Environmental Analysis of a Marine Geophysical Survey by the R/V *Marcus G. Langseth* in the Northeast Atlantic Ocean, June–July 2013

Prepared for

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ABSTRACT

Lamont-Doherty Earth Observatory (L-DEO), with funding from the U.S. National Science Foundation (NSF), plans to conduct a high-energy, 2-D and 3-D seismic survey in the northeast Atlantic Ocean west of Spain in June–July 2013. The seismic survey would use a towed array of 18 airguns with a total discharge volume of ~3300 in^3. The seismic survey would take place in international waters and within the Exclusive Economic Zone (EEZ) of Spain in water depths >3000 m. On behalf of L-DEO, the U.S. State Department will seek authorization from Spain for clearance to work in its EEZ.

NSF, as the funding and action 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 NSF program priorities. It would provide data necessary to study the rifted continental to oceanic crust transition in the Deep Galicia Basin west of Spain.

The Environmental Analysis (EA) in this document addresses NSF's requirements under Executive Order 12114, "Environmental Effects Abroad of Major Federal Actions", for the proposed NSF federal action. L-DEO is requesting an Incidental Harassment Authorization (IHA) from the U.S. National Marine Fisheries Service (NMFS) to authorize the incidental, i.e., not intentional, harassment of small numbers of marine mammals should this occur during the seismic survey. The analysis in this document also supports the IHA application process and provides information on marine species that are not addressed by the IHA application, including seabirds and sea turtles that are listed under the U.S. Endangered Species Act (ESA), including candidate species. As analysis on endangered/threatened species was included, this document will be used to support ESA Section 7 consultations with NMFS and U.S. Fish and Wildlife Service (USFWS). Alternatives addressed in this 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.

Numerous species of marine mammals inhabit the northeast Atlantic Ocean. 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 the ***threatened*** loggerhead turtle and roseate tern.

Potential impacts of the seismic survey on the environment would be primarily a result of the operation of the airgun array. A multibeam echosounder and a sub-bottom profiler would also be operated. Impacts would be associated with increased underwater noise, which may result in avoidance behavior by marine mammals, sea turtles, seabirds, and fish, and other forms of disturbance. An integral part of the planned survey is a monitoring and mitigation program designed to 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 also are not likely to be caused by the other types of sound sources to be used. However, given the high levels of sound emitted by a large array of airguns, a precautionary approach is warranted. The planned monitoring and mitigation measures would reduce the possibility of injurious effects.

Protection measures designed to mitigate the potential environmental impacts to marine mammals 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, the populations to which they belong, or their habitats.

LIST OF ACRONYMS

~	approximately
AMVER	Automated Mutual-Assistance Vessel Rescue
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CITES	Convention on International Trade in Endangered Species
dB	decibel
DoN	Department of the Navy
EA	Environmental Analysis
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
GIS	Geographic Information System
h	hour
hp	horsepower
Hz	Hertz
ICES	International Council for the Exploration of the Sea
IHA	Incidental Harassment Authorization (under MMPA)
in	inch
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
m	meter
min	minute
MMPA	(U.S.) Marine Mammal Protection Act
ms	millisecond
n.mi.	nautical mile
NAST	North Atlantic Subtropical Gyral Province
NEPA	(U.S.) National Environmental Policy Act
NMFS	(U.S.) National Marine Fisheries Service
NRC	(U.S.) National Research Council
NSF	National Science Foundation
OBIS	Ocean Biogeographic Information System
OBH	Ocean Bottom Hydrophone
OBS	Ocean Bottom Seismometer
ODP	Ocean Drilling Program
OEIS	Overseas Environmental Impact Statement
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
TTS	Temporary Threshold Shift
UNEP	United Nations Environment Programme
U.S.	United States of America
USC	United States Code
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 Environmental Analysis (EA) is to provide the information needed to assess the potential environmental impacts associated with the use of an 18-airgun array during the proposed seismic surveys. The EA was prepared under Executive Order 12114, "Environmental Effects Abroad of Major Federal Actions". This EA tiers to the Final Programmatic Environmental Impact Statement (EIS)/Overseas Environmental Impact Statement (OEIS) for Marine Seismic Research funded by the National Science Foundation or Conducted by the U.S. Geological Survey (June 2011) and Record of Decision (June 2012), referred to herein as PEIS. The EA 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 EA will also be used in support of an application for an Incidental Harassment Authorization (IHA) from the National Marine Fisheries Service (NMFS) and Section 7 consultations under the Endangered Species Act (ESA). The requested IHA would, if issued, allow the non-intentional, non-injurious "take by harassment" of small numbers of marine mammals during the proposed seismic survey by L-DEO in the northeast Atlantic Ocean during June–July 2013.

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 necessary to study the rifted continental to oceanic crust transition in the Deep Galicia Basin west of Spain. This margin and its conjugate are among the best studied magma-poor, rifted margins in the world, and the focus of studies has been the faulting mechanics and modification of the upper mantle associated with such margins. Over the years, a combination of 2-D seismic reflection profiling, general marine geophysics, and ocean drilling have identified a number of interesting features of the margin. Further study of these features would characterize the last stage of continental breakup and the initiation of seafloor spreading, relate post-rifting subsidence to syn-rifting lithosphere deformation, and inform the nature of detachment faults. It is a cooperative program with scientists from the U.K., Germany, Spain, and Portugal. The proposed activities would continue 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 EA is described in § 1.8 of the PEIS, including

- Executive Order 12114, "Environmental Effects Abroad of Major Federal Actions";
- Marine Mammal Protection Act (MMPA); and
- Endangered Species Act (ESA).

II. ALTERNATIVES INCLUDING PROPOSED ACTION

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

Proposed Action

The project objectives and context, activities, and mitigation measures for L-DEO's planned seismic surveys are described in the following subsections.

(1) Project Objectives and Context

L-DEO plans to conduct seismic surveys in the Deep Galicia Basin of the northeast Atlantic Ocean west of Spain (Fig. 1). As noted previously, the goal of the proposed research is to collect data necessary to study the rifted continental to oceanic crust transition in the Deep Galicia Basin west of Spain. This margin and its conjugate are among the best studied magma-poor, rifted margins in the world, and the focus of studies has been the faulting mechanics and modification of the upper mantle associated with such margins. Over the years, a combination of 2-D seismic reflection profiling, general marine geophysics, and ocean drilling have identified a number of interesting features of the margin. Among these are the S reflector, which has been interpreted to be a detachment fault overlain with fault bounded, rotated, continental crustal blocks and underlain by serpentinized peridotite, and the Peridotite Ridge, composed of serpentinized peridotite and thought to be upper mantle exhumed to the seafloor during rifting. To achieve the project's goals, the Principal Investigators (PIs), Drs. D.S. Sawyer (Rice University), J.K. Morgan (Rice University), and D.J. Shillington (L-DEO) propose to use a 3-D seismic reflection survey, 2-D survey, and a long-offset seismic program extending through the crust and S detachment into the upper mantle to characterize the last stage of continental breakup and the initiation of seafloor spreading, relate post-rifting subsidence to syn-rifting lithosphere deformation, and inform the nature of detachment faults. Ocean Bottom Seismometers (OBSs) and Ocean Bottom Hydrophones (OBHs) would also be deployed during the program. It is a cooperative program with scientists from the U.K., Germany, Spain, and Portugal.

(2) Proposed Activities

(a) Location of the Activities

The proposed survey area is located between ~41.5–42.5°N and ~11.5–17.5°W in the northeast Atlantic Ocean west of Spain (Fig. 1). Water depths in the survey area range from ~3500 m to >5000 m. The seismic surveys would be conducted in International Waters and within the EEZ of Spain, and are

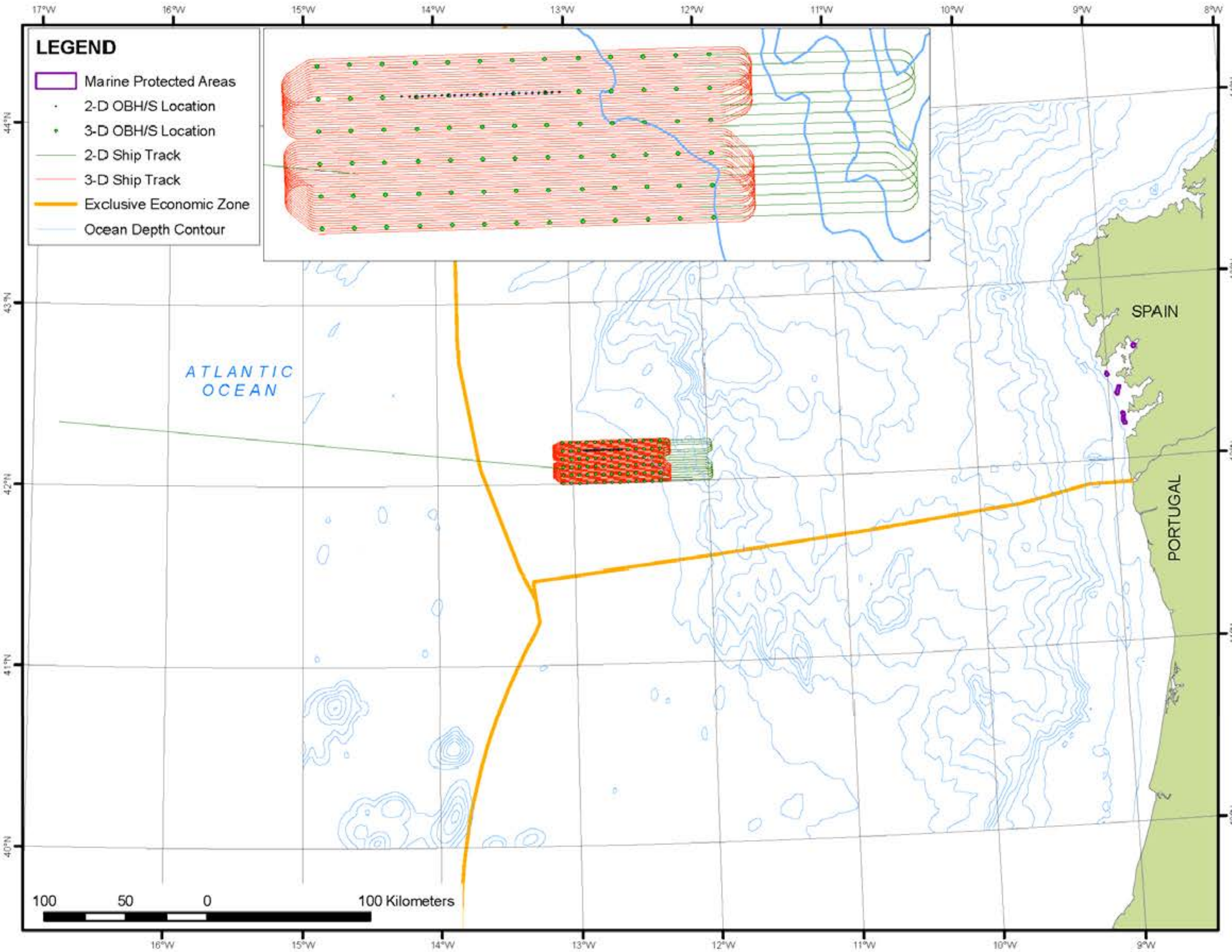

Figure 1. Location of the proposed seismic surveys and OBH/S instruments at the proposed study site in the northeast Atlantic Ocean during June–July 2013, and marine protected areas in Spain.

scheduled to occur for ~39 days during 1 June–14 July 2013. Some minor deviation from these dates is possible, depending on logistics and weather.

(b) Description of the Activities

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 survey would involve one source vessel, the R/V *Marcus G. Langseth*. The *Langseth* would deploy an array of 18 airguns as an energy source with a total volume of ~3300 in^3. The receiving system would consist of four 6000-m hydrophone streamers at 200-m spacing and up to 78 OBH/S instruments. The OBH/Ss would be deployed and retrieved by a second vessel, the R/V *Poseidon*, provided by the German Science Foundation. As the airgun array is towed along the survey lines, the hydrophone streamer would receive the returning acoustic signals and transfer the data to the on-board processing system. The OBH/Ss record the returning acoustic signals internally for later analysis.

A total of ~5834 km of survey lines, including turns, would be shot in a grid pattern with a single line extending to the west (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.

In addition to the operations of the airgun array, a multibeam echosounder (MBES) and a sub-bottom profiler (SBP) would also be operated from the R/V *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 for the entire cruise.

(c) Schedule

The R/V *Poseidon* would depart from Lisbon, Portugal on 22 May and spend ~1 day in transit to the proposed survey area. The *Poseidon* would first deploy 53 OBH/Ss as part of the 3-D survey; these instruments would be deployed by 1 June. The *Poseidon* would then deploy 25 OBH/Ss for the 2-D survey; these instruments would be deployed by 5 June. The *Langseth* would depart from Lisbon, Portugal, or Vigo, Spain, on 1 June 2013 and spend ~1 day in transit to the proposed survey area. The *Langseth* would be expected to begin seismic acquisition on 6 June. The *Poseidon* would wait in the survey area until the *Langseth* completes a transect line of the 2-D survey. The *Poseidon* would then recover the 25 OBH/Ss and redeploy them for the 3-D survey, for a total of 78 instruments on the seafloor. The *Poseidon* would leave the survey area for arrival in Vigo, Spain, on ~13 June. The seismic surveys would be expected to take ~39 days, with completion on ~12 July. The *Langseth* would then transit to Lisbon or Vigo. Because of scheduling constraints, the *Poseidon* would not be able to depart from Galway, Ireland, until 25 August 2013 to retrieve the OBH/Ss. Retrieval would take ~16 days, and the *Poseidon* would then transit for ~1 day to Vigo, Spain, for arrival on ~11 September.

(d) Vessel Specifications

The R/V *Marcus G. 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 *Poseidon* has a length of 60.8 m, a beam of 11.4 m, and a maximum draft of 4.7 m. The ship is powered by diesel-electric propulsion. The traction motor produces 930 kW and drives one propeller directly. The propeller has five blades, and the shaft typically rotates at 220 revolutions per minute (rpm).

The vessel also has a 394 hp bowthruster, which would not be used during OBH/S deployment and retrieval. The *Poseidon* typically cruises at 8.5 kt (15.7 km/h) and has a range of 7408 km.

