encompassing all Exp 313 sites (Fig. 1), which has sampled ~12 sequences (Fig. 3). Some will be imaged along depocenter axes, others along peripheries, so we should image the full suite of potential shelf/slope, process-related seismic geomorphologies. Only one boundary (m5.6) will be missed. Fig. 3 shows that the volume proposed will image at least eight Miocene clinoform rollovers; these paleo-shelf edges record primary depositional processes associated with base-level change.

We have prepared a 2-year budget for acquisition/initial commercial processing of the volume (Fig.1). The data will be acquired on *Langseth*; processing will be done by a commercial company to pre-stack time-migrated (PSTM) shot gathers and 3D image volume (see quote in "Other Supplementary Documents"). The 12 km survey width optimizes turn efficiency and allows full data acquisition to be completed in two 6-km wide 'racetracks'. The 50 km dip-length enables imaging of early Miocene topsets landward of Site M27 to middle Miocene toe-of-clinoform morphologies basinward of Site M29 (Fig. 3).

We will focus on imaging the upper 1 s two-way travel time; we expect to achieve vertical resolution of 5 m or better and horizontal resolution of 15 m or better. We will record with 1 ms sampling to a travel-time depth of 4 s to image diffractions necessary for proper migration. These constraints dictate a shallow, high frequency source array and a recording design that minimizes spatial aliasing. We expect in-line dips to be <4°, and cross-line dips to be <8°, the latter along inward-facing walls of incised valleys. To reduce aliasing of diffractions that will arise from lateral discontinuities and pinchouts, we plan to collect data with a nominal bin size of 6.25 m in-line and 18.75 m cross-line. *Langseth* will tow four 3-km streamers spaced 75 m apart to provide the necessary range of source-receiver offsets required for complete imaging to a maximum estimated target depth of 5-6 km.

We estimate cruise duration based on industry acquisition standards (e.g., 30% downtime and infill) prior *Langseth* 3D projects, consultations with R. Steinhaus, Chief Sci. Officer on *Langseth*, and use of industry acquisition planning software. We anticipate leaving from/returning to Newark, NJ, a ~80 nmi transit to/from the survey area (Fig. 1). Setup/deployment/streamer ballasting should take 3 days; gear retrieval and transit at the end will be 1 day. *Langseth* will use two flip-flopping gun arrays designed for high-resolution surveying, resulting in eight CMP lines spaced at 18.75 m for each sail line. The 12 km-wide area will be covered with 80 sail lines. Total shiptime dock-to-dock is 34 days.

Data acquisition will result in 5 terabytes of field data. PGS (see quote in "Other Supplementary Documents") has responded with a detailed work plan at a competitive cost. Their approach comprises 27 processing steps leading to various 3D PSTM shot gathers and data volumes; these will provide the community with interpretable reflection results and material for follow-on data analysis proposals. The data will be processed at 2 ms sampling rate unless the records show signal above 250 Hz, in which case the processing will proceed at 1 ms. Estimated data processing time is 5 mo. Two 1-week visits to the PGS facility by two co-PIs are budgeted to participate in and oversee the data preparation. Following a post-cruise workshop for the interested community of users (see UTIG Budget and Justification), we will upload delivered results to UTIG's Academic Science Portal of the Marine Geoscience Data System, and will also upload raw data/navigation to LDEO's Seismic Reflection Data Management System.

This is a collaborative effort between PIs with decades of experience collecting, processing and analyzing marine seismic data along continental margins, and in particular NJ. M. Nedimovic (MN) has recently completed a successful 2-month cruise as a Co-PI aboard *Langseth* collecting multi-streamer 2D data. His experience planning and executing that campaign (that included 6 volunteer watch-standers onboard to gain scientific experience) is valuable for the proposed project. Post-cruise, MN will provide primary oversight of the commercial processing; he will make two 5-day trips to the processing facility in Houston. He will be joined on both trips by a second Co-PI. G.Mountain (GM) has participated in every 2D MCS acquisition survey comprising the MAT. In his role as Exp313 Co-Chief, GM is in touch with Expedition-based research that will both augment and benefit from results of the proposed 3D volume. GM, MN and N. Christie-Blick (NCB) are professors at their respective institutions with years of teaching experience that can be applied to educational aspects of pre- and post-cruise workshops and the at-sea experience of volunteer watch-standers. NCB brings lengthy experience in applying sequence stratigraphic principles at the outcrop scale, which tied to the Exp313 wells is what the proposed 3D imagery will closely rival. J. Austin (JA) and C. Fulthorpe (CF) bring decades of experience in using both 2D and 3D MCS and ultra high-resolution acoustic tools (CHIRP, boomer, swath bathymetry) to the study of sediment transport on passive margins. With ONR support, they have studied the latest Pleistocene-Holocene stratigraphic succession of the NJ shelf for 25 yrs. Furthermore, both have analyzed 3D data volumes on the NW Australian continental margin, and both have been ODP/IODP Co-Chiefs in continental shelf drilling efforts (JA: Leg 174A, CF: Exp317). All co-PIs will help run shorebased workshops pre- and post-data acquisition, and 4 will sail aboard *Langseth* and participate in the instruction of volunteer watch-standers in the theory and practice of seismic acquisition, processing and interpretation. In addition to their instructional duties, GM, JA and CF will stand 8-hr watches each day at sea; MN will oversee data QC and be on-call to troubleshoot acquisition-related problems.

The 3D, pre-stack time migrated data volume will be delivered from the processing company to JA and CF, to be loaded onto a 3D visualization workstation. The co-PIs will convene a data appraisal, first-look interpretation workshop at UTIG for the interested scientific community shortly thereafter. Research themes identified will initiate sub-groups to focus on developing important research goals. Workshop products are TBD, but the intent is clear: 1) to debut the 3D data to interested researchers, 2) to task those present with developing strategies for achieving realistic goals using the 3D volume, and 3) to rapidly link a wide community of potential researchers to the 3D data by making it publically available at the close of the workshop (see the "Data Management Plan").

INTELLECTUAL MERIT

The NJ margin is among the best siliciclastic passive margins for elucidating the timing/amplitude of eustatic change over millions of years, and for examining quantitatively the link between sea-level change and the stratigraphic record. Consequently, this margin has been a key location in all long-range plans of scientific ocean drilling since it was first identified by COSOD II (1987). While Exp313 continuously cored/logged boreholes within shallow-water facies, and has recovered complete stratigraphic information, 3D seismic imaging is needed to put that sampled record in a spatially accurate, stratigraphically meaningful context. The 29 researchers of the Exp313 scientific party are an especially valuable knowledge base of the mid-Cenozoic evolution of the NJ shelf; they and other scientists involved in research of the MAT represent a large body of experts for whom the proposed seismic geomorphology will be a tremendous asset. 3D imagery will allow them to map sequences around Exp313 sites, including shoreline positions and flanking diagnostic shallow-water features (e.g., fluvial incisions, estuary complexes, point bars). The long-term objectives remain to: 1) determine the amplitude and timing of global sea-level changes during the "Ice House" 2) establish the impact of base-level changes on the preserved stratigraphic record; and 3) improve understanding of the response of shorelines/nearshore environments to changes in global sea level, a societally relevant topic today.

BROADER IMPACTS

The team of co-PIs envisions 3 phases of robust interaction with the user community before, during and after 3D acquisition aboard *Langseth*: 1) A pre-acquisition workshop to acquaint interested participants with the project (an announcement of opportunity was placed [May 2012; see 'Other Suppl. Docs.'] on the GeoPRISMS and Consortium for Ocean Leadership [COL] websites; additional announcements will follow funding) will be held at Rutgers prior to data acquisition. The scientific value of 3D data will be displayed, the history of research on the NJ margin will be highlighted, and plans for data acquisition will be laid out. Discussions will aim at reaching a consensus concerning acquisition details and processing features of the community data volume by a commercial company. 2) Community interaction during acquisition will be primarily the hands-on participation of students/young scientists aboard *Langseth* (~12 bunks are available for volunteers [see 'Mentoring Plan']). The survey area is <40 nmi from Atlantic City, so rotation of more than one group is possible by at-sea transfer, enabling a variety of education/outreach activities with perhaps occasional live satellite feeds showing the deployment/recovery of seismic gear, etc. 3) A post-acquisition workshop at UTIG will focus on avenues for community analysis/interpretation of the processed 3D volume, once that volume is available ~5 mo post-acquisition.

The Rutgers Geology Museum has previously hosted exhibits of scientific drilling in the Coastal Plain, focusing on the K/Pg boundary core obtained at Bass River, NJ (ODP Leg 174AX; Olsson et al., 1997). We will prepare similar exhibits/talks to highlight the integration of 3D seismic with drilling. We expect that 3D images will become integral to IODP outreach, along with Exp313 results. We will showcase NJ margin results for the European Union (which funded Exp313 drilling/logging costs through IODP), for ICDP (which funded some drilling costs), the COL (responsible for logging/data management) and IODP-MI (which managed Exp313). We will provide the IODP Data Bank, and, if asked, the ECORD/ESO Drilling Operator, with 3D image data. LDEO/UTIG have an ongoing collaboration through NSF to archive marine seismic data. We will make the commercially processed 3D data available to this facility, with the expectation that they will become an enduring demonstration of how 3D imaging can improve understanding of passive margin stratigraphic evolution.

A final note about societal relevance. The proposed 3D volume, tied to cored and logged drillsites, will provide a valuable opportunity to understand better the causes of an increase in mid-Neogene deposition at many passive margins around the globe (e.g., Bartek et al., 1991.). The same Appalachian hinterland that was the source of the sedimentary record offshore NJ, and concentrated on by the MAT, fed a similar pulse of sediments into the Gulf of Mexico. Consequently, increasing knowledge of the evolution of the NJ shelf may help to improve exploration strategies in the Gulf, a proven hydrocarbon province.