Other details of the Poseidon *include the following:*

Owner:	Federal State of Schleswig-Holstein
Operator:	Briese Schiffahrts GmbH & Co. KG Abteilung Forschungsschifffahrt Hafenstraße 12, 26789 Leer
Flag:	Germany
Date Built:	1976
Gross Tonnage:	1105
Accommodation Capacity:	26 including 11 scientists

(e) Airgun Description

During the survey, the airgun array to be used would consist of 18 airguns (plus 2 spares), with a total volume of ~3300 in^3. The airgun array is described in § 2.2.3.1 of the PEIS, and the airgun configuration is illustrated in Figure 2.13 of the PEIS. It would be towed at a depth of 9 m. The shot interval would be ~15 s (37.5 m).

(f) OBH/S Description and Deployment

A 2-D closely spaced array would be the first deployment of OBH/Ss, which would consist of 25 instruments, spaced 1 km apart, along the first acquisition pass of the *Langseth*. This array would record only the first *Langseth* transect line and would be recovered after ~5 days. The second deployment for the 3-D survey would consist of a total of 78 OBH/Ss, spaced ~5 km apart, in a rectangular grid. This array would be deployed for a total of 2–3 months. Fifty OBH/Ss would be provided by the University of Southampton, U.K., and 28 OBH/Ss would be provided by the University of Kiel, Germany. The former would use a mixture of LC4x4, LC2000-2, and LC2000-4 instruments, each with dimensions 1×0.6×1 m. The anchors would be 82.5-kg, 3-legged concrete ballast weights that have a footprint of 0.7×0.7 m. The latter would be various K.U.M. Kiel OBH/Ss with anchors consisting of 40–70 kg pieces of railway track and a footprint of 1.2×1.2 m.

Once an OBH/S is ready to be retrieved, an acoustic release transponder interrogates the instrument at a frequency of 9–11 kHz, and a response is received at a frequency of 10–12 kHz. The burn-wire release assembly is then activated, and the instrument is released from the anchor to float to the surface.

(g) Multibeam Echosounder and Sub-bottom Profilers

Along with the airgun operations, two additional acoustical data acquisition systems would be operated during the survey. 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.

(3) Monitoring and Mitigation Measures

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. With the proposed monitoring and mitigation provisions, potential effects on most if not all individuals are expected to be limited to minor behavioral disturbance. Those potential effects are expected to have negligible impacts both on individual marine mammals and on the associated species and stocks.

To minimize the likelihood that potential impacts could occur to the species and stocks, airgun operations would be conducted in accordance with all applicable U.S. federal regulations and IHA requirements.

L-DEO's mitigation measures are described in § 2.4.4.1 of the PEIS. Included are

- mitigation during planning phases;
- monitoring by protected species visual observers (PSVOs) for marine mammals and sea turtles;
- passive acoustic monitoring (PAM);
- PSVO data and documentation; and
- 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).

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 unlikely that concentrations of large whales would be encountered, but if so, they would be avoided.

(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 phases of the proposed activities. Part of the considerations was whether the research objectives could be met with a smaller source than the full, 36-airgun, 6600-in^3 *Langseth* array, and it was decided that the scientific objectives could be met using two 18-airgun arrays, operating in "flip-flop" mode, and towed at a depth of ~9 m. Thus, the source volume would not exceed 3300 in^3 at any time. The PIs worked with L-DEO and NSF to identify potential time periods 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 R/V *Langseth*. Most 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.

(b) Proposed Exclusion Zones

Received sound levels have been predicted by L-DEO's model (Diebold et al. 2010; see also Appendix H of the PEIS) as a function of distance from the airguns for the 18-airgun array and for a single 1900LL 40-in^3 airgun, which would be used during power downs (Figs. 2 and 3). This modeling approach uses ray tracing for the direct wave traveling from the array to the receiver and its associated source ghost (reflection at the air-water interface in the vicinity of the array), in a constant-velocity half-space (infinite homogeneous ocean layer, unbounded by a seafloor). In addition, propagation measurements of pulses from the 18-airgun array have been reported in deep (~1600 m) and shallow (50 m) water in the Gulf of Mexico in 2007–2008 (Diebold et al. 2010); at the slope site (intermediate water depth), only propagation measurements of pulses from the 36-airgun array were obtained.

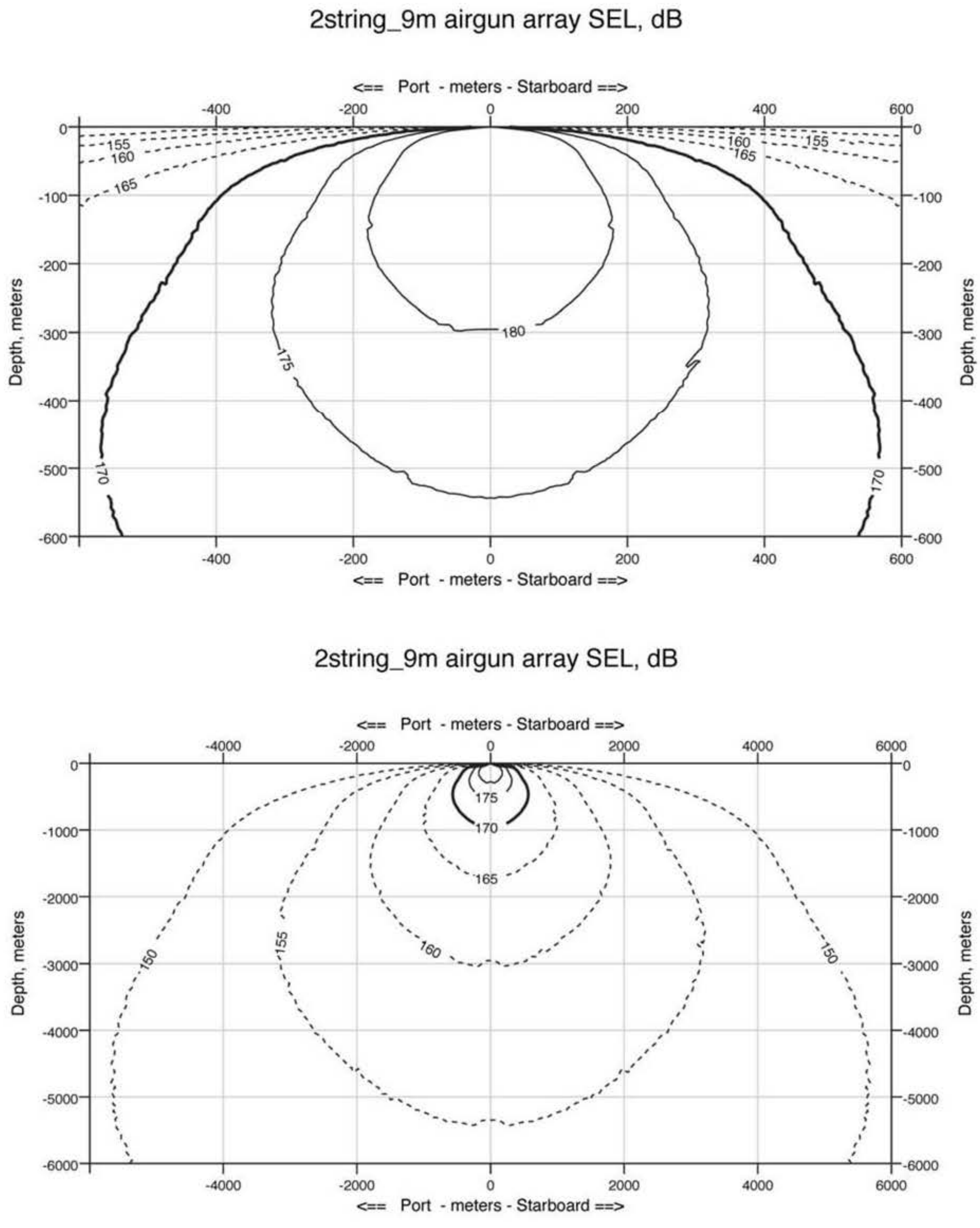

FIGURE 2. Modeled received sound levels (SELs) from the 18-airgun subarray planned for use during the survey in the northeast Atlantic Ocean during June–July 2013, at a 9-m tow depth. Received rms levels (SPLs) are expected to be ~10 dB higher. The plot at the top provides the radius to the 170-dB SEL isopleth as a proxy for the 180-dB rms isopleth, and the plot at the bottom provides the radius to the 150-dB SEL isopleth as a proxy for the 160-dB rms isopleth. A maximum depth of 2000 m is considered.

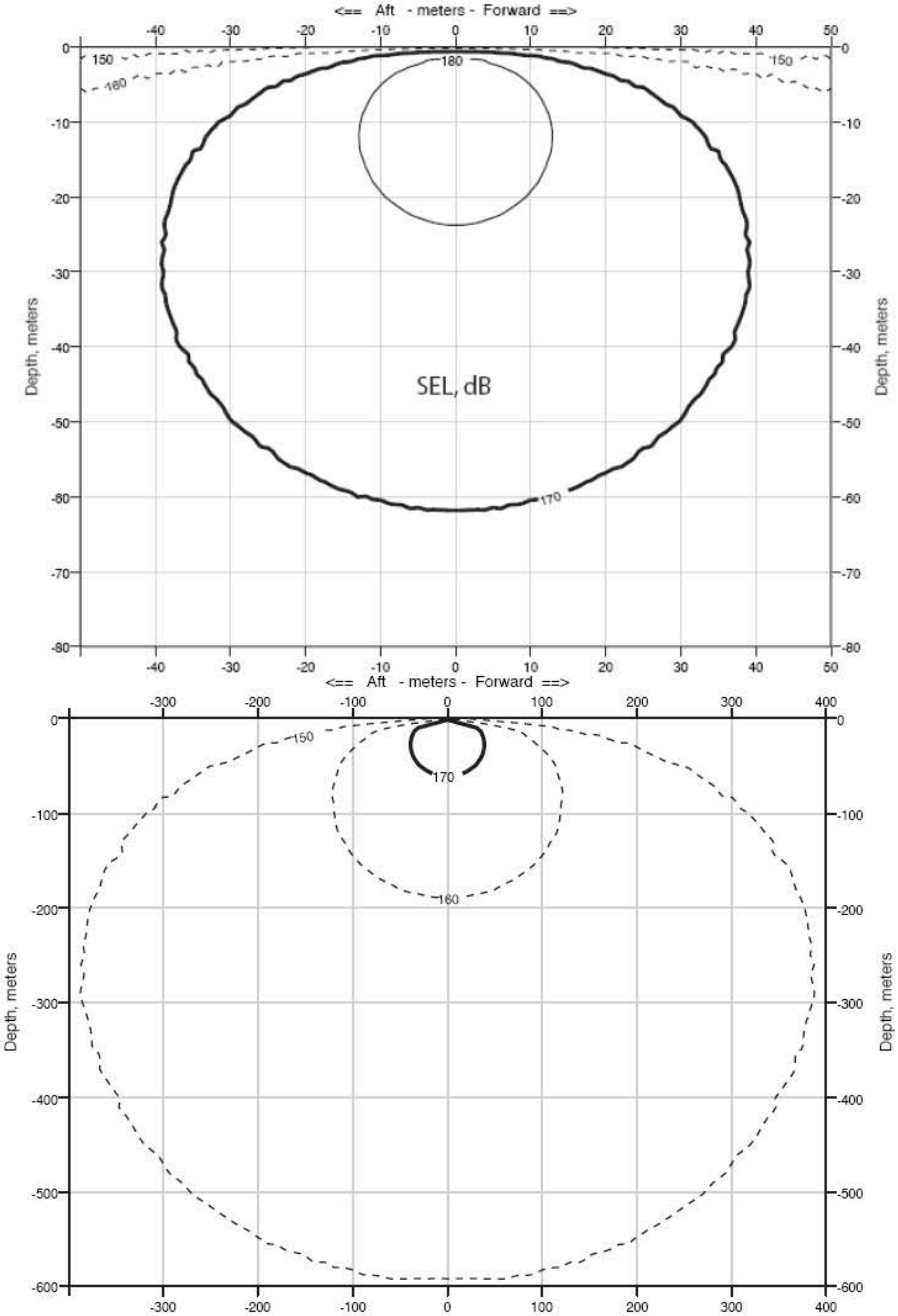

FIGURE 3. Modeled received sound levels (SELs) from a single 40-in^3 airgun planned for use as a mitigation gun during the proposed survey in the northeast Atlantic Ocean, during June–July 2013. Received rms levels (SPLs) are expected to be ~10 dB higher. Received rms levels (SPLs) are expected to be ~10 dB higher. The plot at the top provides the radius to the 170-dB SEL isopleth as a proxy for the 180-dB rms isopleth and the plot at the bottom provides the radius to the 150-dB SEL isopleth as a proxy for the 160-dB rms isopleth.

For deep and intermediate-water cases, these field measurements cannot be used readily to derive mitigation radii, because at those sites the calibration hydrophone was located at a roughly constant depth of 350–500 m, which may not intersect all the isopleths at their widest point from the sea surface down to the maximum relevant water depth for marine mammals of ~2000 m. Figures 2 and 3 for the 36-airgun array in Diebold et al. (2010) show how the values along the maximum SPL line that joins the points where the isopleths attain their maximum width (providing the maximum distance associated with each sound level) can differ from values obtained along a constant depth line. At short ranges, where the direct arrivals dominate and the effects of seafloor interactions are minimal, the data recorded at the deep and slope sites are suited for comparison with modeled levels at the depth of the calibration hydrophone. At longer ranges, the comparison with the mitigation model—constructed from the maximum SPL through the entire water column at varying distances from the airgun array—is the most relevant. The results are summarized below.