RESULTS FROM PRIOR NSF SUPPORT

Gregory Mountain and **Nicholas Christie-Blick** have not received NSF support in the past 5 years.
Mladen Nedimović (w/ PIs from LDEO, WHOI + SIO; only LDEO support listed): OCE-0648303, *Collab. Res.: Seismic structure + evolu-tion of oceanic crust along the Juan de Fuca Ridge + its Flanks*, 04/01/07-03/31/10, $173,519. Resulted in 3 PhD chapters, 15 AGU abstracts, 11 peer-reviewed papers (4 in G^3, 2 in *Nature*, 2 in *EPSL*, 2 in *JGR*, and 1 in *Geology*).
Craig Fulthorpe and **James Austin**, OCE 0550004 (PIs Fulthorpe, Austin, Lavier [UTIG]), *The NW Shelf, Australia: the next step in a global approach to understanding the role of eustasy in the generation and preservation of stratigraphy,* $464,278; 2/1/06-1/31/09 + 2 no-cost extensions to 1/31/11. Commercially donated 3D+2D MCS, logs and well-completion reports were used to investigate stratal architecture of a siliciclastic-rich interval of the N. Carnarvon Basin, where late mid-Miocene siliciclastics prograded across a Paleogene carbonate ramp under wave-dominated conditions during a time of base-level fall. Thus far resulted in (Liu et al., 2011; Sanchez et al., 2012a, 2012b; 1 Ph.D. (Sanchez); aid for C. Liu to visit UTIG from China to collaborate, 2008-2010.

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SUMMARY PROPOSAL BUDGET

YEAR 1

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months)	
	Proposed	Granted
AWARD NO.		

ORGANIZATION
Rutgers University New Brunswick

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Gregory Mountain

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Gregory S Mountain - Professor**	(b) (4), (b) (6) [redacted]				
2.					
3.					
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)					
7. (**1**) TOTAL SENIOR PERSONNEL (1 - 6)					
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS					
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)					
3. (**0**) GRADUATE STUDENTS					
4. (**0**) UNDERGRADUATE STUDENTS					
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)					
6. (**0**) OTHER					
TOTAL SALARIES AND WAGES (A + B)					
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)					
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)					
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				(b) (4) [redacted]	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)					
2. FOREIGN					
F. PARTICIPANT SUPPORT COSTS (b) (4) [redacted]					
1. STIPENDS $					
2. TRAVEL					
3. SUBSISTENCE					
4. OTHER					
TOTAL NUMBER OF PARTICIPANT — TOTAL PARTICIPANT COSTS				(b) (4) [redacted]	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES					
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					
3. CONSULTANT SERVICES					
4. COMPUTER SERVICES					
5. SUBAWARDS					
6. OTHER					
TOTAL OTHER DIRECT COSTS					
H. TOTAL DIRECT COSTS (A THROUGH G)					
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) (b) (4) [redacted]					
TOTAL INDIRECT COSTS (F&A)				(b) (4) [redacted]	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)					
K. RESIDUAL FUNDS					
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				**787,551**	

M. COST SHARING PROPOSED LEVEL $ **Not Shown** AGREED LEVEL IF DIFFERENT $

PI/PD NAME	FOR NSF USE ONLY		
Gregory Mountain	INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME*	Date Checked	Date Of Rate Sheet	Initials - ORG
Emmeline Crowley			

1 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

SUMMARY PROPOSAL BUDGET

YEAR 2

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION
Rutgers University New Brunswick

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Gregory Mountain

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Gregory S Mountain - Professor**	0.00	0.00	0.00	0	
2.					
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	0	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	0	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (0) GRADUATE STUDENTS				0	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				0	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				0	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				0	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				(b) (4) [redacted]	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)					
2. FOREIGN					
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ 0					
2. TRAVEL 0					
3. SUBSISTENCE 0					
4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				(b) (4) [redacted]	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					
3. CONSULTANT SERVICES					
4. COMPUTER SERVICES					
5. SUBAWARDS					
6. OTHER					
TOTAL OTHER DIRECT COSTS					
H. TOTAL DIRECT COSTS (A THROUGH G)					
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) (b) (4) [redacted]					
TOTAL INDIRECT COSTS (F&A)				(b) (4) [redacted]	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)					
K. RESIDUAL FUNDS					
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				2,268	

M. COST SHARING PROPOSED LEVEL $ **Not Shown** AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Gregory Mountain

ORG. REP. NAME*
Emmeline Crowley

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

2 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

SUMMARY PROPOSAL BUDGET

Cumulative

ORGANIZATION **Rutgers University New Brunswick**	FOR NSF USE ONLY PROPOSAL NO.	DURATION (months) Proposed / Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR **Gregory Mountain**	AWARD NO.	

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Gregory S Mountain - Professor**	(b) (4), (b) (6) [redacted]				
2.					
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)					
7. (**1**) TOTAL SENIOR PERSONNEL (1 - 6)					
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS					
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)					
3. (**0**) GRADUATE STUDENTS					
4. (**0**) UNDERGRADUATE STUDENTS					
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)					
6. (**0**) OTHER					
TOTAL SALARIES AND WAGES (A + B)					
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)					
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)					
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				(b) (4) [redacted]	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)					
2. FOREIGN					
F. PARTICIPANT SUPPORT COSTS (b) (4) [redacted] 1. STIPENDS $ 2. TRAVEL 3. SUBSISTENCE 4. OTHER					
TOTAL NUMBER OF PARTICIPANT — TOTAL PARTICIPANT COSTS				(b) (4) [redacted]	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				(b) (4) [redacted]	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					
3. CONSULTANT SERVICES					
4. COMPUTER SERVICES					
5. SUBAWARDS					
6. OTHER					
TOTAL OTHER DIRECT COSTS					
H. TOTAL DIRECT COSTS (A THROUGH G)					
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)					
TOTAL INDIRECT COSTS (F&A)				(b) (4) [redacted]	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)					
K. RESIDUAL FUNDS					
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				**789,819**	
M. COST SHARING PROPOSED LEVEL $ **Not Shown**	AGREED LEVEL IF DIFFERENT $				

PI/PD NAME **Gregory Mountain**	FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME* **Emmeline Crowley**	Date Checked	Date Of Rate Sheet	Initials - ORG

C *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

RUTGERS BUDGET JUSTIFICATION

(b) (4), (b) (6)

[redacted]

(b) (4), (b) (6)

[redacted]

BUDGET SUMMARY

Collaborative Research: Community-Based 3D Imaging that Ties Clinoform Geometry to Facies Successions and Neogene Sea-Level Change

Rutgers University

(b) (4), (b) (6)

[redacted]

J. Total Costs	**$787,551**	**$2,268**	**$789,819**

SUMMARY PROPOSAL BUDGET

YEAR 1

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months)	
	Proposed	Granted
AWARD NO.		

ORGANIZATION
University of Texas at Austin

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Craig S Fulthorpe

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months	Funds Requested By proposer	Funds granted by NSF (if different)
1. Craig S Fulthorpe - Sr. Research Scientist	(b) (4), (b) (6) [redacted]		
2. James A Austin, Jr. - Sr. Research Scientist			
3.			
4.			
5.			
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)			
7. (2) TOTAL SENIOR PERSONNEL (1 - 6)			
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)			
1. (0) POST DOCTORAL SCHOLARS			
2. (1) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)			
3. (0) GRADUATE STUDENTS			
4. (0) UNDERGRADUATE STUDENTS			
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)			
6. (0) OTHER			
TOTAL SALARIES AND WAGES (A + B)			
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)			
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)			
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEED			
TOTAL EQUIPMENT		(b) (4) [redacted]	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)			
2. FOREIGN			
F. PARTICIPANT SUPPORT COSTS			
1. STIPENDS $ 0			
2. TRAVEL 0			
3. SUBSISTENCE 0			
4. OTHER 0			
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS		0	
G. OTHER DIRECT COSTS			
1. MATERIALS AND SUPPLIES		(b) (4) [redacted]	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION			
3. CONSULTANT SERVICES			
4. COMPUTER SERVICES			
5. SUBAWARDS			
6. OTHER			
TOTAL OTHER DIRECT COSTS			
H. TOTAL DIRECT COSTS (A THROUGH G)			
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) (b) (4) [redacted]			
TOTAL INDIRECT COSTS (F&A)		(b) (4) [redacted]	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)			
K. RESIDUAL FUNDS			
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)		79,603	
M. COST SHARING PROPOSED LEVEL $ Not Shown	AGREED LEVEL IF DIFFERENT $		

PI/PD NAME
Craig S Fulthorpe

ORG. REP. NAME*
Barbara Reyes

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

1 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

SUMMARY PROPOSAL BUDGET

YEAR 2

FOR NSF USE ONLY

ORGANIZATION University of Texas at Austin	PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR Craig S Fulthorpe	AWARD NO.		

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. Craig S Fulthorpe - Sr. Research Scientist	[redacted]				
2. James A Austin, Jr. - Sr. Research Scientist					
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE					
7. (2) TOTAL SENIOR PERSONNEL (1 - 6)					
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL SCHOLARS					
2. (2) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)					
3. (0) GRADUATE STUDENTS					
4. (0) UNDERGRADUATE STUDENTS					
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)					
6. (0) OTHER					
TOTAL SALARIES AND WAGES (A + B)					
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)					
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)					
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				[redacted]	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)					
2. FOREIGN					
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ [redacted] 2. TRAVEL 3. SUBSISTENCE 4. OTHER					
TOTAL NUMBER OF PARTICIPANT TOTAL PARTICIPANT COSTS				[redacted]	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				[redacted]	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					
3. CONSULTANT SERVICES					
4. COMPUTER SERVICES					
5. SUBAWARDS					
6. OTHER					
TOTAL OTHER DIRECT COSTS					
H. TOTAL DIRECT COSTS (A THROUGH G)					
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) [redacted]					
TOTAL INDIRECT COSTS (F&A)				[redacted]	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)					
K. RESIDUAL FUNDS					
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				114,828	
M. COST SHARING PROPOSED LEVEL $ Not Shown	AGREED LEVEL IF DIFFERENT $				

PI/PD NAME Craig S Fulthorpe	FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME* Barbara Reyes	Date Checked	Date Of Rate Sheet	Initials - ORG

2 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

SUMMARY PROPOSAL BUDGET

Cumulative

		FOR NSF USE ONLY		
ORGANIZATION **University of Texas at Austin**		PROPOSAL NO.	DURATION (months)	
			Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR **Craig S Fulthorpe**		AWARD NO.		