Comparisons at short ranges between sound levels for direct arrivals recorded by the calibration hydrophone and modeled results for the same array tow depth for the 36-airgun array are in good agreement (Figs. 12 and 14 in Diebold et al. [2010]). As a consequence, isopleths falling within this domain can be predicted reliably by the L-DEO model, even if they would be sampled imperfectly by measurements obtained at a single depth. At longer distances, the calibration data show that seafloor reflected and sub-seafloor refracted arrivals dominate, whereas the direct arrivals become weak and/or incoherent (Figs. 11, 12 and 16 in Diebold et al. [2010]). Aside from local topography effects, the region around the critical distance (~5 km in Figs. 11 and 12, and ~4 km in Fig. 16 in Diebold et al. [2010]) is where the observed levels rise very close to the mitigation model curve. However, the observed sound levels are found to fall almost entirely below the mitigation model curve (Figs. 11, 12, and 16 in Diebold et al. [2010]). Thus, analysis of the GoM calibration measurements demonstrates that although simple, the L-DEO model is a robust tool for estimating mitigation radii.

Here we use for the 18-airgun array the deep-water radii obtained from modeled levels in deep water down to a maximum depth of 2000 m. The intermediate-water radii are derived from the deep-water ones by applying a correction factor (multiplication) of 1.5, such that observed levels at very near offsets fall below the corrected mitigation curve (Fig. 16 in Diebold et al. [2010]).

Measurements have not been reported for the single 40-in^3 airgun. The PEIS defines a low-energy source as any towed acoustic source whose received level is ≤180 dB at 100 m, including any single airgun with a volume ≤425 in^3. In § 2.4.2 of the PEIS, Alternative B (the Preferred Alternative) conservatively applies a 100-m exclusion zone (EZ) for all low-energy acoustic sources in water depths >100 m. That approach is adopted here for the single Bolt 1900LL 40-in^3 airgun that would be used during power downs. No fixed, full 160-dB zone has been defined yet for the same suite of low-energy sources, therefore, L-DEO model results are used here to determine the 160 dB radius for the 40-in^3 airgun.

Table 1 shows the 180-dB EZ for the single airgun from the PEIS and, using the modeled measurements for the 18-airgun array and the 160-dB EZ for the single airgun, the distances at which the rms sound levels are expected to be received. The 180-dB re 1 μPa_{rms} distance is the safety criterion as specified by NMFS (2000) for cetaceans. The 180-dB distance would also be used as the EZ for sea turtles, as required by NMFS in most other recent seismic projects (e.g., Smultea et al. 2004; Holst et al. 2005a,b; Holst and Beland 2008; Holst and Smultea 2008; Hauser et al. 2008; Holst 2009; Antochiw et al. n.d.). If marine mammals or sea turtles are detected within or about to enter the appropriate EZ, the airguns would be powered down (or shut down if necessary) immediately.

TABLE 1. Modeled distances from the airgun array to which sound levels ≥180 and 160 dB re 1 μPa_{rms} and from the mitigation gun to which a sound level ≥160 dB re 1 μPa_{rms} are expected to be received during the proposed survey in the northeast Atlantic Ocean, 1 June–12 July 2013, and the PEIS 180-dB EZ for the mitigation airgun. Modeled distances are from an L-DEO model for an 18-airgun, 3300-in^3 subarray in deep water towed at a depth of 9 m. The 180-dB EZ for the single mitigation airgun is the conservative EZ for all low-energy acoustic sources in water depths >100 m applied in the Preferred Alternative of the PEIS.

Source and Volume	Water Depth (m)	Predicted RMS Radii (m)	
		180 dB	160 dB
Single Bolt airgun, 40 in^3	>1000 m	100	385
18 airguns, 3300 in^3	>1000 m	568	4550

Southall et al. (2007) made detailed recommendations for new science-based noise exposure criteria. NSF would be prepared to revise its procedures for estimating numbers of mammals should NMFS implement new acoustic criteria guidelines. However, currently the procedures are based on best practices noted by Pierson et al. (1998) and Weir and Dolman (2007).

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. The proposed time for the cruise in June–July 2013 is the most suitable time logistically for the R/V *Langseth* and the participating scientists. If the IHA is issued for another period, it could result in significant delay and disruption not only of this cruise, but also of additional studies that are planned on the R/V *Langseth* for 2013 and beyond. An evaluation of the effects of this Alternative Action is given in § IV.

Alternative 2: No Action Alternative

An alternative to conducting the proposed activities is the “No Action” alternative, i.e., do not 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.

The purpose of the proposed action is to collect data necessary to study the rifted continental to oceanic crust transition in the Deep Galicia Basin west of Spain. This margin and its conjugate are among the best studied magma-poor, rifted margins in the world, and the focus of studies has been the faulting mechanics and modification of the upper mantle associated with such margins. Over the years, a combination of 2-D seismic reflection profiling, general marine geophysics, and ocean drilling conducted by scientists from a number of countries have identified a number of interesting features of the margin. Further study of these features would characterize the last stage of continental breakup and the initiation of seafloor spreading, relate post-rifting subsidence to syn-rifting lithosphere deformation, and inform the nature of detachment faults. It is a cooperative program with scientists from the U.K., Germany, Spain, and Portugal. The methodology to achieve this goal would be to conduct a multi-scale seismic investigation of the Deep Galicia Basin using the R/V *Langseth*.

The “No Action” alternative could also, in some circumstances, result in significant delay of other studies that would be planned on the R/V *Langseth* and the R/V *Poseidon* for 2013 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 provides 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. An evaluation of the effects of this Alternative Action is given in § IV.

Alternatives Considered but Eliminated from Further Analysis

(1) Alternative E1: Alternative Location

The survey location has been specifically identified because of the geological features under investigation. While alternative survey locations may be possible, the Deep Galicia Basin west of Spain is the only site where the main scientific research questions posed could be addressed: What are the mechanisms of magma-poor continental rifting, what is the mechanism of low-angle detachment faulting, and how is the upper mantle exhumed at the seafloor?

The Deep Galicia Basin is an end-member of magma-poor continental breakup and the transition from crustal extension to mantle exhumation at the seafloor to establishment of normal seafloor spreading. This area is unique because of the absence of thick post-rifting sediments, of mobile salt deposits, of volcanic rocks deposited after the rifting period, and reactivation of the rifted margin. The lack of these features makes it possible to (1) use seismic reflection and refraction methods to image the syn-rift sediments, the faulted continental crust, the exhumed mantle, and the hydration/serpentinization of the upper few kilometers of the upper mantle, and (2) use Integrated Ocean Drilling Program (IODP) drill ships to sample the deep rifting related rocks.

The proper selection of a 3-D seismic experiment depends on the existence of prior 2-D seismic characterization of the region and samples from scientific ocean drilling. The study of rifting depends on the combination of seismic imaging and scientific ocean drilling. Based on both seismic acquisition and drilling, the Deep Galicia Basin is the best characterized magma-poor rifted margin. As a result, there are a series of competing hypotheses for the mechanisms of magma-poor rifting. These hypotheses make distinct predictions that are testable using the proposed seismic experiment. There is no other place where these claims can be made. 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 R/V *Langseth*, and its primary capability is to conduct high-energy 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/Analysis
Proposed Action: Conduct a marine geophysical survey and associated activities in the northeast Atlantic Ocean	Under this action, the following activities are proposed: (1) acquire a 2-D seismic reflection profile using 25 OBH/Ss, and (2) conduct a 3-D seismic program using 78 OBH/Ss. When considering mobilization, demobilization, refueling, equipment maintenance, weather, marine mammal activity, and other contingencies, the proposed activities would be expected to be completed in ~39 days. The affected environment, environmental consequences, and cumulative impacts of the proposed activities are described in Sections III, IV, and V, respectively. The standard monitoring and mitigation measures identified in the NSF PEIS would apply, along with any additional requirements identified by regulating agencies. All necessary permits and authorizations, including an IHA, would be requested from regulatory bodies.
Alternatives	Description/Analysis
Alternative 1: Alternative Survey Timing	Under this Alternative, L-DEO would conduct survey operations at a different time of the year to reduce impacts on marine resources and users, and improve monitoring capabilities. However, most marine mammal species are probably year-round residents in the survey area, so altering the timing of the proposed project likely would result in no net benefits for those species. Further, consideration would be needed for constraints for vessel operations and availability of equipment (including the vessel) and personnel. Limitations on scheduling the vessels include the additional research studies planned on the vessels for 2013 and beyond. The standard monitoring and mitigation measures identified in the NSF PEIS would apply. These measures are described in further detail in this document (Section 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. Whereas this alternative would avoid impacts to marine resources, it would not meet the purpose and need for the proposed action. Geological data of scientific value and relevance increasing our understanding of Earth processes and the rifted continental to oceanic crust transition in the Deep Galicia Basin west of Spain would not be collected. The collection of new data, interpretation of these data, and introduction of new results into the greater scientific community and applicability of these data to other similar settings would not be achieved. 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 geological features under investigation. While alternative survey locations may be possible, the Deep Galicia Basin is the only site where the main scientific research questions posed could be addressed: What are the mechanisms of magma-poor continental rifting, what is the mechanism of low-angle detachment faulting, and how is the upper mantle exhumed at the seafloor. 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 R/V *Langseth*, and its primary capability is to conduct high-energy 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, whereas 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 EA:

- *Transportation*—Only two vessels, the R/V *Langseth* and R/V *Poseidon*, would be used during the marine seismic survey. Therefore, 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;
- *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 activities are proposed to occur in the marine environment. Therefore, no changes to current land uses or activities within 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 only short-term displacement of soil and seafloor sediments through the placement of OBH/Ss on the seafloor. Proposed activities would not adversely affect geologic resources as only minor 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. Human activities in the area around the survey vessel would be limited to commercial fishing activities; however, because of the distance from local ports, fishing activity is expected to be limited, and no significant impacts on fishing would be anticipated particularly because of the short duration of the proposed activities (~1 month). Fishing and potential impacts to fishing are described in further detail in Sections III and IV, respectively. No other socioeconomic impacts would be anticipated as 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*—There are no known cultural resources in the proposed Project area. Therefore, no impacts to cultural resources would be anticipated.

Oceanography

The proposed survey area is located in the North Atlantic Subtropical Gyral Province (NAST), which is bounded to the west and northwest by the Gulf Stream, to the northeast at ~40–42ºN by the bifurcation of the flow between the Azores Current and the North Atlantic Current, and to the south at ~25–30ºN by the Subtropical Convergence (Longhurst 2007). Because of density differences between the water masses, most of the region has a complex vertical stratification pattern (Skov et al. 2008). The NAST can contain both errant cold-core eddies originating in the Gulf Stream and cyclonic, warm-core eddies created by isolated seamounts (Longhurst 2007).

A spring phytoplankton bloom occurs in the North Atlantic Ocean because of increasing light conditions and nutrient availability. The bloom starts at a latitude of ~35ºN in December–January and then develops across the North Atlantic during spring and summer, moving north to arctic waters in June. At the same time, stratified nutrient-depleted waters of the NAST gyre also extend north. The spring phytoplankton bloom could temporarily produce high zooplankton densities, particularly in areas where the spring bloom combines with physical factors, e.g., upwelling areas, fronts, and seamounts, to concentrate zooplankton. North of 40°N, the primary production is ~ 90 g carbon/m^2 per year (Johnson et al. n.d.).

Protected Areas

Although there are several areas along the coasts of Spain that have been designated or proposed as protected areas, none are located in far offshore waters near the proposed survey area. The National Park of the Atlantic Islands of Galicia is located off the west coast of Spain (Fig. 1). The park, designated in 2002, covers 72 km^2 of marine area and includes the archipelagos of Cíes, Ons, Sálvora, and Cortegada. Other marine protected areas are located on the north, southwest, and Mediterranean coasts of Spain.

Marine Mammals

Thirty-nine species of marine mammals, including 29 odontocetes, 7 mysticetes, and 3 pinnipeds, are known to occur in the eastern North Atlantic Ocean. Of those, 25 cetacean species (6 mysticetes and 19 odontocetes) could occur near the proposed survey site (Table 3). Six of the 25 species are listed under the U.S. Endangered Species Act (ESA) as ***Endangered***: the North Atlantic right, humpback, blue, fin, sei, and sperm whales. Nine cetacean species, although present in the wider eastern North Atlantic Ocean, likely would not be found near the proposed survey area at ~42°N because their ranges generally do not extend south of ~45°N in northeastern Atlantic waters (Atlantic white-sided dolphin, *Lagenorhynchus acutus*, and white-beaked dolphin, *Lagenorhynchus albirostris*), or their ranges in the northeast Atlantic Ocean generally do not extend north of ~20°N (Clymene dolphin, *Stenella clymene*), 30°N (Fraser's dolphin, *Lagenodelphis hosei*), 34°N (spinner dolphin, *Stenella longirostris*), 35°N (melon-headed whale, *Peponocephala electra*), 37º (rough-toothed dolphin, *Steno bredanensis*), or 40°N (Bryde's whale, *Balaenoptera brydei*, and pantropical spotted dolphin, *Stenella attenuata*). Although Spitz et al. (2011) reported two strandings records of melon headed whales for the Bay of Biscay, this species will not be discussed further, as it is unlikely to occur in the proposed survey area.

Table 3. The habitat, regional abundance, and conservation status of marine mammals that could occur in or near the proposed survey site.

Species	Occurrence near survey location	Habitat	Abundance in the North Atlantic	ESA[1]	IUCN[2]	CITES[3]
Mysticetes North Atlantic right whale	Rare	Coastal and shelf waters	396[4]	EN	EN	I
Humpback whale	Common-Uncommon	Mainly nearshore waters and banks	11,570[5]	EN	LC	I
Common minke whale	Common-Uncommon	Coastal, offshore	121,000[6]	NL	LC	I
Sei whale	Common-Uncommon	Mostly pelagic	12-13,000[7]	EN	EN	I
Fin whale	Common-Uncommon	Slope, mostly pelagic	24,887[8]	EN	EN	I
Blue whale	Common-Uncommon	Coastal, shelf and pelagic	937[9]	EN	EN	I
Odontocetes Sperm whale	Common-Uncommon	Usually deep pelagic, steep topography	13,190[10]	EN	VU	I
Pygmy sperm whale	Rare	Deep waters off shelf	395[4,11]	NL	DD	II
Dwarf sperm whale	Rare	Deep waters off shelf		NL	DD	II
Cuvier's beaked whale	Common-Uncommon	Slope and pelagic	6992[12]; 100,000[13]	NL	LC	II
Northern bottlenose whale	Common-Uncommon	Pelagic	~40,000[14]	NL	DD	I
True's beaked whale	Rare	Pelagic	6992[12]	NL	DD	II
Gervais beaked whale	Uncommon	Pelagic	6992[12]	NL	DD	II
Sowerby's beaked whale	Uncommon	Pelagic	6992[12]	NL	DD	II
Blainville's beaked whale	Uncommon	Pelagic	6992[12]	NL	DD	II
Common bottlenose dolphin	Common-Uncommon	Coastal, shelf, pelagic	19,295[15]	NL	LC	II
Atlantic spotted dolphin	Common-Uncommon	Shelf, offshore	50,978[4]	NL	DD	II
Striped dolphin	Common-Uncommon	Off continental shelf	67,414[15]	NL	LC	II
Short-beaked common dolphin	Common-Uncommon	Shelf, pelagic, high relief	116,709[15]	NL	LC	II
Risso's dolphin	Common-Uncommon	Shelf, slope, seamounts	20,479[4]	NL	LC	II
Pygmy killer whale	Rare	Pelagic	N.A.	NL	DD	II
False killer whale	Common-Uncommon	Pelagic	N.A.	NL	DD	II
Killer whale	Common-Uncommon	Coastal, widely distributed	N.A.	NL	DD	II
Long-finned pilot whale	Common-Uncommon	Mostly pelagic	780,000[16]	NL	DD	II
Short-finned pilot whale	Common-Uncommon	Mostly pelagic, high-relief		NL	DD	II

N.A. Not available or not assessed.
[1] U.S. Endangered Species Act: EN = Endangered, NL = Not listed (ECOS 2012)
[2] Codes for IUCN classifications: EN = Endangered; VU = Vulnerable; LC = Least Concern; DD = Data Deficient. Classifications are from the IUCN Red List of Threatened Species (IUCN 2012).
[3] Convention on International Trade in Endangered Species of Wild Fauna and Flora (UNEP-WCMC 2012); Appendix I = Threatened with extinction; Appendix II = not necessarily now threatened with extinction but may become so unless trade is closely controlled.
[4] Western North Atlantic, in U.S. and southern Canadian waters (Waring et al. 2012)
[5] Likely negatively biased (Stevick et al. 2003)
[6] Central and Northeast Atlantic (IWC 2012)
[7] North Atlantic (Cattanach et al. 1993)
[8] Central and Northeast Atlantic (Víkingsson et al. 2009)
[9] Central and Northeast Atlantic (Pike et al. 2009).
[10] For the northeast Atlantic, Faroes-Iceland, and the U.S. east coast (Whitehead 2002)
[11] Both *Kogia* species
[12] For all beaked whales (Anonymous 2009)
[13] Worldwide estimate (Taylor et al. 2008)
[14] Eastern North Atlantic (NAMMCO 1995)
[15] European Atlantic waters beyond the continental shelf (Anonymous 2009)
[16] *Globicephala sp*. combined, Central and Eastern North Atlantic (IWC 2012)

The harbor porpoise *Phocoena phocoena*) does not occur in deep offshore waters. No harbor porpoise were detected visually or acoustically during summer surveys off the continental shelf in the Biscay Bay area during 1989 and 2007 (Lens 1991; Basto d'Andrade 2008; Anonymous 2009). Pinniped species are also not known to occur in the deep waters of the survey area.

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 NSF/USGS PEIS. One of the qualitative analysis areas (QAAs) defined in the PEIS is on the Mid-Atlantic Ridge, at 26ºN, 40ºW, ~2800 km from the proposed survey area. The general distribution of mysticetes and odontocetes in the North Atlantic is discussed in § 3.6.3.4 and § 3.7.3.4 of the PEIS, respectively. The rest of this section deals specifically with species distribution off the north and west coast of the Iberian Peninsula.

Several systematic surveys have been conducted in the Bay of Biscay area, which has been found to be one of the most productive areas and the centre of highest cetacean diversity in the northeast Atlantic (Hoyt 2005). The second North Atlantic Sightings Survey (NASS) occurred in waters off the continental shelf from the southern U.K. to northern Spain in July–August 1989 (Lens 1991). The Cetacean Offshore Distribution and Abundance in the European Atlantic (CODA) included surveys from the U.K. to southern Spain during July 2007 (Basto d'Andrade 2008; Anonymous 2009). Additional information is available from coastal surveys off northwest Spain (e.g., López et al. 2004; Spyrakos et al. 2011), stranding records for northwest Spain (e.g., López et al. 2003), and sighting records off western-central (Brito et al. 2009) and southern (Castor et al. 2010) Portugal. Records from the Ocean Biogeographic Information System (OBIS) database hosted by Rutgers and Duke University (Read et al. 2009) were also included.

(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 (Reeves et al. 2002). Historically, it also occurred off southeast Greenland (Knowlton et al. 1992; Mellinger et al. 2011), but the status of the eastern North Atlantic population of right whales is currently unknown. There were few sightings of right whales in the eastern North Atlantic during the 20th century, including off Iceland, Spain (including the Bay of Biscay), the Azores, Portugal, and Madeira (Casinos and Vericad 1976; Aguilar 1981; Brown 1986; Knowlton et al. 1992; Martin and Walker 1997). Recent (2007–2008), visual and acoustic detections of North Atlantic right whales off southeast Greenland (Mellinger et al. 2011) and a sighting in the Azores in January 2009 (Silva et al. 2012) suggest that there could be a remaining central or eastern sub-population of North Atlantic right whales. No right whales were identified during summer surveys in the Bay of Biscay and adjacent waters off northwest Spain during 1989 (Lens 1991) or 2007 (Basto d'Andrade 2008; Anonymous 2009).

Humpback Whale (*Megaptera novaeangliae*)

A small number of humpback whales migrate from their summer feeding grounds in the North Atlantic to Cape Verde (Wenzel et al. 2009). No humpback whales were identified during summer surveys in the Bay of Biscay and adjacent waters off northwest Spain during 1989 (Lens 1991) or 2007 (Basto d'Andrade 2008; Anonymous 2009). However, Casinos and Vericad (1976) reported several records of this species for the Bay of Biscay. In addition, there are five OBIS records off northwest Spain, including two whaling records (Smith 2002), two sightings by the U.K. Royal Navy near 44.5°N, 10–14°W (Maughan 2003), and one sighting at 42.2°N, 9.5°W (College of the Atlantic, Allied Whale 2004). López et al. (2002) also reported a stranding off northwest Spain in 1993. Single humpback whale sightings have been made off the west central coast of Portugal (Brito et al. 2009) and off southern Portugal (Castro et al. 2010).

Common Minke Whale (*Balaenoptera acutorostrata*)

Basto d'Andrade (2008) reported one minke whale during a survey of the Bay of Biscay and adjacent waters off northwest Spain in July 2007. However, the abundance and density for this area based on the 2007 survey was estimated at zero (Anonymous 2009; Macleod et al. 2009). For the waters north (~45.5–53°) of the Bay of Biscay, abundance was estimated at 1218 minke whales with a density estimate of $0.004/km^2$ (Anonymous 2009; Macleod et al. 2009). Lens (1991) did not report any confirmed minke whale sightings during a summer survey in the Bay of Biscay area in 1989. Casinos and Vericad (1976) reported two records of minke whales in the Bay of Biscay. In addition, there are seven OBIS sightings of minke whales off northwest Spain just east of the proposed survey area between 41.6–44.1ºN and 9.6–10.2ºW (Maughan 2003). López et al. (2002) also reported 10 strandings off northwest Spain during 1990–1999, and Lens et al. (2005) reported two stranded minke whales off northwest Spain for 2004–2005. Brito et al. (2009) reported one minke whale off west central Portugal, and Castro et al. (2010) reported one sighting off southern Portugal.

Sei Whale (*Balaenoptera borealis*)

During a survey of European waters from the U.K. to the southern coast of the Iberian Peninsula in July 2007, sei whale sightings (n = 18) were only made in the survey block off northwest Spain (Basto d'Andrade 2008; Anonymous 2009). The abundance estimate for the area off northwest Spain was 366 sei whales, and the density estimate was $0.002/km^2$ (Anonymous 2009; Macleod et al. 2009). Lens (1991) did not report any sei whale sightings during a summer survey in the Bay of Biscay area in 1989. During the 20th century, sei whales were taken off northwest Spain, one of the major whaling grounds off the Iberian Peninsula (Sanpera and Aguilar 1992). There are 242 OBIS whaling records of sei whales off northwest Spain (Smith 2002) and one sighting just east of the survey area at ~42ºN, 10ºW (Maughan 2003).

Fin Whale (*Balaenoptera physalus*)

Fin whales were the most frequently identified cetacean species during summer surveys in the Bay of Biscay area in 1989 (n = 38) and 2007 (n = 297). Several sightings were made within and near the survey area off northwest Spain (Lens 1991; Basto d'Andrade 2008; Anonymous 2009). During the July 2007 survey of European waters from the U.K. to the southern coast of the Iberian Peninsula, the survey block off northwest Spain had the highest density of fin whales ($0.019/km^2$), and the best abundance estimate was 3206 (Anonymous 2009; Cañadas et al. 2009; Macleod et al. 2009). Fin whale density was predicted to be highest in areas with sea surface temperatures of 16–19°C and depths of 1000–3500 m, with peak densities occurring within 50 m of the 2000-m isobath (Anonymous 2009). There are nearly 4000 OBIS whaling records of fin whales off northwest Spain (Smith 2002) and five sightings during July 1995 just northeast of the survey area at ~44.5ºN, 10.3ºW (Maughan 2003). Single fin whale sightings were also made in coastal waters of northwest Spain during surveys by López et al. (2004) and Spyrakos et al. (2011).

Blue Whale (*Balaenoptera musculus*)

The blue whale's summer range in the northeast Atlantic extends from the waters north of Svalbard and the Barents Sea south to the Bay of Biscay (Rice 1998). Although the winter range is mostly unknown, some occur near Cape Verde (Rice 1998). No blue whales were identified during summer surveys in the Bay of Biscay and adjacent waters during 1989 or 2007 (Lens 1991; Basto d'Andrade 2008; Anonymous 2009). Casinos and Vericad (1976) reported one record for the Bay of Biscay. There are 15 OBIS whaling records for blue whales off the northwest coast of Spain (Smith 2002), and several more whaling records for west-central Portugal (Brito et al. 2009).

(2) Odontocetes

Sperm Whale (*Physeter macrocephalus*)

During acoustic and visual surveys of European waters from the U.K. to the southern Iberian Peninsula in July 2007, sperm whale densities were highest in the Bay of Biscay and off the northwestern Iberian Peninsula, and a total of 247 sperm whales were detected acoustically (Anonymous 2009; Swift et al. 2009). Sperm whales were one of the most commonly sighted cetacean species during summer surveys of the Bay of Biscay area in 1989 (n = 30) and 2007 (n = 42). Several sightings were made within and near the survey area off northwest Spain (Lens 1991; Basto d'Andrade 2008; Anonymous 2009). The best abundance estimate for the area off northwest Spain was 611, and the density estimate was 0.003/km^2 (Anonymous 2009; Cañadas et al. 2009; Macleod et al. 2009). In the Bay of Biscay, sperm whale habitat consists of the complex canyon area of the lower northern Celtic-Biscay shelf edge, the edge of the Biscay abyssal plain, and the Santander canyon near Bilbao, Spain (Anonymous 2009).

There are over 4000 OBIS whaling records of sperm whales off northwest Spain (Smith 2002). In addition, sperm whales have been sighted by U.K. Royal Navy vessels just to the east of the survey area at 42.7°N, 9.6°W and off the north coast of Spain near ~45°N, 8.6°W (Maughan 2003).

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

There are no OBIS sightings of pygmy or dwarf sperm whales near the proposed survey area off northwest Spain (IOC 2012). However, there are at least nine stranding records of pygmy sperm whales in the Bay of Biscay and northwest Spain for 1984–2010 (López et al. 2002; Lens et al. 2005; Santos et al. 2006; Spitz et al. 2011), and one stranding of a dwarf sperm whale in the Bay of Biscay in 1999 (Spitz et al. 2011).

Cuvier's Beaked Whale (*Ziphius cavirostris*)

Several sightings (n = 13) of Cuvier's beaked whale were made during surveys of the Bay of Biscay and adjacent waters off northwest Spain in July 2007 (Basto d'Andrade 2008). In addition, 60 sightings of Cuvier's beaked whale were made in the Bay of Biscay during 1998–2002 (Kiszka et al. 2007). The best abundance estimate for all beaked whales combined for the area off northwest Spain was 597, and the density estimate was 0.004/km^2 (Anonymous 2009; Macleod et al. 2009). Casinos and Vericad (1976) also reported at least two records for the Bay of Biscay. Five strandings were reported for northwest Spain during the 1990s (López et al. 2002). Spitz et al. (2011) reported on 10 strandings for the Bay of Biscay: 2 in 1998–1999 and 8 during 2000–2008.

There are no OBIS sightings of Cuvier's beaked whale near the proposed survey area off northwest Spain (IOC 2012).

Northern bottlenose whale (*Hyperoodon ampullatus*)

One sighting of two northern bottlenose whales was made during surveys of the Bay of Biscay and adjacent waters off northwest Spain in July 2007 (Basto d'Andrade 2008). Nine sightings of 32 individuals were made in deep waters (average depth of 3349 m) of the southern Bay of Biscay during 1998–2002; the mean group size was 2.8 (Kiszka et al. 2007). In addition, five sightings of seven northern bottlenose whales were made during aerial surveys of the Bay of Biscay between 2001 and 2006 (Certain 2008).

Casinos and Vericad (1976) reported several records of this species for the Bay of Biscay, and one stranding was reported for the Bay of Biscay by Spitz et al. (2011).

There are no OBIS sightings of northern bottlenose whale near the proposed survey area off northwest Spain (IOC 2012).

True's Beaked Whale (*Mesoplodon mirus*)

In the eastern Atlantic Ocean, there are stranding records of True's beaked whale from Ireland (54ºN) to the Canaries (29ºN; MacLeod et al. 2006). One True's beaked whale was seen in the southern Bay of Biscay during 1998–2002 (Kiszka et al. 2007). Four sightings of unidentified beaked whales were also made during surveys of the Bay of Biscay area in July–August 1989 (although no sightings occurred off northwest Spain; Lens 1991), two sightings of unidentified beaked whales were made in the Bay of Biscay in 1999 (Kiszka et al. 2007), one sighting was made during 2001–2006 (Certain 2008), and nine sightings were reported during surveys of the Bay of Biscay and adjacent waters off northwest Spain in July 2007 (Basto d'Andrade 2008).