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Craig S Fulthorpe - Sr. Research Scientist**	(b) (4), (b) (6) [redacted]				
2. **James A Austin, Jr. - Sr. Research Scientist**					
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)					
7. (**2**) TOTAL SENIOR PERSONNEL (1 - 6)					
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS					
2. (**3**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)					
3. (**0**) GRADUATE STUDENTS					
4. (**0**) UNDERGRADUATE STUDENTS					
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)					
6. (**0**) OTHER					
TOTAL SALARIES AND WAGES (A + B)					
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)					
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)					
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				(b) (4) [redacted]	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)					
2. FOREIGN					
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ (b) (4) [redacted] 2. TRAVEL 3. SUBSISTENCE 4. OTHER					
TOTAL NUMBER OF PARTICIPANT ... TOTAL PARTICIPANT COSTS				(b) (4) [redacted]	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				(b) (4) [redacted]	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					
3. CONSULTANT SERVICES					
4. COMPUTER SERVICES					
5. SUBAWARDS					
6. OTHER					
TOTAL OTHER DIRECT COSTS					
H. TOTAL DIRECT COSTS (A THROUGH G)					
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)					
TOTAL INDIRECT COSTS (F&A)				(b) (4) [redacted]	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)					
K. RESIDUAL FUNDS					
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				**194,431**	
M. COST SHARING PROPOSED LEVEL $ **Not Shown**	AGREED LEVEL IF DIFFERENT $				

PI/PD NAME **Craig S Fulthorpe**	FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME* **Barbara Reyes**	Date Checked	Date Of Rate Sheet	Initials - ORG

C *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

BUDGET SUMMARY

Collaborative Research: Community-Based 3D Imaging that Ties Clinoform Geometry to Facies Successions and Neogene Sea-Level Change

The University of Texas at Austin

May 1, 2013 - April 30, 2015

(b) (4), (b) (6)

[redacted]

BUDGET JUSTIFICATION

Collaborative Research: Community-Based 3D Imaging that Ties Clinoform Geometry to Facies Successions and Neogene Sea-Level Change

The University of Texas at Austin Institute for Geophysics (UTIG)

May 1, 2013 - April 30, 2015

(b) (4), (b) (6)

[redacted]

(b) (4), (b) (6)

[redacted]

SUMMARY PROPOSAL BUDGET

YEAR 1

ORGANIZATION **Columbia University**				FOR NSF USE ONLY PROPOSAL NO.	DURATION (months) Proposed / Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR **Nicholas Christie-Blick**				AWARD NO.	
A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Nicholas Christie-Blick - Professor**	(b) (4), (b) (6) [redacted]				
2. **Mladen Nedimovic - Adjunt Research Scientist**					
3. **Total Salaries**					
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE					
7. (**3**) TOTAL SENIOR PERSONNEL (1 - 6)					
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS					
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)					
3. (**0**) GRADUATE STUDENTS					
4. (**0**) UNDERGRADUATE STUDENTS					
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)					
6. (**1**) OTHER					
TOTAL SALARIES AND WAGES (A + B)					
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)					
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)					
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				(b) (4), (b) (6) [redacted]	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)					
2. FOREIGN					
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ **0** 2. TRAVEL **0** 3. SUBSISTENCE **0** 4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				(b) (4) [redacted]	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					
3. CONSULTANT SERVICES					
4. COMPUTER SERVICES					
5. SUBAWARDS					
6. OTHER					
TOTAL OTHER DIRECT COSTS					
H. TOTAL DIRECT COSTS (A THROUGH G)					
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) (b) (4) [redacted]					
TOTAL INDIRECT COSTS (F&A)				(b) (4) [redacted]	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)					
K. RESIDUAL FUNDS					
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				**94,508**	
M. COST SHARING PROPOSED LEVEL $ **Not Shown**	AGREED LEVEL IF DIFFERENT $				
PI/PD NAME **Nicholas Christie-Blick**				FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION	
ORG. REP. NAME* **Maribel Respo**				Date Checked / Date Of Rate Sheet	Initials - ORG

1 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

SUMMARY PROPOSAL BUDGET

YEAR 2

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months)	
	Proposed	Granted
AWARD NO.		

ORGANIZATION
Columbia University

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Nicholas Christie-Blick

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. Nicholas Christie-Blick - Professor	0.00	0.00	0.00	0	
2. Mladen Nedimovic - Adjunt Research Scientist	0.00	0.00	0.00	0	
3. Total Salaries	0.00	0.00	0.00	0	
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (3) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	0.00	0	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	0	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (0) GRADUATE STUDENTS				0	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				0	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				0	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				0	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				[redacted]	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)					
2. FOREIGN					
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ 0					
2. TRAVEL 0					
3. SUBSISTENCE 0					
4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				[redacted]	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					
3. CONSULTANT SERVICES					
4. COMPUTER SERVICES					
5. SUBAWARDS					
6. OTHER					
TOTAL OTHER DIRECT COSTS					
H. TOTAL DIRECT COSTS (A THROUGH G)					
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) [redacted]					
TOTAL INDIRECT COSTS (F&A)				[redacted]	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)					
K. RESIDUAL FUNDS					
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				4,911	

M. COST SHARING PROPOSED LEVEL $ **Not Shown** AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Nicholas Christie-Blick

ORG. REP. NAME*
Maribel Respo

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

2 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

SUMMARY PROPOSAL BUDGET

Cumulative

ORGANIZATION	FOR NSF USE ONLY		
Columbia University	PROPOSAL NO.	DURATION (months)	
		Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR **Nicholas Christie-Blick**	AWARD NO.		

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Nicholas Christie-Blick - Professor**	(b) (4) [redacted]				
2. **Mladen Nedimovic - Adjunt Research Scientist**					
3. **Total Salaries**					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE					
7. (**3**) TOTAL SENIOR PERSONNEL (1 - 6)					
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS					
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)					
3. (**0**) GRADUATE STUDENTS					
4. (**0**) UNDERGRADUATE STUDENTS					
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)					
6. (**1**) OTHER					
TOTAL SALARIES AND WAGES (A + B)					
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)					
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)					
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				(b) (4) [redacted]	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)					
2. FOREIGN					
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				(b) (4) [redacted]	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					
3. CONSULTANT SERVICES					
4. COMPUTER SERVICES					
5. SUBAWARDS					
6. OTHER					
TOTAL OTHER DIRECT COSTS					
H. TOTAL DIRECT COSTS (A THROUGH G)					
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)					
TOTAL INDIRECT COSTS (F&A)				(b) (4) [redacted]	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)					
K. RESIDUAL FUNDS					
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				**99,419**	

M. COST SHARING PROPOSED LEVEL $ **Not Shown** AGREED LEVEL IF DIFFERENT $

PI/PD NAME	FOR NSF USE ONLY		
Nicholas Christie-Blick	INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME*	Date Checked	Date Of Rate Sheet	Initials - ORG
Maribel Respo			

C *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

BUDGET JUSTIFICATION

The following is confidential information that The Trustees of Columbia University requests not be released to persons outside the Government, except for purposes of review and evaluation

(b) (4), (b) (6)

[redacted]

TITLE: Collaborative Research: Community-Based 3D Imaging That Ties Clinoform Geometry

PRINCIPAL INVESTIGATOR(S): Nicholas Christie-Blick, PI; Mladen Nedimovic, Co-PI

PERIOD OF PERFORMANCE: May 1, 2013 - April 30, 2015

(b) (4), (b) (6)

[redacted]

CURRENT AND PENDING SUPPORT
8/7/12

Gregory Mountain

A Supporting Agency	B Project Title	C Award Amount	D Pd Covered Award	E Man-Mos. Acad. Sum. Cal.	F Location
A. Current Support					
(b) (4), (b) (6) [redacted]					
Dept. of Energy / subcontract from Battelle Corp.	Midwestern Regional Carbon Sequestration Partnership (MCRSP): Rutgers	$568,800	07/01/12 - 06/30/16	1/1/1/1 (all Sum.)	Rutgers
B. Pending Support					
(b) (4), (b) (6) [redacted]					

Current and Pending Support

(See GPG Section II.C.2.h for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Craig Fulthorpe

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

(b) (4), (b) (6)

[redacted]

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

(b) (4), (b) (6)

[redacted]

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

(b) (4), (b) (6)

[redacted]

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: $ Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: $ Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Summ:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

 USE ADDITIONAL SHEETS AS NECESSARY

Current and Pending Support

(See GPG Section II.C.2.h for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: James Austin, Jr.

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

(b) (4), (b) (6)

[redacted]

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

(b) (4), (b) (6)

[redacted]

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

(b) (4), (b) (6)

[redacted]

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

(b) (4), (b) (6)

[redacted]

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

(b) (4), (b) (6)

[redacted]

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

CURRENT AND PENDING SUPPORT
8/6/2012

NICHOLAS CHRISTIE-BLICK

A Supporting Agency	B Project Title	C Award Amount	D Period Covered Award	E Man-Month Acad. Sum. Cal.	F Location

A. Current Support
NONE

(b) (4), (b) (6)
[redacted]

CURRENT AND PENDING SUPPORT
8/7/2012

MLADEN NEDIMOVIC

A Supporting Agency	B Project Title	C Award Amount	D Period Covered Award	E Man-Month Acad. Sum. Cal.	F Location
A. Current Support					
NSF OCE 10-29411	COLLABORATIVE RESEARCH: EVOLUTION AND HYDRATION OF THE JUAN DE FUCA CRUST AND UPPERMOST MANTLE: A PLATE-SCALE SEISMIC INVESTIGATION FROM RIDGE TO TRENCH (CARBOTTE, S., PI; CARTON, H., NEDIMOVIC, M., CO-PI's)	223,709	3/1/12 2/28/13	NC/YR	LDEO
NSF EAR 06-07687	COLLABORATIVE RESEARCH: UPLIFT AND FAULTING AT THE TRANSITION FROM SUBDUCTION TO COLLISION- A FIELD AND MODELING STUDY OF THE CALABRIAN ARC. (STECKLER, M., PI; SEEBER, L., CO-PI; STARK, C., CO-PI; SCHAEFER, J., CO-PI; MALINVERNO, A., CO-PI; W/ NEDIMOVIC, M.; ARMBRUSTER, J.; KIM, W.Y.)	1,764,627	8/1/06 7/31/13	2/1/.5/1/NC/ NC/NC	LDEO
NSF OCE 09-26614	MEGATHRUST SEISMIC HAZARDS BY REFLECTION MAPPING (SHILLINGTON, D., PI; WEBB, S., NEDIMOVIC, M.; CO-PI'S)	713,878	1/1/10 12/31/12	NC	LDEO

(b) (4), (b) (6)
[redacted]

MLADEN NEDIMOVIC

(b) (4), (b) (6)

[redacted]

RUTGERS FACILITIES, EQUIPMENT & OTHER RESOURCES

FACILITIES:

Laboratory: 900 sq ft computer processing, visualization laboratory for students, researchers, faculty and visitors

Clinical:
N/A

Animal:
N/A

Computer: Instruction and pre-cruise data review for the first community workshop will be held in an 1800 sq ft instructional computer lab equipped with 16 HP 6200 Small Form Factor Computers. Each is at least a first generation i5 processor with 4GB of ram, and all are running Scientific Linux 6 as the default operating system. Fundamentals of 2D multichannel seismic processing will be demonstrated and participants will be able to complete training exercises on these machines using Seismic Unix. These same machines are connected via a Cisco 2948 switch which operates at 100 mb/s (FastEthernet), and bound to our department's LDAP and served home directories from our file server. The latter is an HP 380 G6, and utilizes a raid 5 disk array with 8TB of space that is backed up 3x daily. During the workshop we will also connect each of the client machines to our Virtual Desktop Infrastructure to enable 2D and 3D seismic visualization running SMT-Kingdom 64-bit licensed software on an HP xw6600 Windows 2008 R2 server with 4GB of ram and dual quadcore Intel Xeon E5420 processors and 1 TB of storage on a RAID 5 array. All of the existing public 2D seismic data and scientific results of IODP Exp313 are stored locally and available for instruction and participant exercises that will be prepared for this workshop.