There are no OBIS sightings of True's beaked whale near the proposed survey area (IOC 2012).

Gervais' Beaked Whale (*Mesoplodon europaeus*)

MacLeod et al. (2006) noted several stranding records for Blainville's beaked whale on the Iberian Peninsula, but there are no OBIS sighting records near the proposed survey area (IOC 2012). Nine sightings of unidentified beaked whales were made during surveys of the Bay of Biscay and adjacent waters off northwest Spain in July 2007 (Basto d'Andrade 2008).

Sowerby's Beaked Whale (*Mesoplodon bidens*)

One sighting of two Sowerby's beaked whales was made during surveys of the Bay of Biscay and adjacent waters off northwest Spain in July 2007 (Basto d'Andrade 2008). In addition, a sighting of three Sowerby's beaked whales was seen in the southern Bay of Biscay during 1998–2002 (Kiszka et al. 2007). Three strandings were reported for the Bay of Biscay by Spitz et al. (2011). There are no OBIS sightings of Sowerby's beaked whale near the proposed survey area (IOC 2012).

Blainville's Beaked Whale (*Mesoplodon densirostris*)

Blainville's beaked whale is the most widely distributed *Mesoplodon* species (Mead 1989), although it is generally limited to pelagic tropical and warmer temperate waters (Jefferson et al. 2008). MacLeod et al. (2006) noted several stranding records for Blainville's beaked whale on the Iberian Peninsula, but there are no OBIS sighting records near the proposed survey area (IOC 2012).

Common Bottlenose Dolphin (*Tursiops truncatus*)

During a survey of European waters from the U.K. to the southern coast of the Iberian Peninsula in July 2007, the survey block off northwest Spain had the lowest bottlenose dolphin density (0.005/km^2); the best estimate of abundance for the same area was 876 (Anonymous 2009; Macleod et al. 2009). Basto d'Andrade (2008) reported eight sightings of bottlenose dolphins during the 2007 summer surveys in the Biscay Bay area, whereas Lens (1991) did not report any sightings of bottlenose dolphins during surveys of the area in the summer of 1989. There is one OBIS sighting of common bottlenose dolphin near the proposed survey area at ~43.5ºN, 9.1ºW (Maughan 2003). Bottlenose dolphins have also been sighted during surveys of coastal waters off northwest Spain (e.g., López et al. 2004; Pierce et al. 2010; Spyrakos et al. 2011).

Atlantic Spotted Dolphin (*Stenella frontalis*)

There are no OBIS sightings of Atlantic spotted dolphin near the proposed survey area (IOC 2012). No sightings of Atlantic spotted dolphins have been reported for surveys in the Bay of Biscay and adjacent waters (Lens 1991; Kiszka et al. 2007; Basto d'Andrade 2008; Certain 2008) or off the central coast of Portugal (Brito et al. 2009).

Striped Dolphin (*Stenella coeruleoalba*)

Striped dolphins were one of the most commonly sighted cetacean species during summer surveys of the Bay of Biscay area and adjacent waters off northwest Spain in 2007; 111 sightings were made, 68 of which were mixed groups of striped and short-beaked common dolphins (Basto d'Andrade 2008). One of the sightings occurred inside the proposed study area (Basto d'Andrade 2008). A single striped dolphin sighting was made by Lens (1991) during summer surveys of the Bay of Biscay area. The best abundance estimate for the area off northwest Spain was 10,501, and the density was estimated at 0.047/km^2 (Anonymous 2009; Cañadas et al. 2009; Macleod et al. 2009).

Surveys of the Bay of Biscay and adjacent waters off northwest Spain showed that increased chlorophyll-*a* concentrations near submarine canyons and shelf-slope breaks were correlated with increased numbers of striped dolphins (Basto d'Andrade 2008).

There are no OBIS sightings of striped dolphins off west Spain; the OBIS sighting closest to the proposed survey area is a sighting by the U.K. Royal Navy to the southeast at 40.8ºN, 9.9ºW (Maughan 2003). During coastal surveys off west Spain, Spyrakos et al. (2011) reported four sightings of striped dolphins.

Short-beaked Common Dolphin (*Delphinus delphis*)

Common dolphins were one of the most commonly sighted cetacean species during summer surveys of the Bay of Biscay area and adjacent waters off northwest Spain in 1989 (Lens 1991) and 2007 (Basto d'Andrade 2008). Fifteen sightings were made during surveys in 1989 (Lens 1991), and 180 sightings (68 of which were mixed groups with striped dolphins) were made in 2007 (Basto d'Andrade 2008). Based on Basto d'Andrade (2008), at least three of the sightings occurred inside the proposed study area. The best abundance estimate for the area off northwest Spain was 21,071, and the density was estimated at 0.077/km^2 (Anonymous 2009; Cañadas et al. 2009; Macleod et al. 2009).

Surveys of the Bay of Biscay and adjacent waters off northwest Spain showed that increased chlorophyll-*a* concentrations near submarine canyons and shelf-slope breaks were correlated with increased numbers of common dolphins (Basto d'Andrade 2008).

There are numerous OBIS sightings of common dolphins around the Iberian Peninsula (IOC 2012). U.K. Royal Navy vessels reported nine sightings between 42.2º–43.5ºN and 9.6º–10.9ºW, and two sightings near 45ºN, 8.4ºW (Maughan 2003). Common dolphins were frequently sighted during surveys of coastal waters off northwest Spain (e.g., López et al. 2004; Pierce et al. 2010; Spyrakos et al. 2011).

Risso's Dolphin (*Grampus griseus*)

One sighting of a group of four Risso's dolphins was made during surveys of the Bay of Biscay area during summer 2007 (Basto d'Andrade 2008). In addition, 14 sightings were made during surveys of the Bay of Biscay and adjacent waters to the north during 1998–2002, and six sightings were made in the Bay of Biscay between 2001 and 2006 (Certain 2008). There have been at least 42 strandings off northwest Spain (Abollo et al. 1998; López et al. 2002; Lens et al. 2005). Risso's dolphins have also been sighted during surveys of coastal waters off northwest Spain (e.g., López et al. 2004; Pierce et al. 2010; Spyrakos et al. 2011). There are no OBIS sightings of Risso's dolphin off northwest Spain; the OBIS sighting closest to the proposed survey area is off Portugal at 41.4ºN, 8.8ºW (Faustino 2000).

Pygmy Killer Whale (*Feresa attenuata*)

Williams et al. (2002) reported two sightings of pygmy killer whales in the southern Bay of Biscay, at ~45.3°N; these are the most northerly sightings for this species. No pygmy killer whales were seen during summer surveys in the Bay of Biscay in 1999 (Lens 1991) or 2007 (Basto d'Andrade 2008). There are no OBIS sightings of the pygmy killer whale near the proposed survey area (IOC 2012).

False Killer Whale (*Pseudorca crassidens*)

Two groups totalling 13 false killer whales were sighted in the central and southern part of the Bay of Biscay during 1998–2002, in water >2000 m deep (Kiszka et al. 2007). There are no OBIS sightings of false killer whales off northwest Spain; there are two OBIS records from the National Whale and Dolphin Sightings and Strandings database off southwest Spain at 36ºN, 6ºW (IOC 2012).

Killer Whale (*Orcinus orca*)

As part of a study to detect the impact of oceano-climatic changes on the marine ecosystem, Hemery et al. (2008) reported that the killer whale disappeared from the southern part of the Bay of Biscay during the course of the study period (1974–2000); however, Kiszka et al. (2007) reported five killer whale sightings for the central and southern part of the Bay of Biscay during 1998–2002, all in deep (>2000 m) oceanic water (Kiszka et al. 2007). Casinos and Vericad (1976) also reported several records of this species for the Bay of Biscay. There are 10 OBIS records of killer whales off the Iberian Peninsula, but none are located near the proposed study area (IOC 2012). López et al. (2002) reported one stranding off northwest Spain in 1990.

Long-finned Pilot Whale (*Globicephala melas*)

The North Atlantic subspecies of the long-finned pilot whale (*G. m. melas*) ranges in the northeast Atlantic from ~68ºN in Norway south to Madeira at ~33ºN (Culik 2010). During a survey of European waters from the U.K. to the southern coast of the Iberian Peninsula in July 2007, the survey block off northwest Spain had the lowest pilot whale density (0.001/km^2); the best estimate of abundance was 194 long-finned pilot whales (Anonymous 2009; Macleod et al. 2009). Modeling predicted that pilot whale densities would be higher in deeper waters, seabed slopes, and areas with warmer temperatures (Anonymous 2009). During the 2007 survey, a total of 18 sightings of long-finned pilot whales were made in the Bay of Biscay and adjacent waters off northwest Spain (Basto d'Andrade 2008); Lens (1991) reported 7 sightings of *Globicephala* sp. for surveys conducted in the area in 1989. There are several OBIS sightings of long-finned pilot whale in the Bay of Biscay area; five sightings were made by the U.K. Royal Navy northeast of the proposed survey area between 44.2º–45.3ºN and 8.1º–9.9ºW (Maughan 2003). Long-finned pilot whales have also been sighted during surveys of coastal waters off northwest Spain (e.g., López et al. 2004; Pierce et al. 2010; Spyrakos et al. 2011).

Short-finned Pilot Whale (*Globicephala macrorhynchus*)

During a survey of European waters from the U.K. to the southern coast of the Iberian Peninsula in July 2007, the survey block off northwest Spain had the lowest pilot whale density (0.001/km^2); the abundance estimate for that same block for long- and short-finned pilot whales combined was 238 (Anonymous 2009; Macleod et al. 2009). There are three OBIS sightings of short-finned pilot whale off the Iberian Peninsula, all reported by the U.K. Royal Navy between 38.6º–45.3ºN and 8.2º–11.2ºW (Maughan 2003). López et al. (2002) reported 15 stranding records for northwest Spain in 1998.

Sea Turtles

Six species of sea turtles, all of which are considered under the ESA to be ***endangered*** or ***threatened***, could occur in or near the proposed survey. General information on the taxonomy, ecology, distribution and movements, and acoustic capabilities of sea turtles are given in § 3.4.1 of the NSF/USGS PEIS. The general distribution of sea turtles in the North Atlantic is discussed in § 3.4.3.4 of the PEIS. The rest of this section deals specifically with their distribution in the eastern North Atlantic, particularly off northwest Spain. The main source of information used in this section is the OBIS database, as few other data are available.

(1) Leatherback Turtle (*Dermochelys coriacea*)

The leatherback turtle is found in the northeast Atlantic as far north as the U.K. and Norway (Spotila 2004). Studies tracking satellite-tagged leatherback turtles have shown that at least three sea turtles have traveled to the waters off northwest Spain—one was tagged in Grenada (Hays et al. 2006), one in Trinidad (Eckert 2006), and another in Ireland (Doyle et al. 2008). The turtle that was tagged in Trinidad traveled as far north as the Bay of Biscay and stayed there until the end of November; it then traveled to Mauritania presumably to feed (Eckert 2006). Using Kernel Home Range estimation, Eckert (2006) suggested that the west coast of the Iberian Peninsula was a high-use area for leatherback turtles. There are no OBIS sightings of leatherback sea turtles near the proposed survey area off northwest Spain but there is one record for the Bay of Biscay (IOC 2012). Leatherback turtles are known to strand on the French coast of the Bay of Biscay (Duguy et al. 1998).

(2) Green Turtle (*Chelonia mydas*)

In the northeast Atlantic Ocean, green turtles are rare visitors to U.K. waters (Pierpoint 2000). There are no OBIS sightings of green turtles near the proposed survey area off northwest Spain (IOC 2012). Green turtles are known to strand on the French coast of the Bay of Biscay (Duguy et al. 1998).

(3) Loggerhead Turtle (*Caretta caretta*)

The most common species of sea turtle in the proposed survey area is likely to be the loggerhead sea turtle. Loggerhead turtles are known to strand on the French coast of the Bay of Biscay (Duguy et al. 1998), but there are no OBIS sightings near the proposed survey area (IOC 2012). However, there are numerous records for the U.K. and southern Iberian Peninsula, and thousands of OBIS records for the Azores (IOC 2012). Bolten et al. (1993) suggested that small (10–82 cm curved carapace length) loggerhead turtles found in the Azores are recruited annually, possibly from the southeastern U.S., and leave the Azores before reaching breeding size.

(4) Hawksbill Turtle (*Eretmochelys imbricata*)

There are no OBIS sightings of hawksbill turtles near the proposed survey area off northwest Spain (IOC 2012). However, there is one OBIS record for the hawksbill turtle near the Azores, one for Ireland, and one for France (IOC 2012).

(5) Olive and Kemp's Ridley Turtles (*Lepidochelys olivacea* and *L. kempii*)

In the Atlantic Ocean, olive ridley turtles inhabit the west coast of Africa and northeastern coast of South America; a few are present in the West Indies, but they do not occur in most of the North Atlantic Ocean (Spotila 2004). Kemp's ridley turtles have been known to strand on the French coast of the Bay of Biscay (Duguy et al. 1998). However, there are no OBIS sightings of olive or Kemp's ridley turtles near the proposed survey area, but several records of Kemp's ridley turtles for the U.K. (IOC 2012).

Seabirds

One ESA-listed seabird species could occur in or near the Project area: the ***Threatened*** 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) Roseate Tern (*Sterna dougallii*)

The Roseate tern is listed as ***Endangered*** under the ESA on the Atlantic Coast south to North Carolina and ***Threatened*** in all other areas of the Western Hemisphere (USFWS 2012), and is listed as ***Least Concern*** on the 2012 IUCN Red List of Threatened Species (IUCN 2012). The nearest breeding colony to the proposed survey area is at Ilse aux Dames, Brittany, but non-breeding roseate terns could occur in small numbers (Varty and Tanner 2009).

Breeding habitat includes sandy or rocky offshore islands and barrier beaches (Gochfeld et al. 1998). European populations winter in West Africa, between Guinea and Gabon (del Hoyo et al. 1996). During the breeding season, roseate terns are strictly coastal, whereas during the non-breeding season, they migrate well offshore and may be primarily pelagic. Roseate terns feed primarily on small marine fish taken over sandbars or shoals, or over schools of pelagic predatory fish (Gochfeld et al. 1998).

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

There are no ESA-listed fish species or candidate species for ESA listing in or near the proposed survey area in the deep waters of the northeast Atlantic Ocean off Spain. There is no Essential Fish Habitat (EFH) and there are no habitats of particular concern (HAPC) in the Spanish EEZ or International Waters where the proposed survey would take place.

Fisheries

ICES Statistical Division IXb (also known as Portuguese Waters-West) was used in the analysis of the ICES fishery statistics. This Division includes Subdivisions IXb and IXb2, the former bounded by 43°N and 36°N latitude, and 11°W and 18°W (FAO 2012). All species caught in this division during 2007–2010 (ICES 2012) were examined and those most likely to occur in the proposed seismic survey area, based on the water depths in the proposed survey area, were included in the following discussion on the fishery. Information on the fishery in all water depths in the Portugal EEZ was also used (Sea Around Us Project 2012). Although the survey area occurs ~100 km north of the EEZ of Portugal, the EEZ of

Spain is much too large to be used for this analysis, incorporating the Bay of Biscay, southwestern Spain, and a large area in the Mediterranean Sea. A brief examination of data from both EEZs indicated that the Portuguese EEZ is appropriate and does indeed reflect results from analysis of the ICES Statistical Division IXb.

In the deep-water areas west of the Iberian Peninsula, commercial fishery catches are likely dominated by large pelagic fish. Sharks, swordfish, and tuna would account for most of the catches. The total aggregated catch for ICES Statistical Division IXb was 4380 t during 2007–2010. Various shark species, particularly blue and shortfin mako, accounted for 58% of the catch weight, followed by swordfish (23%) and various tunas, especially yellowfin (9%). These pelagic fish are harvested using various gear types including pole-and-line, longlines, purse seines, and hooks/gorges.

Portuguese (55% overall) and Spanish (42% overall) vessels accounted for most of the harvest, although German and U.K. vessels also recorded harvests (each 2% overall) during 2007–2010. The total annual commercial catch weights recorded for ICES Statistical Division IXb during 2007–2010 ranged from 772 to 1369 t. Typical vessels fishing for pelagic species in this area would be large (>30 m long). Most of the fishing effort in ICES Statistical Division IXb is expended in areas where water depths are considerably less than those associated with the proposed seismic survey area.

In the Portuguese EEZ, the average annual total catch during 2002–2006 was ~110,700 t (Sea Around Us Project 2012). Dominant species caught were "mixed group" (29.5%) and European pilchard (43.1%). Most of the catch by country was by Portugal (90.9%). Dominant gear types were purse seines (47.7%), bottom trawls (17.5%), and mid-water trawls (7.5%).

IV. Environmental Consequences

Proposed Action

(1) Direct Effects on Marine Mammals and Sea Turtles and Their Significance

The material in this section includes a brief summary of the anticipated potential effects (or lack thereof) of airgun sounds on marine mammals and sea turtles. A more comprehensive review of the relevant background information appears in § 3.4.1, § 3.6.4.3, § 3.7.4.3, and Appendix E of the PEIS. This section also includes estimates of the numbers of marine mammals that could be affected by the proposed seismic surveys scheduled to occur during June–July 2013. 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} is also provided.

Summary of Potential Effects of Airgun Sounds

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 an injury (Southall et al. 2007). 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. As a result of the monitoring and mitigation measures, no marine mammals are expected to be exposed to sounds from the survey at levels causing behavioral disturbance.

***Tolerance*.—**Numerous studies have shown that pulsed sounds from airguns are often readily detectable in the water at distances of many kilometers. 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. 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. 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). If a marine mammal does react briefly to an underwater sound by changing its behavior or moving a small distance, the impacts of the change are unlikely to be significant to the individual, let alone the stock or population. However, if a sound source displaces marine mammals from an important feeding or breeding area for a prolonged period, impacts on individuals and populations could be significant (e.g., Lusseau and Bejder 2007; Weilgart 2007). 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 might be disturbed to some biologically important degree by a seismic program are based primarily on behavioral observations of a few species. Detailed studies have been done on humpback, gray, bowhead, and sperm whales. Less detailed data are available for some other species of baleen whales and small toothed whales, but for many species, there are no data on responses to marine seismic surveys.

Baleen Whales

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

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 that 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. However, some individual humpback whales, especially males, approached within distances of 100–400 m.

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. 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. It has been suggested that South Atlantic humpback whales wintering off Brazil may be displaced or even strand upon exposure to seismic surveys, but data from subsequent years, indicated that there was no observable direct correlation between strandings and seismic surveys.

There are no data on reactions of *right whales* to seismic surveys, but results from the closely related *bowhead whale* 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. However, more recent research on bowhead whales corroborates earlier evidence that, during the summer feeding season, bowheads are not as sensitive to seismic sources.

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}. Those findings were generally consistent with the results of experiments conducted on larger numbers of gray whales that were migrating along the California coast, and western Pacific gray whales feeding off Sakhalin Island, Russia.

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. Singing fin whales in the Mediterranean moved away from an operating airgun array.

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. 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. The beluga, however, is a species that (at least at times) shows long-distance (10s of km) avoidance of seismic vessels. 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.

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, and they continue to call, but foraging behavior can be altered upon exposure to airgun sound. There are almost no specific data on the behavioral reactions of *beaked whales* to seismic surveys. 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. Most beaked whales tend to avoid approaching vessels of other types, and may also dive for an extended period when approached by a vessel. 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.

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). 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. 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 have not been formally adopted by NMFS for use in regulatory processes and during mitigation programs associated with seismic surveys. However, some aspects of the recommendations have been taken into account in certain environmental impact statements and small-take authorizations. NMFS has indicated that it may issue new noise exposure criteria for marine mammals that account for the now-available scientific data on 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.

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 will reduce or (most likely) avoid any possibility of hearing impairment.

Non-auditory physical effects may also occur in marine mammals exposed to strong underwater pulsed sound. Possible types of non-auditory physiological effects or injuries that might (in theory) occur in mammals close to a strong sound source include stress, neurological effects, bubble formation, and other types of organ or tissue damage. It is possible that some marine mammal species (i.e., beaked whales) may be especially susceptible to injury and/or stranding when exposed to strong transient sounds. However, there is no definitive evidence that any of these effects occur even for marine mammals in close proximity to large arrays of airguns. Such effects, if they occur at all, would presumably be limited to short distances and to activities that extend over a prolonged period. Marine mammals that show behavioral avoidance of seismic vessels, including most baleen whales, some odontocetes, and some pinnipeds, are especially unlikely to incur non-auditory physical effects. The brief duration of exposure of any given mammal, the deep water in the study area, and the planned monitoring and mitigation measures would further reduce the probability of exposure of marine mammals to sounds strong enough to induce non-auditory physical effects.

Sea Turtles

There is substantial overlap in the frequencies that sea turtles detect 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 PSOs stationed on the *Langseth* would also watch for sea turtles, and airgun operations would be shut down if a turtle enters the designated EZ.

(2) 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 18-airgun array, as a result of its design, directs the majority of the energy downward, and less energy laterally, is also an inherent mitigation measure.

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

(3) Potential Numbers of 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 ~5834 km of seismic surveys in the northeast Atlantic Ocean. The main sources of distributional and numerical data used in deriving the estimates are described in the next subsection.

(a) 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 presented in the CODA final report for surveys off northwest Spain in 2007 (Anonymous 2009; Macleod et al. 2009) to estimate how many animals could be exposed during the proposed survey. The density reported for "unidentified large whale" was allocated to the humpback whale, and the density for beaked whales was allocated to Cuvier's beaked whale, as this was the most numerous species of beaked whale sighted during surveys off northwest Spain (see Basto d'Anstrade 2008). Except for beaked whales and bottlenose dolphins, all reported densities were corrected for trackline detection probability [*f*(0)] and availability [*g*(0)] biases by the authors of the CODA report. We chose not to correct the other densities, as *f*(0) and *g*(0) are specific to the location and cetacean habitat. Although there is some uncertainty about the representativeness of the data and the assumptions used in the calculations below, the approach used here is believed to be the best available approach.

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 4 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 4. 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.

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 turns, 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.

Furthermore, as summarized in "Summary of Potential Airgun Effects", above, and the PEIS, delphinids seem to be less responsive to airgun sounds than are some mysticetes. 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. A ≥170 dB re 1 μPa disturbance criterion (rather than ≥160 dB) is considered appropriate for delphinids (and pinnipeds), which tend to be less responsive than the more responsive cetaceans. The estimates of "takes by harassment" of delphinids given below are thus considered precautionary.

TABLE 4. Densities and estimates of the possible numbers of individuals that could be exposed to ≥160 dB re 1 μPa_{rms} during L-DEO's proposed seismic survey in the Deep Galicia Basin west of Spain during June–July 2013. The proposed sound source consists of an 18-airgun array with a total discharge volume of ~3300 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 ($\#/km^2$) MacLeod et al. (2009)[1]	Correction Factor[2]	Estimated Density ($\#/km^2$)	Ensonified Area (km^2)	Calculated Take[3]	% of Regional Pop'n[4]	Requested Level B Take Authorization
Mysticetes							
North Atlantic right whale	*0*		*0*	8046	*0*	*0*	*0*
Humpback whale	*0.001*		*0.001*	8046	*8*	*0.07*	*8*
Minke whale	0		0	8046	0	<0.01	3[5]
Sei whale	*0.002*		*0.002*	8046	*16*	*0.13*	*16*
Fin whale	*0.019*		*0.019*	8046	*153*	*0.61*	*153*
Blue whale	*0*		*0*	8046	*0*	*0.21*	*2*[5]
Odontocetes							
Sperm whale	*0.003*		*0.003*	8046	*24*	*0.18*	*24*
Pygmy/dwarf sperm whale	0		0	8046	0	<0.01	0
Northern bottlenose whale	0		0	8046	0	0.01	4[5]
Cuvier's beaked whale	0.004		0.004	8046	32	0.46	32
Mesoplodon spp[6].	0		0	8046	0	0.10	7[5]
Bottlenose dolphin	0.005		0.005	8046	40	0.21	40
Atlantic spotted dolphin	0		0	8046	0	<0.01	0
Striped dolphin	0.047		0.047	8046	378	0.56	378
Short-beaked common dolphin	0.077		0.077	8046	620	0.53	620
Risso's dolphin	0		0	8046	0	0.02	4[5]
Pygmy killer whale	0		0	8046	0	N/A	0
False killer whale	0		0	8046	0	N/A	10[5]
Killer whale	0		0	8046	0	N/A	5[5]
Long-finned pilot whale	0.001		0.001	8046	8	<0.01	8
Short-finned pilot whale	0		0	8046	0	<0.01	5[5]

[1] Densities from MacLeod et al. 2009 were corrected for *f*(0) and *g*(0) by the authors, except for bottlenose dolphin and beaked whales; there is only one density estimate, so no minimum, mean, or maximum density is given

[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 regional populations in the North Atlantic (Table 3); N/A means not available

[5] Requested take authorization was increased to group size for species for which densities were not available but that have been sighted near the proposed survey area

[6] May include True's, Gervais', Sowerby's, and Blainville's beaked whales

(b) 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 8.2 x the area excluding overlap, so a marine mammal that stayed in the survey area during the entire survey could be exposed ~8 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, ~6437 km^2 (~8046 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 R/V *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 1279 (Table 4). That total includes 201 cetaceans listed as ***Endangered*** under the ESA, including 153 fin whales (0.61%), 24 sperm whales (0.18%), 16 sei whales (0.13% of the regional population), and 8 humpback whales (0.07%).

In addition, 32 beaked whales (particularly Cuvier's beaked whale) could be exposed during the survey (Table 4). Most (82%) of the cetaceans potentially exposed are delphinids; the short-beaked common dolphin, striped dolphin, and bottlenose dolphin are estimated to be the most common delphinid species in the area, with estimates of 620 (0.53% of the regional population), 378 (0.56%), and 40 (0.21%) exposed to ≥160 dB re 1 μPa_{rms}, respectively.

(4) Conclusions for Marine Mammals and Sea Turtles

The proposed seismic project would involve towing an 18-airgun array with a total discharge volume of 3300 in^3 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".

(a) 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 North Atlantic QAA; that Level A effects were highly unlikely; and that operations were unlikely to adversely affect ESA-listed species.

In this EA, estimates of the numbers of marine mammals that could be exposed to airgun sounds during the proposed program have been presented, together with the requested "take authorization". The estimated numbers of animals potentially exposed to sound levels sufficient to cause appreciable disturbance are very low percentages of the regional population sizes (Table 4). 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.

(b) 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.

(5) 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. 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, fisheries, and associated EFH. Furthermore, there are no ESA-listed fish species or EFH in the deep, offshore waters of the survey area.

Two deployments of OBH/S instruments would be made: 25 instruments for the 2-D survey, and 78 instruments for the 3-D survey. All OBH/Ss would be recovered after the proposed surveys. The OBH/S anchors are either 82.5-kg, 3-legged concrete ballast weights that have a footprint of 0.7×0.7 m or 40–70 kg pieces of railway track with a footprint of 1.2×1.2 m. OBH/S anchors would be left behind upon equipment recovery. Although OBH/S placement would disrupt a very small area of seafloor habitat and could disturb benthic invertebrates, the impacts are expected to be localized and transitory. There are no HAPCs in the deep, offshore waters of the survey area.

Given the proposed activities, no significant impacts on marine invertebrates, marine fish, and their fisheries would be anticipated.

(6) 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.

(7) 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.

(8) 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).

(a) Past and future research activities in the area

There have been a series of 2-D seismic experiments in the Deep Galicia Basin and nearby areas. Groupe Galice acquired ~1700 km of 2-D multichannel seismic data in 1975 in the Deep Galicia Basin and over the region. These data provided high quality data for the area. The Iberia Seismic Experiment (ISE) took place in 1997 and acquired ~4000 km of multichannel seismic data in the Deep Galicia Basin and the margin to the east and south. These data contributed significantly to the siting of the proposed 3-D seismic experiment.