Office:

MAJOR EQUIPMENT:

OTHER RESOURCES:

The PI will prepare lectures and instructional material for the participants in the pre-cruise workshop as well as at sea during the acquisition phase.

NSF Form 1363 (10/99)

FACILITIES, EQUIPMENT & OTHER RESOURCES

FACILITIES: Identify the facilities to be used at each performance site listed and, as appropriate, indicate their capacities, pertinent capabilities, relative proximity, and extent of availability to the project. Use "Other" to describe the facilities at any other performance sites listed and at sites for field studies. Use additional pages if necessary.

Laboratory:

The University of Texas at Austin Institute for Geophysics ("UTIG") has some laboratory space at the main Institute building and a larger space in another building nearby for staging preparation for field work.

Clinical:

N/A

Animal:

N/A

Computer:

UTIG is connected to the University of Texas at Austin and the internet via a 10 gigabit Ethernet connection. Internally, a switched 10/1 gigabit LAN interconnects Solaris and Linux workstations, PCs and Macintoshes. Significant computer resources include 32 64bit Linux computers with nearly 300 cores and 1.2TB of memory. Five servers participate in a 4Gb/s fiber-channel SAN with 20TB of disk. 25TB of public fast disk with tiered demand migration to 105TB of slower disk and 220TB of tape serve Unix and Windows clients; 300TB of other network disk is online. An assortment of tape drives (3480, 4mm, 8mm, DLT, LTO3/4) allow data to be staged to disk or processed directly. Plotting devices include two 42" HP inkjet plotters, several letter-to-tabloid-size color printers and many black-and-white printers. A 42" scanner is available. Software available on all systems includes program development tools, plotting tools, and both public domain and commercial data analysis packages. All PCs and Macs have common graphics tools and office productivity applications, and share files with the Unix systems.

Office:

UTIG's main office space at the University of Texas's J.J. Pickle Research Campus, 10100 Burnet Road, Bldg. 196, Austin, Texas, is available for the proposed research.

MAJOR EQUIPMENT: List the most important items available for this project and, as appropriate, identify the location and pertinent capabilities of each.

- 2 x 32 core servers 2.7GHz/64GB/100G/4gigE
- 3 x 16 core servers 2.2+GHz/32GB/3TB/4gigE
- 7 x 12 core servers 2.9+GHz/24+GB/10TB/4gigE
- 3 x 8 core servers 2.2+GHz/16GB/1-4TB/2gigE
- 17 x 4 core servers 2.2+GHz/4-10GB/140GB/2gigE
- 1 x 4 core Sun x4200 server 2.8GHz/24G/140GB/4gigE
- 1 x 4 core Sun T2000 server 1GHz/8GB/140GB/4gigE
- 3 x 2 core Sun servers 900Mhz/4Gbyte/72G/1gigE
- 4Gb/s FC SAN; 10G network; SAM-FS data migration software
- Paradigm Focus seismic processing software
- Paradigm Geodepth pre-stack migration software
- Geoquest, Landmark interpretation software
- Arc/GIS, Caris Multi-Beam, Matlab software
- Two HP 42" color plotters; 42" scanner

OTHER RESOURCES: Provide any information describing the other resources available for the project. Identify support services such as consultant, secretarial, machine shop, and electronics shop, and the extent to which they will be available for the project. Include an explanation of any consortium/contractual/sub award arrangements with other organizations.

UTIG has administrative and computer support personnel.

LDEO FACILITIES, EQUIPMENT AND OTHER RESOURCES

FACILITIES

Laboratory:
N/A

Clinical:
N/A

Animal:
N/A

Computer:
Computing resources at LDEO include an extensive network of Sun and Linux workstations, fileservers and peripherals. Site-licensed software is available for interactive MCS data manipulation, 2D and 3D imaging, waveform analysis, and graphical visualization from both Landmark and Paradigm (e.g., Promax, SeisWorks, Focus, STRATA, etc.). The multichannel seismic reflection processing facility has five linux based 3.06 GHz Intel Xeon multithread dual CPU DELL workstations each with 3 GB of RAM and 750 GB internal raid arrays, and a unix based SUN enterprise 450 server with 296 MHz dual CPU, 2 GB of RAM and 510 GB of disk space. These are all 21-inch dual monitor stations. A 16 node 32 CPU linux-box cluster connected to a NAS raid array providing 100 TB useable disk space is available. There are also a number of other SUN Ultrasparc 10 stations. The MCS facility also has two 3490E cartridge drives with stack loaders, two DLT7000 cartridge drives, and two DLT2000 cartridge drives.

Office:
Office space, heating, air conditioning, administrative support, grants management and financial services, library and other academic services to support the effort are all provided under the negotiated ICR.

MAJOR EQUIPMENT:
N/A

OTHER RESOURCES:
N. Christie-Blick (PI) and M. Nedimovic (Co-PI) will participate in the planning of the cruise, the pre-cruise workshop, the post-processing data review, and the post-cruise workshop at which community-based opportunities for analysis/interpretation of the processed 3D volume and integration with Exp313 results will be developed. M. Nedimovic (Co-PI) will also take part in the cruise, and the data processing in Houston.

Data Management Plan

This project will create ~7.5 terabytes of 120-channel, 3D seismic reflection field data integrated with navigation in standard SEG-D and UKOOA formats, respectively. Metadata related to QA/QC monitoring of MCS operations, routine to all such activities aboard the *R/V Langseth*, will be recorded as well. Additional digital data gathered from other shipboard sensors, including multibeam sonar, gravity and meteorological data, will be transmitted to the Lamont Database group that will, in turn, ensure that these data are deposited in appropriate national archives for long-term preservation. The 'raw' MCS field data will be copied to the Academic Seismic Portal at Lamont-Doherty (http://www.marine-geo.org/portals/seismic/), where it will undergo additional QA/QC in preparation for archiving purposes and for its delivery to the processing center.

The MCS field shot data described above will be copied to a robust external hard drive and delivered to the commercial processing company of choice (e.g., PGS of Houston, TX; see accompanying quote), where a prearranged flow of processing steps, overseen by the PIs, will produce a 3D 'volume' of pre-stack, time-migrated data within ~5 mos. of the end of data acquisition. Processed data will be returned to Lamont-Doherty in standard SEG-Y format, with navigation embedded in trace headers.

A copy of the processed dataset will be sent to the Univ. of Texas, Austin/Institute for Geophysics where it will be served on a network of 3D-data MCS workstations. All public data from Exp313 will be installed on this network and integrated with these seismic data for access during a community workshop at UTIG, whose purpose is to examine data quality and develop strategies for maximizing the opportunities for the ensuing stage of scientific analysis.

The processed 3D data volume will be transferred to the Academic Seismic Portal at the Univ. of Texas, Austin/Institute for Geophysics (http://www.ig.utexas.edu/sdc/) which handles processed seismic data and where it will be instantly available for public distribution without restriction. The field shot data archived at the Lamont-Doherty Academic Seismic Portal will be made available at this time as well. Like any other data set released by this national facility, rules concerning derivative products and re-distribution will apply, but any qualified user who abides by these agreements will have complete access to both the processed data and the raw field data.

Postdoctoral Researcher Mentoring Plan

We seek no funds for Post-Doctoral Researchers to conduct scientific analysis of data acquired in the proposed project. While individuals selected by the PIs through an application process will be invited to participate on the cruise, they may or may not be Post-Docs. 4-6 months pre-cruise a public call will go out for 'young researchers' (grad students / post-docs / young scientists) who are looking towards a career that requires knowledge of 3D MCS acquisition, processing and/or interpretation. Following the advice of the MG&G program of NSF, we are providing this 'qualified' mentoring plan to define clearly the manner in which Post-Doctoral researchers may benefit from the proposed project.

We are acting on recommendations of the 2010 community workshop entitled *Challenges and Opportunities in Academic Marine Seismology* (http://www.steveholbrook.com/mlsoc/workshop_report.pdf) that encouraged (1) greater community access to 3D MCS data, and (2) providing bunk space on cruises that could yield hands-on learning experiences for the upcoming generation of marine scientists. Accordingly, we ask that up to 12 berths aboard the *R/V Langseth* be reserved for these young researchers. Funds are requested to subsidize their travel to and from the ship, but we seek no other financial support for them prior to, during, or following the cruise. (Of course, the daily operational costs of the *Langseth* will absorb their 'room and board' expenses at sea.) Their exact roles and contributions to the project will depend on the skills they bring with them. We hope to have the luxury of more applicants than berths and be able to select those best qualified to benefit from this opportunity.

The goals will be to: (1) provide a 'learning by doing' experience to a broad range of participants; (2) transfer experience from the 4 on-board PIs to these young researchers in such areas as planning and running a cruise, handling gear on deck, the theory and practice of seismic processing, applications of 2 and 3D MCS, etc.; and (3) stimulate members of the group to participate in the data showcase workshop (see the Project Description) and pursue a research project using the data they helped to collect. Each of the 4 PIs who will be on the *Langseth* have lecture experience, and 2 teach marine geology and geophysics at the college and graduate level. We are all prepared to conduct lessons at sea, tailored to the backgrounds and interests of the young researchers.