The Deep Sea Drilling Project (DSDP) Leg 47, in 1979, drilled one site to the southeast of the Deep Galicia Basin, providing important regional stratigraphic information. There was also one Ocean Drilling Program (ODP) drilling expedition in the Deep Galicia Basin. ODP Leg 103, in 1985, drilled at five sites in the Deep Galicia Basin and areas immediately to the east. This leg provided key information for developing models of magma-poor rifted margins. There have been two other ODP legs, Leg 149 (1993) and Leg 173 (1997), that drilled in the Iberia Abyssal Plain, to the south of the Galicia.

As part of the Integrated Ocean Drilling Program (IODP), the riserless drilling vessel *JOIDES Resolution* conducted scientific research at several drill sites off the southwestern Iberian Peninsula during 16 November 2011–16 January 2012. Other scientific research activities may be conducted in this region in the future; however, no other marine geophysical surveys are proposed in the region 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 June–July 2013 timeframe, but research activities planned by other entities are possible, although unlikely.

(b) Vessel noise and collisions

Vessel traffic in and near the proposed survey area would consist mainly of commercial vessels, and possibly commercial fishing vessels. Major trans-Atlantic shipping lanes from Europe to South America pass just to the east of the survey area. Based on the data available through the Automated Mutual-Assistance Vessel Rescue (AMVER) system managed by the U.S. Coast Guard, up to 49 commercial vessels per month passed near the proposed survey area from 2007 to early 2011, but since April 2011, vessel traffic near the survey area seems to have decreased to 5–14 vessels per month (USCG 2012).

The total transit distance (~9000 km) by L-DEO's vessel *Langseth* and the support vessel *Poseidon* would be minimal relative to total transit length for vessels operating in the proposed survey area during

June and July. Thus, the combination of L-DEO's operations with the existing shipping operations is expected to produce only a negligible increase in overall ship disturbance effects on marine mammals.

(c) Fisheries

The commercial fisheries in the general area of the proposed survey are described in § III. The primary contributions of fishing to potential cumulative impacts on marine mammals and sea turtles involve direct removal of prey items, noise, potential entanglement (Reeves et al. 2003), and the direct and indirect removal of prey items. In the coastal waters of northwest Spain, delphinids in particular common dolphins, bottlenose dolphins, and long-finned pilot whales are taken as bycatch during fishing operations (e.g., López et al. 2002, 2003; Fernández-Contreras et al. 2009); turtles are also taken as bycatch off the southwestern Iberian Peninsula (e.g., Wallace et al. 2010). However, fishing operations in the proposed survey area likely would be limited because of the deep water and distance from land. 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 fishing operations is expected to produce only a negligible increase in overall disturbance effects on marine mammals and sea turtles. Operation of the *Langseth* and *Poseidon* would not be expected to significantly impact commercial fishing operations in the area.

(9) Unavoidable Impacts

Unavoidable impacts to the species of marine mammals and turtles 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, is a temporary phenomenon that does not involve injury, and is unlikely to have long term consequences for the few individuals involved. No long-term or significant impacts would be expected on any of these individual marine mammals or turtles, or on the populations to which they belong. Effects on recruitment or survival would be expected to be (at most) negligible.

(10) Coordination with Other Agencies and Processes

This EA was prepared by LGL on behalf of L-DEO and NSF pursuant to Executive Order 12114. Potential impacts to endangered species and critical habitat have also been assessed in the document; therefore, it will be used to support the ESA Section 7 consultation process with NMFS and USFWS. This document will also be used as supporting documentation for an IHA application submitted by L-DEO to NMFS, under the U.S. MMPA, for "taking by harassment" (disturbance) of small numbers of marine mammals, for this proposed seismic project.

L-DEO and NSF would coordinate the planned marine mammal monitoring program associated with the seismic survey with any parties that express interest in this survey activity. L-DEO and NSF have coordinated, and will continue to coordinate, with other applicable Federal agencies as required, and will comply with their requirements. On behalf of L-DEO, the U.S. State Department will seek authorization from Spain for clearance to work in its EEZ.

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 (~39 days in June–July) are the dates when the personnel and equipment essential to meet the overall project objectives are available.

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

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 rifted continental to oceanic crust transition in the Deep Galicia Basin west of Spain would also be lost and greater understanding of Earth processes would not be gained. The no Action Alternative would not meet the purpose and need for the proposed activities.

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VI. LITERATURE CITED

Abollo, E., A. López, C. Gestal, P. Benavente, and S. Pascual. 1998. Long-term recording of gastric ulcers in cetaceans stranded on the Galician (NW Spain) coast. **Diseases Aquat. Organ.** 32:71-72.

Aguilar, A. 1981. The black right whale, *Eubalaena glacialis*, in the Cantabrian Sea. **Rep. Int. Whal. Comm.** 31:457-459.

Anonymous. 2009. Cetacean offshore distribution and abundance in the European Atlantic (CODA). Unpubl. rep. to the European Commission. 42 p. + Annexes. Accessed on 26 November 2012 at http://biology.st-andrews.ac.uk/coda/documents/CODA_Final_Report_11-2-09.pdf.

Antochiw, D., A. Dubuque, S. Milne, D. Palacios, and M. Piercy. n.d. Marine mammal and sea turtle monitoring report for the Costa Rica 3D seismic survey (Bangs Crisp Project) in the Pacific Ocean offshore Costa Rica, 7 April 2011–12 May 2011, R/V *Marcus G. Langseth*. Rep. from RPS, Houston, TX, for Lamont-Doherty Earth Observatory of Columbia Univ., Palisades, NY, and Nat. Mar. Fish. Serv., Silver Spring, MD. 45 p. + app.

Basto d'Andrade, M.I.L. 2008. Spatial distribution of cetaceans in the Bay of Biscay and implications of the Marine Strategy Directive for their conservation. M.Sc. thesis, Universidade de Lisboa, Lisbon. 69 p.

Bolten, A.B., H.R. Martins, K.A. Bjorndal and J. Gordon. 1993. Size distribution of pelagic-stage loggerhead sea turtles (*Caretta caretta*) in the waters around the Azores and Madeira. **Arquipélago Life Mar. Sci.** 11A:49-54.

Brito, C., N. Vieira, E. Sá, and I. Carvalho. 2009. Cetaceans' occurrence off the west central Portugal coast: a compilation of data from whaling, observations of opportunity and boat-based surveys. **JMATE** 2:10-13. Accessed in August 2011 at http://www.oers.ca/journal/Volume%202/200921brinto.pdf.

Brown, S.G. 1986. Twentieth-century records of right whales (*Eubalaena glacialis*) in the northeast Atlantic Ocean. **Rep. Int. Whal. Comm. Spec. Iss.** 10:121-127.

Cañadas, A., M.L. Burt, K. Macleod, E. Rogan, B. Santos, J.A. Vázquez, and P.S. Hammond. 2009. Appendix II: Model-based estimates of cetacean abundance in offshore European Atlantic waters. Unpubl. rep. for the European Commission. Accessed at http://biology.st-andrews.ac.uk/coda/documents/CODA_Appendix_II_model-based_estimates.pdf on 26 November 2012,

Casinos, A. and J.-R. Vericad. 1976. The cetaceans of the Spanish coasts: a survey. **Mammalia** 40(2):267-290.

Castro, J., S. Magalhaes, P. Verborgh, and R. de Stephanis. 2010. First survey of cetaceans in the south of Portugal. 24th Ann. Meet. Europ. Cetac. Soc., Stralsund, Germany 22–24 March 2010.

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

Certain, G., V. Ridoux, O. van Canneyt, and V. Bretagnolle. 2008. Delphinid spatial distribution and abundance estimates over the shelf of the Bay of Biscay. **ICES J. Mar. Sci.** 65:656-666.

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

College of the Atlantic, Allied Whale. 2004. Allied Humpback Whale Catalogue, 1976–2003. OBIS. Retrieved 2012-11-27 from http://www.iobis.org.

Culik, B.M. 2010. Odontocetes: the toothed whales: distribution, behaviour, migration, and threats. *Globicephala melas* (Traill, 1809). UNEP/CMS Secretariat, Bonn, Germany. Accessed on 29 October 2012 at http://www.cms.int/reports/small_cetaceans/data/G_melas/g_melas.htm.

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

del Hoyo, J., A. Elliot, and J. Sargatal (eds.). 1996. Handbook of the birds of the world, Vol. 3: Hoatzin to auks. Lynx Edicions, Barcelona, Spain. 821 p.

Doyle, T.K., J.D.R. Houghton, P.F. O'Súilleabháin, V.J. Hobson, F. Marnell, J. Davenport, and G.C. Hays. 2008. Leatherback turtles satellite-tagged in European waters. **Endang. Spec. Res.** 4:23-31.

Duguy, R., P. Moriniere, and C. Le Milinaire. 1998. Factors of mortality of marine turtles in the Bay of Biscay. **Oceanolog. Acta** 21(2):383-388.

Eckert, S.A. 2006. High-use oceanic areas for Atlantic leatherback sea turtles (*Dermochelys coriacea*) as identified using satellite telemetered location and dive information. **Mar. Biol.** 149:1257-1267.

ECOS (U.S. Fish and Wildlife Service Environmental Conservation Online System). 2012. Species report–listed animals. Accessed on 1 November 2012 at http://ecos.fws.gov/tess_public/pub/listedAnimals.jsp.

FAO (Food and Agriculture Organization of the United Nations). 2012. Fisheries and Aquaculture Department. FAO Major Fishing Areas: Atlantic, Northeast (Major Fishing Area 27). Accessed on 3 December 2012 at http://www.fao.org/fishery/area/Area27/en.

Faustino, C. 2000. Cetacean distribution in the Portuguese continental coast (in Portuguese). University of Algarve, 69. Retrieved 2012-11-28 from http://www.iobis.org.

Fernández-Contreras, M.M., L. Cardona, C.H. Lockyer, and A. Aguilar. 2009. Incidental by-catch of short-beaked common dolphins (*Delphinus delphis*) in the pair trawler fishery off north-western Spain. Working pap. SC/61/SM30. Int. Whal. Comm., Cambridge, U.K.

Gochfeld M., J. Burger, and I.C.T. Nisbet. 1998. Roseate tern (*Sterna dougallii*). *In:* A. Poole and F. Gill (eds.), The Birds of North America, No. 370. The Birds of North America, Inc., Philadelphia, PA.

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

Greene, C.R., Jr. 1997. Physical acoustics measurements. p. 3-1 to 3-63 *In*: W.J. Richardson (ed.), Northstar marine mammal monitoring program, 1996: marine mammal and acoustical monitoring of a seismic program in the Alaskan Beaufort Sea. LGL Rep. 2121-2. Rep. from LGL Ltd., King City, Ont., and Greeneridge Sciences Inc., Santa Barbara, CA, for BP Explor. (Alaska) Inc., Anchorage, AK, and Nat. Mar. Fish. Serv., Anchorage, AK, and Silver Spring, MD. 245 p.

Hauser, D.D.W., M. Holst, and V.D. Moulton. 2008. Marine mammal and sea turtle monitoring during Lamont-Doherty Earth Observatory's marine seismic program in the Eastern Tropical Pacific, April–August 2008. LGL Rep. TA4656/7-1. Rep. from LGL Ltd., King City, Ont., and St. John's, Nfld., for Lamont-Doherty Earth Observatory of Columbia Univ., Palisades, NY, and Nat. Mar. Fish. Serv., Silver Spring, MD. 98 p.

Hays, G.C., V.J. Hobson, J.D. Metcalfe, D. Righton, and D.W. Sims. 2006. Flexible foraging movements of leatherback turtles across the North Atlantic Ocean. **Ecology** 87(10):2647-2656.

Hemery, G., F. D'Amico, I. Castege, B. Dupont, J. D'Elbee, Y. Lalanne, and C. Mouches. 2008. Detecting the impact of oceano-climatic changes on marine ecosystems using a multivariate index: the case of the Bay of Biscay (North Atlantic-European Ocean). **Global Change Biol.** 14:27-38.

Holst, M. 2009. Marine mammal and sea turtle monitoring during Lamont-Doherty Earth Observatory's TAIGER marine seismic program near Taiwan, April–July 2009. LGL Rep. TA4553-4. Rep. from LGL Ltd., King City, Ont. for Lamont-Doherty Earth Observatory of Columbia Univ., Palisades, NY, and Nat. Mar. Fish. Serv., Silver Spring, MD. 103 p.

Holst, M. and J. Beland. 2008. Marine mammal and sea turtle monitoring during Lamont-Doherty Earth Observatory's seismic testing and calibration study in the northern Gulf of Mexico, November 2007–February 2008. LGL Rep. TA4295-2. Rep. from LGL Ltd., King City, Ont., for Lamont-Doherty Earth Observatory of Columbia Univ., Palisades, NY, and Nat. Mar. Fish. Serv., Silver Spring, MD. 77 p.

Holst, M. and M.A. Smultea. 2008. Marine mammal and sea turtle monitoring during Lamont-Doherty Earth Observatory's marine seismic program off Central America, February–April 2008. LGL Rep. TA4342-3. Rep. from LGL Ltd., King City, Ont., for Lamont-Doherty Earth Observatory of Columbia Univ., Palisades, NY, and Nat. Mar. Fish. Serv., Silver Spring, MD. 133 p.

Holst, M., M.A. Smultea, W.R. Koski, and B. Haley. 2005a. Marine mammal and sea turtle monitoring during Lamont-Doherty Earth Observatory's marine seismic program in the eastern tropical Pacific Ocean off Central America, November–December 2004. LGL Rep. TA2822-30. Rep. from LGL Ltd., King City, Ont., for Lamont-Doherty Earth Observatory of Columbia Univ., Palisades, NY, and Nat. Mar. Fish. Serv., Silver Spring, MD. 125 p.

Holst, M., M.A. Smultea, W.R. Koski, and B. Haley. 2005b. Marine mammal and sea turtle monitoring during Lamont-Doherty Earth Observatory's marine seismic program off the northern Yucatán Peninsula in the southern Gulf of Mexico, January–February 2005. LGL Rep. TA2822-31. Rep. from LGL Ltd., King City, Ont., for Lamont-Doherty Earth Observatory of Columbia Univ., Palisades, NY, and Nat. Mar. Fish. Serv., Silver Spring, MD. 96 p.