NATIONAL SCIENCE FOUNDATION
Grant Letter

Award: 1260237 **PI Name:** Mountain, Gregory

Award Date January 15, 2014
Award No. OCE-1260237
Proposal No. OCE-1260237

Ms. D. Dee Evans
Assistant Director, Office of Sponsored Agreement Management
Rutgers, The State University
of New Jersey
3 Rutgers Plaza
ASB III, 2nd floor
New Brunswick, NJ 08901-8559

Dear Ms. Evans:

The National Science Foundation hereby awards a grant of $369,358 to Rutgers, The State University of New Jersey for support of the project described in the proposal referenced above as modified by revised budget dated December 11, 2013.

This project, entitled "Collaborative Research: Community-Based 3D Imaging That Ties Clinoform Geometry to Facies Successions and Neogene Sea-Level Change," is under the direction of
Gregory S. Mountain, in collaboration with the following proposals

Proposal No:	PI Name/Institution
1259135	Craig S. Fulthorpe, University of Texas at Austin

.

This award is effective January 15, 2014 and expires December 31, 2015.

This is a continuing grant which has been approved on scientific / technical merit. Contingent on the availability of funds and the scientific progress of the project, NSF expects to continue support at approximately the following level:

FY 2015 $312,295

The scientific / technical progress of the project is documented through submission and approval of annual and final project reports to NSF. Such reports are to be submitted electronically via NSF's Research.gov web portal [http://www.research.gov/]. Information regarding the specific due dates of such reports also is available through Research.gov.

This grant is awarded pursuant to the authority of the National Science Foundation Act of 1950, as amended (42 U.S.C. 1861-75) and is subject to Research Terms and Conditions (RTC), dated June 2011, and NSF RTC Agency Specific Requirements, dated January 14, 2013, available at http://www.nsf.gov/awards/managing/rtc.jsp and the following terms and conditions:

This award is subject to the Federal Funding Accountability and Transparency Act (FFATA) award term entitled, Reporting Subawards and Executive Compensation, which has been incorporated into the NSF Terms and Conditions referenced above.

If the awardee has any questions related to the pre-populated data associated with this award in the FFATA Subaward Reporting System, such questions should be submitted to: FFATAReporting@nsf.gov or by phone to: (800) 673-6188.

NATIONAL SCIENCE FOUNDATION
Grant Letter

Award:1260237 **PI Name:**Mountain, Gregory

The Foundation authorizes the awardee to enter into the proposed contractual arrangements and to fund such arrangements with award funds up to the amount indicated in the approved budget. Such contractual arrangements should contain appropriate provisions consistent with Articles 8.a.4. and 9 of the NSF Grant General Conditions (GC-1) (dated January 14, 2013) or Articles 5 and 40 of the Research Terms and Conditions (dated June 2011), as well as any special conditions included in this award.

The awardee agrees to administer/monitor all subcontracts/subawards it enters into and supports with NSF funds in accordance with the applicable federal cost principles and the applicable federal administrative requirements.

Please view the project reporting requirements for this award at the following web address [https://reporting.research.gov/fedAwardId/1260237].

The attached budget indicates the amounts, by categories, on which NSF has based its support.

The cognizant NSF program official for this grant is Bilal U. Haq, (703) 292-8582.
The cognizant NSF grants official contact is Irene Sattler, (703) 292-4813.

Sincerely,

Vanessa L. Richardson
Grants and Agreements Officer

CFDA No. 47.050
sponpgms@orsp.rutgers.edu

NATIONAL SCIENCE FOUNDATION

Grant Letter

Award:1259135 **PI Name:**Fulthorpe, Craig

Award Date January 15,
2014
Award No. OCE-1259135
Proposal No. OCE-1259135

Dr. Susan Wyatt Sedwick
Director of Sponsored Projects
University of Texas at Austin
101 E. 27th Street, Suite 5.300
Austin, TX 78712-1532

Dear Dr. Sedwick:

The National Science Foundation hereby awards a grant of $122,307 to University of Texas at Austin for support of the project described in the proposal referenced above as modified by revised budget dated December 3, 2013.

This project, entitled "Collaborative Research: Community-Based 3D Imaging That Ties Clinoform Geometry to Facies Successions and Neogene Sea-Level Change," is under the direction of
Craig S. Fulthorpe, Mladen Nedimovic, James A. Austin, Jr., in collaboration with the following proposals

Proposal No:	PI Name/Institution
1260237	Gregory S. Mountain, Rutgers, The State University of New Jersey

.

This award is effective January 15, 2014 and expires December 31, 2015.

This is a continuing grant which has been approved on scientific / technical merit. Contingent on the availability of funds and the scientific progress of the project, NSF expects to continue support at approximately the following level:

FY 2015	$103,848

The scientific / technical progress of the project is documented through submission and approval of annual and final project reports to NSF. Such reports are to be submitted electronically via NSF's Research.gov web portal [http://www.research.gov/]. Information regarding the specific due dates of such reports also is available through Research.gov.

This grant is awarded pursuant to the authority of the National Science Foundation Act of 1950, as amended (42 U.S.C. 1861-75) and is subject to Research Terms and Conditions (RTC, dated June 2011) and the NSF RTC Agency-Specific Requirements (dated January 14, 2013) are available at http://www.nsf.gov/awards/managing/rtc.jsp.
This institution is a signatory to the Federal Demonstration Partnership (FDP) Phase V Agreement which requires active institutional participation in new or ongoing FDP demonstrations and pilots. .

This award is subject to the Federal Funding Accountability and Transparency Act (FFATA) award term entitled, Reporting Subawards and Executive Compensation, which has been incorporated into the NSF Terms and Conditions referenced above.

If the awardee has any questions related to the pre-populated data associated with this award in the FFATA Subaward Reporting System, such questions should

NATIONAL SCIENCE FOUNDATION
Grant Letter

Award: 1259135 **PI Name:** Fulthorpe, Craig

be submitted to: FFATAReporting@nsf.gov or by phone to: (800) 673-6188.

Please view the project reporting requirements for this award at the following web address [https://reporting.research.gov/fedAwardId/1259135].

The attached budget indicates the amounts, by categories, on which NSF has based its support.

The cognizant NSF program official for this grant is Bilal U. Haq, (703) 292-8582.
The cognizant NSF grants official contact is Irene Sattler, (703) 292-4813.

Sincerely,

Vanessa L. Richardson
Grants and Agreements Officer

CFDA No. 47.050
osp@austin.utexas.edu

National Science Foundation
4201 Wilson Boulevard
Arlington, VA 22230
www.nsf.gov

COOPERATIVE AGREEMENT(CA)

AWARD: OCE-1211494

EFFECTIVE DATE: April 1, 2012

EXPIRATION DATE: March 31, 2017

PROJECTED TOTAL AWARD FUNDING:

(Subject to availability of funds)
$43,987,010

CUMULATIVE AMOUNT:

$8,847,010

SOLICITATION:

(Incorporated by reference, as amended)

NSF 04-052

Division of Ocean Sciences: Integrative Programs Section - IPS

CFDA NUMBER:
47.050

OTHER AWARDS UNDER THIS PROGRAM:

Show List of Awards

AWARDEE: THE TRUSTEES OF COLUMBIA UNIVERSITY IN T COLUMBIA UNIVERSITY

PROJECT TITLE: Ship Operations - R/V Langseth

PROJECT ABSTRACT: https://www.fastlane.nsf.gov/servlet/showaward?award=1211494

Principal Investigator(s)	Proposal No.	Institution (s)
Sean M. Higgins	OCE-1211494	THE TRUSTEES OF COLUMBIA UNIVERSITY IN T COLUMBIA UNIVERSITY

David S. Goldberg

Paul W. Ljunggren

NSF Contact Information:

Financial/Administrative questions: e-mail your NSF Grants and Agreements Official, Erica M. Stein, at estein@nsf.gov or call the Division at 703-292-8242 .

Programmatic questions: e-mail your NSF Program Officer, Rose Dufour, at rdufour@nsf.gov or call the Program Division at 703-292-8811 .

This CA is entered into between the United States of America, represented by the National Science Foundation (NSF), and the above named Awardee pursuant to the authority of the National Science Foundation Act of 1950, as amended (42 USC 1861-1875). This CA is provided electronically to the Awardee. The Awardee is responsible for full compliance with all Programmatic and Financial/Administrative Terms and Conditions as initially stated or as updated over the life of this CA. The Awardee's request to draw down funds under this CA will represent acceptance by the Awardee of all Terms and Conditions of the CA. The Authorized Organizational Representative (AOR) will be electronically notified of any changes to these Terms and Conditions and is encouraged to immediately review these changes and contact the Grants and Agreements Official or Program Officer within thirty days with any questions.

Financial/Administrative Terms and Conditions (FATC):

General FATC:
http://www.nsf.gov/publications/pub_summ.jsp?ods_key=NSF99999FATC004

Award Specific FATC:

1. Order of Precedence:

This Cooperative Agreement (CA) consists of the following terms and conditions in descending order of precedence:

A. Cooperative Agreement Specific Terms and Conditions
B. General Programmatic Terms and Conditions for Proposal Submission Guidelines for the Integrative Programs Section (IPS) (NSF 04-052) - For Ship Operations Awards, http://www.nsf.gov/pubs/policydocs/nsf04052.pdf (as amended)
C. National Science Foundation (NSF) Cooperative Agreement Supplemental Financial & Administrative Terms and Conditions for Managers of Large Facilities http://www.nsf.gov/awards/managing/co-op_conditions.jsp, Effective February 1, 2012 (as amended)
D. National Science Foundation (NSF) Cooperative Agreement Financial and Administrative Terms (CAFATC), http://www.nsf.gov/awards/managing/co-op_conditions.jsp Effective February 1, 2012 (as amended)

This CA contains certain applicable Federal administrative standards hereby incorporated by reference (as amended). The applicable requirements are contained in:

-2 CFR Part 215, "Uniform Administrative Requirements for Grants and Agreements with Institutions of Higher Education, Hospitals, and other Nonprofit Organizations" (OMB Circular A-110)
-2 CFR Part 220 (OMB Circular A-21), "Cost Principles for Educational Institutions"
-OMB Circular A-133, "Audits of States, Local Governments, and Non-Profit Organizations"

2. Funding:

A. For the total amount of NSF funding that has been obligated under this cooperative agreement, see "CUMULATIVE AMOUNT" on the cover page of this document.