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

ICES (International Council for the Exploration of the Sea). 2012. Catch statistics. Accessed on 3 December 2012 at http://www.ices.dk/fish/CATChSTATISTICS.asp.

IOC (Intergovernmental Oceanographic Commission of UNESCO). 2012. The Ocean Biogeographic Information System. Web. http://www.iobis.org. Consulted on 26/10/2012.

IUCN (The World Conservation Union). 2012. IUCN Red List of Threatened Species, Version 2012.2. Accessed on 1 November 2012 at http://www.iucnredlist.org.

IWC (International Whaling Commission). 2012. Whale population estimates–The International Whaling Commission's most recent information on estimated abundance. Accessed on 1 November 2012 at http://iwcoffice.org/estimate.

Jann, B., J. Allen, M. Carrillo, S. Hanquet, S.K. Katona, A.R. Martin, R.R. Reeves, R. Seton, P.T. Stevick, and F.W. Wenzel. 2003. Migration of a humpback whale (*Megaptera novaeangliae*) between the Cape Verde Islands and Iceland. **J. Cetac. Res. Manage.** 5:125-129.

Jefferson, T.A., M.A. Webber, and R.L. Pitman. 2008. Marine mammals of the world—A comprehensive guide to their identification. Elsevier, Academic Press, Amsterdam, Netherlands. 573 p.

Johnson, T., K. Nygaard, and F. Olsgard. n.d. The North-east Atlantic Ocean – huge, deep and heavily exploited. In: European Environmental Agency, Europe's biodiversity – biogeographical regions and seas. 21 p. Accessed on 16 December 2012 at http://edz.bib.uni-mannheim.de/daten/edz-bn/eua/02/C__DOKUME~1_ZEFZEI_LOKALE~1_TEMP_plugtmp_nea_ocean.pdf.

Kiszka, J., K. Macleod, O., Van Canneyt, D. Walker, and V. Ridoux. 2007. Distribution, encounter rates, and habitat characteristics of toothed cetaceans in the Bay of Biscay and adjacent waters from platform-of-opportunity data. **ICES J. Mar. Sci**. 64:1033-1043.

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

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

Lens, S. 1991. North Atlantic sightings survey 1989: report of the Spanish cruise. **Rep. Int. Whal. Comm.** 41:539-543.

Lens, S., J. Pantoja, J.A. Vázquez, and E. Urquiola. 2005. Spain progress report on cetacean research, May 2004 to April 2005 with statistical data for the calendar year 2004. Working pap. SC/57. Int. Whal. Comm., Cambridge, U.K.

Longhurst, A.R. 2007. Ecological geography of the sea, 2nd ed. Academic Press, Elsevier Inc., San Diego. 542 p.

López, A., M.B. Santos, G.J. Pierce, A.F. González, X. Valeiras, and A. Guerra. 2002. Trends in strandings and by-catch of marine mammals in north-west Spain during the 1990s. **J. Mar. Biol. Ass. U.K.** 82:513-521.

López, A., G.J. Pierce, M.B. Santos, J. Gracia, and A. Guerra. 2003. Fishery by-catches of marine mammals in Galician waters: results from on-board observations and interview survey of fishermen. **Biol. Conserv.** 111:25-40.

López, A., G.J. Pierce, X. Valeiras, M.B. Santos, and A. Guerra. 2004. Distribution patterns of small cetaceans in Galician waters. **J. Mar. Biol. Ass. U.K.** 84:283-294.

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

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

Macleod, K., M.L. Burt, A. Cañadas, E. Rogan, B. Santos, A. Uriarte, O. Van Canneyt, J.A. Vázquez, and P.S. Hammond. 2009. Appendix I: Design-based estimates of cetacean abundance in offshore European Atlantic waters. Unpubl. rep. to the European Commission presented to the IWC Scientific Committee. Accessed at http://biology.st-andrews.ac.uk/coda/documents/CODA_Appendix_I_design-based_estimates.pdf in November 2012.

Martin, A.R. and F.J. Walker. 1997. Sighting of a right whale (*Eubalaena glacialis*) with calf off S.W. Portugal. **Mar. Mamm. Sci.** 13(1):139-140.

Maughan, B. 2003. United Kingdom Royal Navy cetacean sightings. United Kingdom Hydrographic Office. Taunton, Somerset, U.K. Retrieved 2012-10-23 from http://www.iobis.org.

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

McCauley, R.D., J. Fewtrell, A.J. Duncan, C. Jenner, M.-N. Jenner, J.D. Penrose, R.I.T. Prince, A. Adhitya, J. Murdoch, and K. McCabe. 2000. Marine seismic surveys: analysis of airgun signals; and effects of air gun exposure on humpback whales, sea turtles, fishes and squid. Rep. from Centre for Marine Science and Technology, Curtin Univ., Perth, W.A., for Austral. Petrol. Prod. Assoc., Sydney, N.S.W. 188 p.

Mead, J.G. 1989. Beaked whales of the genus *Mesoplodon*. p. 349-430 *In*: S.H. Ridgway and R.J. Harrison (eds.), Handbook of marine mammals, Vol. 4: River dolphins and the larger toothed whales. Academic Press, San Diego, CA. 444 p.

Mellinger, D.K., S.L. Nieukirk, K. Klinck, H. Klinck, R.P. Dziak, P.J. Clapham, and B. Brandsdóttir. 2011. Confirmation of right whales near a nineteenth-century whaling ground east of southern Greenland. **Biol. Lett.** 7:411-413.

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

NAMMCO (North Atlantic Marine Mammal Commission). 1995. Report of the joint meeting of the Scientific Committee working groups on northern bottlenose and killer whales and management procedures. p. 89-99 *In*: NAMMCO Annual Report 1995, NAMMCO, Tromsø, Norway.

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

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

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

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

Pierce, G.J., M. Caldas, J. Cedeira, M. Begoña Santos, Á. Llavona, P. Covelo, G. Martinez, J. Torres, M. Sacau, and A. López. 2010. Trends in cetacean sightings along the Galician coast, north-west Spain, 2003–2007, and inferences about cetacean habitat preferences. **J. Mar. Biol. Ass. U.K.** 90(8):1547-1560.

Pierpoint, C. 2000. Bycatch of marine turtles in UK and Irish waters. JNCC Report No. 310. 32 p.

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

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

Read, A.J., P.N. Halpin, L.B. Crowder, B.D. Best, and E. Fujioka (eds.). 2009. OBIS-SEAMAP: Mapping marine mammals, birds and turtles. World Wide Web electronic publication. Accessed on 20 September 2011 at http://seamap.env.duke.edu.

Reeves, R.R., B.S. Stewart, P.J. Clapham, and J.A. Powell. 2002. Guide to marine mammals of the world. Chanticleer Press, New York, NY. 527 p.

Reeves, R.R., B.D. Smith, E. Crespo, G. Notarbartolo di Sciara and the Cetacean Specialist Group. 2003. Dolphins, whales, and porpoises: 2003–2010 conservation action plan for the world's cetaceans. IUCN Species Survival Commission, Gland, Switzerland.

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

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

Sanpera C, and A. Aguilar. 1992. Modern whaling off the Iberian Peninsula during the 20th century. **Rep. Int. Whal. Comm.** 42: 723–730.

Santos, M.B., G.J. Pierce, A. López, R.J. Reid, V. Ridoux, and E. Mente. 2006. Pygmy sperm whales *Kogia breviceps* in the Northeast Atlantic: new information on stomach contents and strandings. **Mar. Mamm. Sci.** 22(3):600–616.

Sea Around Us Project. 2012. Fisheries, ecosystems, and biodiversity. EEZ waters Portugal. Accessed on 3 December 2012 at http://www.seaaroundus.org/eez/620.aspx.

Silva, M.A., L. Steiner, I. Cascão, M.J. Cruz, R. Prieto, T. Cole, P.K. Hamilton, and M. Baumgartner. 2012. Winter sighting of a known western North Atlantic right whale in the Azores. **J. Cetac. Res. Manage.** 12(1):65-69.

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

Skov, H., T. Gunnlaugsson, W.P. Budgell, J. Horne, L. Nøttestad, E. Olsen, H. Søiland, G. Víkingsson, and G. Waring. 2008. Small-scale spatial variability of sperm and sei whales in relation to oceanographic and topographic features along the Mid-Atlantic Ridge. **Deep-sea Res. II** 55:254-268. Retrieved 2012-10-23 from http://www.iobis.org.

Smith, T.D. (ed.). 2002. World whaling database: individual whale catches, North Atlantic. *In*: M.G Barnard and J.H. Nicholls (comp.), HMAP Database (www.hull.ac.uk/history/MHSC/hmap12.htm). Retrieved 2012-10-23 from http://www.iobis.org.

Smultea, M.A., M. Holst, W.R. Koski, and S. Stoltz. 2004. Marine mammal monitoring during Lamont-Doherty Earth Observatory's seismic program in the southeast Caribbean Sea and adjacent Atlantic Ocean, April–June 2004. LGL Rep. TA2822-26. Rep. from LGL Ltd., King City, Ont., for Lamont-Doherty Earth Observatory of Columbia Univ., Palisades, NY, and Nat. Mar. Fish. Serv., Silver Spring, MD. 106 p.

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

Spitz, J., Y. Cherel, S. Bertin, J. Kiszka, A. Dewez, and V. Ridoux. 2011. Prey preferences among the community of deep-diving odontocetes from the Bay of Biscay, Northeast Atlantic. **Deep-Sea Res. I.** 58:273-282.

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

Spyrakos, E., T.C. Santos-Diniz, G. Martinez-Iglesias, J.M. Torres-Palenzuela, and G.J. Pierce. 2011. Spatiotemporal patterns of marine mammal distribution in coastal waters of Galicia, NW Spain. **Hydrobiologia** 670:87-109.

Stevick, P.T., J. Allen, P.J. Clapham, N. Friday, S.K. Katona, F. Larsen, J. Lien, D.K. Mattila, P.J. Palsbøll, J. Sigurjónsson, T.D. Smith, N. Øien, and P.S. Hammond. 2003. North Atlantic humpback whale abundance and rate of increase four decades after protection from whaling. **Mar. Ecol. Prog. Ser.** 258:263-273.

Swift, R.J., D. Gillespie, J.A. Vázquez, K. Macleod, and P.S. Hammond. 2009. Appendix IV: Abundance of sperm whales (*Physeter macrocephalus*) estimated from acoustic data for Blocks 2, 3 and 4 (French and Spanish sectors). Unpubl. rep. to the European Commission. Retrieved 2012-11-26 from http://biology.st-andrews.ac.uk/coda/documents/CODA_Appendix_IV_Acoustic_sperm_whale_estimates.pdf.

Taylor, B.L., R. Baird, J. Barlow, S.M. Dawson, J. Ford, J.G. Mead, G. Notarbartolo di Sciara, P. Wade, and R.L. Pitman. 2008. *Ziphius cavirostris*. *In*: IUCN 2012. IUCN Red List of Threatened Species, Version 2012.2. Accessed on 5 December 2012 at http://www.iucnredlist.org/details/23211/0

Tolstoy, M., J. Diebold, L. Doermann, S. Nooner, S.C. Webb, D.R. Bohenstiehl, T.J. Crone, and R.C. Holmes. 2009. Broadband calibration of R/V *Marcus G. Langseth* four-string seismic sources. **Geochem. Geophys. Geosyst.** 10, Q08011, doi:10.1029/2009GC002451.

UNEP-WCMC (United Nations Environment Programme-World Conservation Monitoring Centre). 2012. Convention on International Trade in Endangered Species of Wild Flora and Fauna. Appendices I, II, and II. Valid from 25 September 2012. Accessed on 1 November 2012 at http://www.cites.org/eng/app/2012/E-2012-09-25.pdf.

USFWS (U.S. Fish and Wildlife Service). 2012. U.S. Fish and Wildlife Service species profile: roseate tern (*Sterna dougallii dougallii*). Environmental Conservation Online System. Accessed on 31 October 2012 at http://ecos.fws.gov/speciesProfile/profile/speciesProfile.action?spcode=B07O.

USCG (United States Coast Guard). 2012. AMVER density plot display. USCG. Available at http://www.amver.com/density.asp.

Varty, N. and K. Tanner. 2009. Background document for roseate tern *Sterna dougallii*. OSPAR Commission. 29 p. Accessed at http://qsr2010.ospar.org/media/assessments/Species/P00415_roseate_tern.pdf 31/10/2012 in November 2012.

Víkingsson, G.A., D.G. Pike, G. Desportes, N. Øien, Th. Gunnlaugsson, and D. Bloch. 2009. Distribution and abundance of fin whales (*Balaenoptera physalus*) in the northeast and central Atlantic as inferred from the North Atlantic sightings surveys 1987–2001. **NAMMCO Sci. Publ**. 7:49-72.

Wallace, B.P., R.L. Lewison, S.L. McDonald, R.K. McDonald, C.Y. Kot, S. Kelez, R.K. Bjorkland, E.M. Finkbeiner, S. Helmbrecht, and L.B. Crowder. 2010. Global patterns of marine turtle bycatch. **Conserv. Lett.** 3:131-142.

Waring, G.T., E. Josephson, K. Maze-Foley, and P.E. Rosel (eds.). 2012. U.S. Atlantic and Gulf of Mexico marine mammal stock assessments–2011. NOAA Tech. Memo. NMFS-NE-221. Nat. Mar. Fish. Serv., Northeast Fish. Sci. Center, Woods Hole, MA. 319 p.

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

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

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

Wenzel, F.W., J. Allen, S. Berrow, C.J. Hazevoet, B. Jann, R.E. Seton, L. Steiner, P. Stevick, P. López Suárez, and P. Whooley. 2009. Current knowledge on the distribution and relative abundance of humpback whales (*Megaptera novaeangliae*) off the Cape Verde Islands, eastern North Atlantic. **Aquatic Mamm.** 35(4):502-510.

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

Williams, A.D., R. Williams, and T. Brereton. 2002. The sighting of pygmy killer whales (*Feresa attenuata*) in the southern Bay of Biscay and their association with cetacean calves. **J. Mar. Biol. Ass. U.K.** 82:509-511.