B. In accordance with the CA-FATC Article entitled "Cooperative Agreement Increments", contingent on the availability of funds, satisfactory scientific/technical progress, and fulfillment of any special conditions of the award, it is the intent of the NSF to provide funds to support ship operations over a period of 5 years, unless the ship is retired or no longer needed to support NSF research.

3. Indirect Cost Rate:

The indirect cost rate to be applied by the awardee during the life of the cooperative agreement shall be [redacted] in accordance with the Awardee's negotiated indirect cost rate agreement dated February 1, 2012, incorporated by reference.

4. Ship Day Rate:

A. Definitions: For the purpose of this Cooperative Agreement the definitions of provisional and final ship day rates are as follows:

a. Provisional Ship Day Rate: A provisional ship rate will be calculated at the beginning of the calendar year, defined as the estimated yearly ship costs divided by the estimated number of operating days.

b. Final Ship Day Rate: A final day ship rate will be calculated after the end of the calendar year, defined as the actual operating costs for the year, divided by the actual number of chargeable ship use days.

B. The Provisional Ship Day Rate will be negotiated jointly by NSF and other federal agencies, as appropriate, with the Awardee once operating schedules have stabilized for the purpose of establishing a Provisional Ship Day Rate but no later than April 1, annually. The rate negotiated will be based on the proposed number of days, provisional estimated costs, and availability of program funds. If, at any time during the course of the corresponding calendar year, the Awardee expects that the Final Ship Day Rate will exceed the provisional rate by 5%, the Awardee shall provide notification to the NSF Program Officer. The Awardee will need to obtain approval from the NSF Program Officer to carry out any planned NSF funded science cruises during the remainder of the calendar year. If approval is provided, a new Provisional Ship Day Rate will be established. Any additional increases in excess of 5% of the re-baselined Provisional Ship Day Rate will require NSF Program Officer notification and approval to carry out future NSF funded science cruises.

C. The target date for annual proposals is November 15. Proposals shall provide a detailed breakdown of proposed costs for the following calendar year and historical costs in accordance with the format specified by the NSF Program Officer. Proof of insurance, including premium costs, limits of coverage, deductible, broker, date of expiration and underwriter, is also to be submitted with the annual ship operations proposal and budget. This should be a copy of the Vessel insurance "cover sheet" as long as it specifies both levels of coverage and premiums allocated to each vessel.

5. Requirements for Contractual Arrangements:

This Article hereby replaces the Article entitled "Subaward Requirements" of the Supplemental Financial and Administrative Terms and Conditions for Managers of Large Facilities. The following requirements apply under this cooperative agreement:

A. Definition: The term contractual arrangements includes contracts, cooperative agreements, purchase orders, orders issued under blanket purchase agreements or similar devices, awards made to sub-recipients regardless of form, and modifications to all the aforementioned to be issued by the Awardee under this agreement.

B. Applicablility: This article applies to initial contractual arrangements valued over $250,000. The Awardee shall not artificially segregate its contractual arrangements to lesser dollar amounts for the purpose of circumventing this requirement. For modifications to contractual arrangements previously approved, NSF Grant and Agreement Officer approval is required for increases of 20% or $100,000, whichever is less. The requirements of this article do not apply to the purchase of fuel.

C. The Foundation authorizes the awardee to enter into the proposed contractual arrangements and to fund such arrangements with award funds up to the amount indicated in the approved budget. Such contractual arrangements should contain appropriate provisions consistent with the applicable Cooperative Agreement Financial and Administrative Terms and Conditions (CA-FATCs), and any special conditions included in this Agreement.

D. Submission:

a. Upon submission of a contractual arrangement request to NSF, the awardee certifies that the contractual arrangement:

i. is appropriate, reasonable and legitimate;
ii. is issued to an organization that has the fiscal authority and responsibility to account for and handle Federal funds; and
iii. is in compliance with all Federal requirements and the Awardee's policies and procedures.

b. The Awardee will submit electronically to NSF a request for prior approval at least 30 calendar days in advance of the anticipated start date of any new contractual arrangement, unless otherwise determined by the cognizant NSF Grants and Agreements Official. Incomplete or insufficient requests will be returned without approval, for proper completion by the Awardee. Upon receipt of a complete and sufficient request, NSF will review and provide a determination within 30 calendar days. All requests shall be submitted electronically via FastLane for review by the Program Officer and the Grants and Agreements Official. The documentation shall include the proposed contractual arrangement document and a memorandum of negotiation which sets forth the principal elements of the purpose, selection procedures and price negotiation, including items, as appropriate, listed below:

i. A description of the supplies or services required.
ii. Identification of the type of contractual arrangement to be issued.
iii. Identification of the proposed subawardee or vendor, an explanation of why and how the proposed subawardee or vendor was selected, and the degree of competition obtained.
iv. For major equipment acquired under MOSA, a description of proposed Major Overhaul items and shipyard bids.
v. The proposed price of the contractual arrangement, together with the Awardees cost or price analysis thereof.
vi. Where the contractual arrangement will be made without competition, the memorandum shall include a detailed justification.

E. Award and Administration:

a. The Awardee shall insert a clause in all contractual arrangements reserving its right to assign the contractual arrangement to any third party should a successor Awardee be selected by the NSF. NSF approval is required for any contractual arrangement reassignment by the Awardee for contractual arrangements valued over $250,000.

b. After review, NSF will provide written notification to proceed to the awardee; this notification shall not be construed as a determination by NSF of the allowability of any cost under this Agreement.

c. The awardee shall make all consultant agreements, contractual arrangements, or other commitments in its own name and shall not bind the Federal Government or the National Science Foundation; and hereby agrees to administer/monitor all contractual arrangements it enters into and supports with NSF funds in accordance with the applicable federal cost principles and the applicable federal administrative requirements; remains responsible for maintaining the necessary documentation on all contractual arrangements and making it available to NSF upon request; and shall include contractual arrangement activities in the annual and final project reports that are submitted to NSF.

F. Emergency Situations:

In emergency situations, such as those that require action to protect life or property or when an immediate repair to a vessel is required to carry out planned ship operations, the Awardee is not required to obtain prior approval. In these cases, the Awardee shall submit its request for approval of the contractual arrangement within 7 calendar days, along with the rationale for not obtaining prior approval.

6. Prompt Notification of Claims:

The Awardee shall give the NSF Program Officer and Grants and Agreements Official immediate notice in writing of any legal action or suit filed, and prompt notice of any claim made against the Awardee, which in the opinion of the Awardee may result in litigation, related in any way to this CA, with respect to which the Awardee may be entitled to reimbursement from the Government.

7. Other Agency Activities:

NSF, as a Federal funding agency for the Project, must be notified prior to significant Awardee or sub-awardee activities leading to any agreements with other foreign, federal, state or local agencies or entities that relate to and substantively affect or impact the progress related to the scope of NSF's scheduled work. Significant changes are broadly defined as adjusting cruise dates outside the submitted windows of time (i.e. submitted through the UNOLS STR process or in peer-reviewed NSF proposals), changing port calls, or requiring added transit obligations. It is not NSF's intent to preclude the operator's ability to augment schedules throughout the year, nor to require notification for simple adjustments to operating schedules, rather to protect NSF's interest with regard to significant changes that affect the Awardee's ability to provide ship operation support for NSF supported cruises or may result in additional potential financial obligations to NSF.

8. Notice to the Government of Labor Disputes:

A. If a labor dispute by Awardee employees delays ship operations, the Awardee shall provide notice and details of the incident to the NSF Program Officer and the NSF Grants and Agreements Officer within 24 hours of the incident.

B. The Awardee agrees to insert the substance of this clause in any contractual arrangement to which a labor dispute may delay the timely performance of this agreement; each subcontract shall provide that in the event its timely performance is delayed or threatened by delay by any actual or potential labor dispute, the subcontractor shall immediately notify the next higher tier subcontractor or the prime Awardee, as the case may be, of all relevant information concerning the dispute.

9. Health and Safety:

A. The Awardee shall take all reasonable precautions in the performance of the work under this CA to protect the health and safety of employees and of members of the public from all hazards and to minimize danger to life and property, and shall comply with all applicable health, safety, and fire protection laws, regulations, and requirements, including those referenced in the Programmatic Terms and Conditions for Ship Operators.

B. The Awardee shall maintain an accurate record of all cases of death, occupational disease or injury arising out of, or in the course of, employment incident to performance of the work under this CA. Cases of personal injury shall be reported to NSF in accordance with Article 2.D of the award specific Programmatic Terms and Conditions within this cooperative agreement.

10. Rights in Data Necessary for the Operation and Maintenance of the Research Vessel

A. Notwithstanding CA-FATC Article 21, Copyrightable Material, or any other clause of this agreement, the Awardee grants to the National Science Foundation in perpetuity the right to use and reproduce data first produced under this award without charge or additional expense (except for whatever reasonable costs are incurred by the Awardee to reproduce the data) as necessary for the operation and management of the ship. This includes the right to make such data available to any party interested in competing for any subsequent award to operate and manage the ship, and any awardees the National Science Foundation selects as the result of any competition.

B. The types and kinds of data deemed necessary for the operation and maintenance of the ship include, but are not limited to:

i. Maintenance guides and histories
ii. Operating manuals and similar plans
iii. User manuals and similar documents
iv. Facility and instrument drawings (including design, shop and as-built drawings), designs and specifications
v. Schematics
vi. Warranty data
vii. Schedules
viii. Software
ix. Inventories
x. Document indexes
xi. Subawards, subcontracts, and vendor agreements
xii. Operations reports

These items will be assessed by NSF and the awardee for the presence of any proprietary data prior to their release to a third party. Proprietary data will not be released without the express permission of its owner.

C. Rights acquired by the National Science Foundation under this clause do not include rights to any data first produced solely for scientific research purposes.

D. Licenses to use data not first produced under this award shall provide for assignment by the Awardee to any successor awardee operating and managing the Ship or NSF.

11. Document Management:

The Awardee shall implement and maintain a secure document management system that contains critical documents related to the Research Vessel and its operations. All record-keeping functions in place for the USCG, EPA, and ABS compliance for the vessel, as well as record-keeping and tracking for ISM Safety Management Systems, if necessary. This includes but is not limited to ISM audits, vessel general permit annual reports, all inspections/drills/safety meetings conducted aboard the vessel, and safety management hazardous condition reports and corrective actions requests. The Awardee shall provide a copy of any document within its document management system upon request of the NSF Program Officer.

12. Property and Equipment:

A. For all property and equipment exceeding $5,000 to which the government holds title, and in accordance with the requirements of OMB Circular A-110, the Awardee must submit annual inventory listings of government-owned property to the NSF Property Administrator, Division of Administrative Services (DAS). The listing should include all government-owned equipment purchased under this agreement or acquired by screening excess through the General Services Administration (GSA); include the type of equipment, serial number, acquisition price, acquisition date and condition of the equipment. The inventory listings and audited financial statements should be submitted electronically to fsrpts@nsf.gov and must be received by DAS no later than September 1st each year. If financial statements are not available electronically, please submit a paper copy to: DAS, NSF Property Administration, 4201 Wilson Boulevard, Room 295, Arlington, VA 22230.

B. Title to equipment purchased with award funds shall vest in the Awardee unless NSF exercises its option to require the Awardee to transfer full title, rights, and interest to any or all equipment to either NSF or any third party named by NSF. Title will remain with the Awardee unless NSF exercises its options no later than 120 days after receipt of a Final Report.

Programmatic Terms and Conditions (PTC):

General PTC:
http://www.nsf.gov/publications/pub_summ.jsp?ods_key=NSF04052TPTC000

Award Specific PTC:

1. Research Vessel:

The purpose of this cooperative agreement is to support the operations of the Research Vessel Langseth owned by NSF and operated by Columbia University to support scientific research.

2. Reporting Requirements:

A. All reports required in this article shall be submitted via FastLane using the appropriate reporting category; for any type of report not specifically mentioned in FastLane, the Awardee will use the "Interim Reporting" function to submit reports. Emergency notifications of personal injury or property damage shall be provided by telephone (office, cell, or other available number) and/or email to NSF Program Officials within 24 hours. If NSF does not acknowledge receipt within 24 hours of the Awardee's notification, the Awardee must continue to try to make notification through other communication methods.

B. The Awardee will provide ad hoc and regular quarterly reports as designated by the NSF Cognizant Program Officer with content, format, and submission time line established by the NSF Cognizant Program Officer. The quarterly report shall provide information pertaining to safety, personnel injuries, property damage, conditions affecting ability to support scheduled oceanographic research, and technical changes that impact financial obligation, as delineated in articles 4.B Ship Day Rate and 7. Other Agency Activities of the award specific Financial and Administrative Terms and Conditions of this cooperative agreement. In addition to the technical information required, the quarterly reports shall provide updated budget information. The updated budget information shall be provided in the form of an updated Section VI from the previously submitted annual report. The Awardee shall also provide a description of any single item, valued over $10,000, purchased during the previous quarter that was not included in the originally approved annual budget, the value of that item, and a short description of the identified need for the item.

C. An Annual Project Report will be submitted following proposal guidelines in NSF 04-052, but only including sections II, III, IV, V, VI, VII and IX. These guidelines can be accessed at: http://www.nsf.gov/geo/oce/pubs/IPS_Guidelines.pdf. An inspection report with updates shall be included. The target due date is November 15. The Annual Project Report shall also include the written summary of its IT security program as described in the Article of the CA-FATC-Large Facilities entitled "Information Security."

D. In the event that a member of the crew or scientific party becomes seriously injured or ill while aboard the vessel, the Operator will notify the NSF Program Officials, with a full written report submitted within seven (7) days after the Awardee becomes aware of said injury or incapacity. A "serious injury" or "serious illness" means an injury or illness which renders the individual unfit for service for at least 48 hours, or which results in the payment of medical and/or other benefits in excess of $10,000.

E. In the event that the Vessel or any of its systems suffers damage in excess of $10,000, or causes damages to another vessel, the marine environment, shore facility in excess of $10,000, and/or safety of the crew and science party is affected, emergency notifications must be provided to the NSF Program Officials. The Awardee shall also notify the UNOLS office; however, the Awardee is not required to obtain confirmation of receipt of the UNOLS notification. If warranted, a full report of incident should be submitted to the NSF Program Officer no later than seven days from determining an inability to provide support as originally scheduled.

F. The Awardee shall furnish the NSF Program Officials information regarding any condition affecting the Awardee's ability to conduct NSF-supported scheduled oceanographic research as soon as possible and followed by written notification no later than seven (7) calendar days from determining an inability to provide support as originally scheduled. In cases where NSF cruises are moved into the following operating year, the Awardee shall ensure that the chief scientist obtained NSF Science Program Manager concurrence.

G. At the completion of any MOSA activities, the Awardee shall provide a detailed report of completed MOSA items and the associated costs.

3. Ship Operation Data:

The Awardee shall furnish the UNOLS Office with Ship Utilization Data cruise reports, Ship Captain post-cruise assessments, and annual Final Ship Schedules. This data shall be provided as frequently as practicable but at least once per year.

4. Data Sharing:

The Awardee shall comply with the NSF Division of Ocean Sciences Sample and Data Policy (as amended).

5. Quality of Service Objectives:

The Awardee's performance under this cooperative agreement shall be evaluated, considering the following factors:

1) Ability to support research programs, in the ability to address scheduling, equipment, and safety issues to provide the best available platform to carry out science goals;

2) Responsiveness of the operator to post cruise assessments and the ability to use criticism constructively to improve operations.

Change History

Prior Awarded Funding Amount:
Per Original Award on
05/14/2012: $8,847,010

From: Kerry Kehoe - NOAA Federal [mailto:kerry.kehoe@noaa.gov]
Sent: Tuesday, April 15, 2014 3:34 PM
To: Blanco, Caroline M; Hassell, Kevin
Cc: David Kaiser - NOAA Federal; Jackie Rolleri - NOAA Federal; Jeff Dillen - NOAA Federal; Randall Schneider - NOAA Federal; Glynnis Roberts - NOAA Affiliate
Subject: Proposed meeting time: Tuesday 4/22 at 3:00

Caroline and Kevin:

Please check with your principals in regards to their availability to meet on Tuesday, April 22 at 3:00 to discuss NSF funding for seismic surveys off the coast of New Jersey. I will ask David and Jeff Dillen to place a hold on their calendars for that time.

Between now and the call, it would be helpful if we could resolve the question as to who is considered to be the award recipient for the purposes of determining the applicability of Subpart F of the CZMA Federal Consistency regulations.

Going into the call, it would also be helpful if the State can identify the effects it is concerned about and the enforceable policies that apply to those effects.

Apart from the present question of the applicability of federal consistency to the proposed seismic survey, let's use this call to look forward as to how the NSF and State can coordinate in the future.

Please confirm as to your availability for this call and I will send out a conference line to use.

Kerry

--
R. Kerry Kehoe
Office of Ocean and Coastal Resource Management
National Oceanic and Atmospheric Administration
301-563-1151

From: Smith, Holly E.
Sent: Monday, April 21, 2014 3:45 PM
To: Kerry Kehoe - NOAA Federal; Hassell, Kevin; Blanco, Caroline M
Cc: David Kaiser - NOAA Federal; Jackie Rolleri - NOAA Federal; Jeff Dillen - NOAA Federal; Randall Schneider - NOAA Federal; Glynnis Roberts - NOAA Affiliate; Bauke (Bob) Houtman (bhoutman@nsf.gov)
Subject: RE: Proposed meeting time: Tuesday 4/22 at 3:00

All – Thank you all for agreeing to meet tomorrow to discuss the proposed marine seismic survey off the coast of New Jersey. Per Kerry's message below, we've done a little further research into the entities that would be considered to be the award recipients.
For the proposed research activities, research funds would go directly to "Rutgers, the State University of New Jersey" (RU) and "University of Texas at Austin" (UTIG). Although the original collaborative proposal received by NSF included research funding requests for RU, UTIG, and Columbia University's Lamont-Doherty Earth Observatory (LDEO), LDEO will not receive research funding. Based on NSF science priorities and current budgetary constraints, the cognizant NSF Program Officer re-negotiated the proposal budget. Funding sought for an LDEO researcher will not be provided. Additionally, subsequent to the original proposal submission but prior to the budget re-negotiation, another LDEO researcher who sought funding accepted a position at UTIG. During budget re-negotiations, that researcher was added to the UTIG budget and therefore would receive funding via UTIG. Therefore, funding for the proposed research activities would only go to RU and UTIG. Through a separate Cooperative Agreement, LDEO would receive funds for vessel operations.

We apologize for the confusion associated with which academic institutions might be involved with the proposed research. The Draft EA was prepared and submitted to NMFS to initiate the Endangered Species Act (ESA) Section 7 consultation process and the Incidental Harassment Authorization (IHA) Application for compliance purposes before it was known that the proposal had been re-negotiated by the NSF Program Officer.

We look forward to discussing our proposed research project with you further tomorrow.
Regards,
Holly Smith

National Science Foundation
4201 Wilson Blvd., Room 725
Arlington, VA 22230
703-292-7713 (direct line)
hesmith@nsf.gov

Appendix L

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SERVICE
OFFICE OF OCEAN AND COASTAL RESOURCE MANAGEMENT
Silver Spring, Maryland 20910

JUN 18 2014

Ms. Virginia KopKash
Assistant Commissioner
Land Use Management
State of New Jersey
Department of Environmental Protection
P.O. Box 420, 401 East State Street
Mail Code 401-07B
Trenton, NJ 08625-0430

Re: Request to Review Federal Funding by the National Science Foundation to Rutgers University for Conducting 3-D Seismic Surveys in Federal Waters Offshore New Jersey

Dear Ms. KopKash:

Thank you for your request to review the federal grant application by Rutgers, The State University of New Jersey, to the National Science Foundation (NSF) to conduct 3-D seismic surveys in federal waters offshore of New Jersey. You requested the National Oceanic and Atmospheric Administration's (NOAA's) Office of Ocean and Coastal Resource Management (OCRM) to approve New Jersey's review of Rutgers' application as an unlisted activity under the Coastal Zone Management Act (CZMA) § 307(d), and NOAA regulations at 15 C.F.R. Part 930, Subpart F. In the alternative, the state has requested that OCRM concur that the activity is subject to the requirements under 15 C.F.R. Part 930, Subpart C and that the NSF is required to submit a consistency determination to New Jersey.

OCRM denies the State of New Jersey's request to review Rutgers' application as an unlisted activity. OCRM agrees that the proposed activity is federal funding assistance to a state or local government entity subject to the requirements of Subpart F of the CZMA Federal Consistency regulations. As such, the requirements of Subpart C do not apply. However, OCRM finds that New Jersey's request for approval to review the activity was not made in a timely manner as required under 15 C.F.R. § 930.98 and must be denied.

CZMA UNLISTED ACTIVITY REVIEW REQUESTS

States with federally-approved coastal management programs are required to list specific types of federal assistance programs subject to consistency review. 15 C.F.R. § 930.98. If an activity is unlisted or outside of the geographic scope of state CZMA federal consistency review approved by OCRM, a state must request OCRM approval to review the activity. The request must be timely submitted, notify the applicant, relevant federal agency, and OCRM that it intends to review the activity and demonstrate that the activity would have reasonably foreseeable effects on the coastal uses or resources of the state; otherwise a state waives its right to review the unlisted activity. *Id.* The waiver does not apply where the state office charged with implementing an approved coastal management program does not receive notice of the application.

PROJECT DESCRIPTION

The NSF is providing research funding to Rutgers and the University of Texas at Austin to conduct a high-energy, 3-D seismic survey in the Atlantic Ocean 25-85 km from the coast of New Jersey in June—July, 2014. As part of this project, Rutgers requested that NSF make available the NSF-owned Research Vessel (R/V *Langseth*), which is operated by the Lamont-Doherty Earth Observatory through a pre-existing cooperative agreement between NSF and Lamont-Doherty. The seismic survey would use a towed array of 4 or 8 airguns with a total discharge volume of ~700 in^3 or 1400 in^3. In addition to the operations of the airgun array, a multi-beam echo-sounder, a sub-bottom profiler and an acoustic Doppler current profiler would be operated from the R/V *Langseth* throughout the survey. The survey would take place outside of state waters within the U.S. Exclusive Economic Zone in water depths of ~30-75 m.

The purpose of the survey is to collect and analyze data on the arrangement of sediments deposited during times of changing sea level from roughly 60 million years ago to present. The data would be used to assess past sea-level rise.

The survey cruise was originally scheduled to depart on June 3, 2014. The departure has been delayed pending issuance by the National Marine Fisheries Service (NMFS) of an Incidental Harassment Authorization pursuant to the Marine Mammal Protection Act (MMPA) § 101(a)(5)(D), and now the consideration by OCRM of the request by New Jersey for approval to review the proposed activity for which Rutgers has applied for NSF financial assistance.

DISCUSSION

1. Applicable Subpart

OCRM has determined that the proposed activity is subject to requirements for the review of federal assistance to state or local government agencies under Subpart F of the CZMA Federal Consistency regulations.

The survey cruise is a combination of several forms of federal assistance. These forms of assistance are inseparable for the purposes of the project. The project could not go forward without each form of assistance. Looking across the various forms of NSF assistance to support the cruise, it is clear that this is a single project to conduct research with Rutgers as the lead Principal Investigator for the project.

NSF is providing the R/V *Langseth*, which is the only vessel of its kind available for conducting this type of survey. Under a pre-existing cooperative agreement with NSF, Lamont-Doherty Earth Laboratory (a private institution affiliated with Columbia University), will operate the vessel including the survey equipment. The cooperative agreement between NSF and Lamont-Doherty is from 2012 and is not part of the Rutgers project; NSF's in-kind support of the R/V *Langseth* for the project is incidental to the project. Lamont-Doherty is the applicant for the MMPA Incidental Harassment Authorization from NMFS.

Rutgers and the University of Texas are receiving federal financial assistance from NSF for the on-board research, which is the purpose of the cruise. Rutgers and the University of Texas are recipients of funding assistance under separate awards from the NSF ($798,819 and $194,431 for Rutgers and Texas, respectively). However, in reviewing the projects proposed by both institutions, the awards are for the same research project as described and funded by NSF. Although Rutgers and the University of Texas are both listed as Principal Investigators for the survey cruise, the research to be conducted builds upon more than two decades of research by Dr. Gregory Mountain of Rutgers in understanding the evolution of siliciclastic systems and quantifying eustatic changes preserved in the clinoformal architecture offshore New Jersey. Given the foundational research by Rutgers for which this project is an extension, the differences in the amounts of the grant awards to Rutgers and the University of Texas, and the area of focus offshore of New Jersey, Rutgers is the lead Principal Investigator for this project.

Being a state university of New Jersey, OCRM finds that Rutgers falls within the definition of "applicant agency" in 15 C.F.R. § 930.92 and that the review provisions of Subpart F for the Consistency for Federal Assistance to State and Local Governments apply.

New Jersey has requested that in the alternative to finding that the activity is subject to the review requirements of Subpart F, that OCRM concur that the activity is subject to the provisions of Subpart C for the review of activities conducted by federal agencies, and that NSF be required to submit a consistency determination for the project. Apart from finding that the project falls within the review provisions of Subpart F and as such is exclusive of Subpart C review, OCRM finds that the project is not being conducted by NSF. Through a competitive process, the research project was developed and proposed by Rutgers and is being conducted by Rutgers. The NSF approved assistance for the project but did not develop the proposal and will not be conducting the research.

2. The Timeliness of the New Jersey's Request to Review Rutgers Application

OCRM finds that New Jersey's unlisted activity request is untimely pursuant to 15 C.F.R. § 930.98.

The CZMA Federal Consistency regulations pertaining to unlisted activity review requests for federal assistance activities state that a state must "immediately" notify OCRM, the applicant agency and federal funding agency of its intent to review an unlisted activity upon notice of the application for federal assistance. 15 C.F.R. § 930.98. While "immediate" is not defined, the term requires a state to exercise due diligence and issue its unlisted notice shortly after receiving notice of the proposed activity. Notice does not need to be actual notice – it may be constructive such as through a Federal Register notice or the publication of an analysis performed pursuant to the National Environmental Policy Act. The regulation also states that OCRM is to be guided by the provisions of 15 C.F.R. § 930.54 for the review of unlisted federal licenses or permits in applying the unlisted activity requirements for federal assistance. At 15 C.F.R. § 930.54(c), it is specified that an unlisted activity review request must be submitted within 30 days of notice of a federal license or permit application. Prior to the revisions of the Federal Consistency regulations in 2000, 15 C.F.R. § 930.54 had also stated that a state must submit an unlisted activity review request "immediately." The preamble to the 2000 rules state that the revision to 15 C.F.R. § 930.54 in regard to the timeframe for submitting an unlisted activity review request was a clarification rather than a change to the rule.

OCRM was first contacted by New Jersey regarding its interest in reviewing the survey cruise on April 11, 2014. The email communication included two attachments: the March 17, 2014, *Federal Register* request for comments on the pending application of Lamont-Doherty for an MMPA Incidental Harassment Authorization (IHA) related to the survey cruise; and the Draft Environmental Assessment (Draft EA) for the Survey prepared for Lamont-Doherty and NSF. In the email communication, New Jersey assumed that the NSF was responsible for submitting either a consistency determination or negative determination for the assistance to Lamont-Doherty under Subpart C of the Federal Consistency regulations, and that Lamont-Doherty could be required to submit a consistency certification for the IHA authorization under the Subpart D provisions pertaining to unlisted federal licenses or permits. There was no mention of the role of Rutgers or NSF assistance to Rutgers in the communication. That is understandable in that the *Federal Register* notice makes no mention of Rutgers, and the Draft EA only mentions Rutgers once as the Principal Investigator with no mention of NSF assistance to Rutgers. The record of communications between OCRM and New Jersey in the days that followed the initial communication from the state shows confusion over the role of Rutgers in the project given that most of the publicly available documents focused on the role of Lamont-Doherty.

On April 16, 2014, Dr. Gregory Mountain, the Principal Investigator for Rutgers on the Project contacted the New Jersey Department of Environmental Protection with an email to Martin Rosen describing his role in the "project funded by NSF" and offering to provide more information on the project.

On April 22, 2014, a conference call was convened by OCRM with staff for the New Jersey Department of Environmental Protection and NSF participating. The conversation included a discussion of the respective roles of Lamont-Doherty and Rutgers and the University of Texas, with Rutgers being described as the lead for the project and Lamont-Doherty and University of Texas having supporting roles, and that Lamont-Doherty was not a recipient for NSF funds as part of the project.

On May 20, 2014, OCRM received by email the New Jersey Department of Environmental Protection's request for approval to review the NSF assistance to Rutgers as an unlisted activity under Subpart F.

On May 29, 2014, NSF responded to New Jersey's unlisted activity review request asserting that the state's request is untimely. OCRM agrees.

Since at least the March 17, 2014, *Federal Register* request for comments by NMFS in regard to the MMPA IHA, the proposed seismic survey has received much attention by environmental groups and organizations representing fishermen in the local press in New Jersey and the attention of at least one member of Congress. The March 17 *Federal Register* notice was constructive notice to New Jersey of the proposed seismic survey. The state took no action to begin to determine what CZMA consistency review authority applied to the activity until April 11, 2014. The state had actual knowledge that the project was under Subpart F of NOAA's regulations by the April 16, 2014, email from Dr. Gregory Mountain that Rutgers was a NSF funding recipient for the project. Even by the most permissive interpretation of the term "immediately" under 15 C.F.R. § 930.98 of 30 days, New Jersey's May 20, 2014, submission of its unlisted activity review request was untimely.

3. Whether the Proposed Activity Has Reasonably Foreseeable Effects on Any Land or Water Use or Natural Resource of the New Jersey Coastal Zone

In order to grant a state request to review an unlisted activity, OCRM must find that the state has shown that there are reasonably foreseeable effects to uses or resources of the coastal zone of the state. That finding is based on the analysis of coastal effects provided by the state and comments received on the request.

The State of New Jersey has alleged reasonably foreseeable effects to fisheries, marine mammals, sea turtles and users of shipwrecks and historical and archaeological resources.

Because New Jersey's unlisted activity request has been found to be untimely and must be denied, OCRM has not determined the sufficiency of the state's analysis of reasonably foreseeable effects from the activity.

CONCLUSION

Based upon a review of the information presented by New Jersey and NSF, OCRM denies the state's request to review the proposed marine geophysical survey in the federal waters offshore of New Jersey.

Please contact David Kaiser, Senior Policy Analyst, OCRM, at 603-862-2719, or Kerry Kehoe, Federal Consistency Specialist, OCRM, at 301-563-1151, if you have any questions.

Sincerely,

Paul M. Scholz
Acting Director

cc:

Ms. Holly E. Smith
Environmental Compliance Officer
National Science Foundation

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