

## **APPENDIX A: Incidental Harassment Authorization**



UNITED STATES DEPARTMENT OF COMMERCE  
National Oceanic and Atmospheric Administration  
NATIONAL MARINE FISHERIES SERVICE  
Silver Spring, MD 20910

SEP 12 2014

Sean Higgins  
Marine Environmental & Safety Coordinator  
Department of Marine Operations  
Lamont-Doherty Earth Observatory  
P.O. Box 1000  
Palisades, New York 10964-8000

Dear Mr. Higgins:

Enclosed is an Incidental Harassment Authorization (Authorization) issued to the Lamont-Doherty Earth Observatory, under the authority of Section 101(a)(5)(D) of the Marine Mammal Protection Act (16 U.S.C. 1361 *et seq.*), to harass small numbers of marine mammals, by Level B harassment, incidental to the R/V *Marcus G. Langseth's* marine seismic survey in the Atlantic Ocean during September through October, 2014.

You are required to comply with the conditions contained in the Authorization. Lamont-Doherty must report the taking of any marine mammal, in a manner prohibited under this Authorization, to the Office of Protected Resources, National Marine Fisheries Service (NMFS), at 301-427-8401.

In addition, Lamont-Doherty must submit a report to the NMFS' Office of Protected Resources within 90 days after completing the survey. The Authorization requires monitoring of marine mammals by qualified individuals before, during, and after seismic activities and reporting of marine mammal observations, including species, numbers, and behavioral modifications potentially resulting from this activity.

If you have any questions concerning the Authorization or its requirements, please contact Jeannine Cody, Office of Protected Resources, NMFS, at 301-427-8401.

Sincerely,

Donna S. Wieting  
Director  
Office of Protected Resources

Enclosures



## INCIDENTAL HARASSMENT AUTHORIZATION

We hereby authorize the Lamont- Doherty Earth Observatory (Lamont- Doherty), Columbia University, P.O. Box 1000, 61 Route 9W, Palisades, New York 10964-8000, under section 101(a)(5)(D) of the Marine Mammal Protection Act (MMPA) (16 U.S.C. 1371(a)(5)(D)) and 50 CFR 216.107, to incidentally harass small numbers of marine mammals incidental to a marine geophysical survey conducted by the R/V *Marcus G. Langseth* (*Langseth*) marine geophysical survey in the Atlantic Ocean offshore Cape Hatteras, NC September through October, 2014.

### 1. Effective Dates

This Authorization is valid from September 15, 2014 through October 31, 2014.

### 2. Specified Geographic Region

This Authorization is valid only for specified activities associated with the *Langseth's* seismic operations as specified in Lamont-Doherty's Incidental Harassment Authorization (Authorization) application and environmental analysis in the following specified geographic area:

- a. In the Atlantic Ocean bounded by the following coordinates: in the Atlantic Ocean, approximately 17 to 422 kilometers (km) (10 to 262 miles (mi)) off the coast off Cape Hatteras, NC between approximately 32-37° N and approximately 71.5-77° W, as specified in Lamont-Doherty's application and the National Science Foundation's Environmental Assessment.

### 3. Species Authorized and Level of Take

- a. This Authorization limits the incidental taking of marine mammals, by Level B harassment only, to the species listed in Table 1 in the area described in Condition 2(a):
  - i. During the seismic activities, if the Holder of this Authorization encounters any marine mammal species that are not listed in Condition 3 for authorized taking and are likely to be exposed to sound pressure levels greater than or equal to 160 decibels (dB) re: 1  $\mu$ Pa, then the Holder must alter speed or course or shut-down the airguns to avoid take.
- b. This Authorization prohibits the taking by injury (Level A harassment), serious injury, or death of any of the species listed in Condition 3 or the taking of any kind of any other species of marine mammal. Thus, it may result in the modification, suspension, or revocation of this Authorization.
- c. This Authorization limits the methods authorized for taking by Level B harassment to the following acoustic sources without an amendment to this Authorization:
  - i. An airgun array with a total capacity of 6,600 cubic inches ( $\text{in}^3$ ) (or smaller).
  - ii. Lamont-Doherty will not operate the multi-beam echosounder, the sub-bottom profiler, or the acoustic Doppler current profiler during transit.

#### 4. Reporting Prohibited Take

The Holder of this Authorization must report the taking of any marine mammal in a manner prohibited under this Authorization immediately to the Office of Protected Resources, National Marine Fisheries Service, at 301–427–8401 and/ or by email to [Jolie.Harrison@noaa.gov](mailto:Jolie.Harrison@noaa.gov) and [ITP.Cody@noaa.gov](mailto:ITP.Cody@noaa.gov).

#### 5. Cooperation

We require the Holder of this Authorization to cooperate with the Office of Protected Resources, National Marine Fisheries Service, and any other Federal, state or local agency monitoring the impacts of the activity on marine mammals.

#### 6. Mitigation and Monitoring Requirements

We require the Holder of this Authorization to implement the following mitigation and monitoring requirements when conducting the specified activities to achieve the least practicable adverse impact on affected marine mammal species or stocks:

##### Visual Observers

- a. Use two, National Marine Fisheries Service-qualified, vessel-based Protected Species Visual Observers (visual observers) to watch for and monitor marine mammals near the seismic source vessel during daytime airgun operations (from civil twilight- dawn to civil twilight-dusk) and before and during start-ups of airguns day or night.
  - i. At least one visual observer will be on watch during meal times and restroom breaks.
  - ii. Observer shifts will last no longer than four hours at a time.
  - iii. Visual observers will also conduct monitoring while the *Langseth* crew deploy and recover the airgun array and streamers from the water.
  - iv. When feasible, visual observers will conduct observations during daytime periods when the seismic system is not operating for comparison of sighting rates and behavioral reactions during, between, and after airgun operations.
  - v. The *Langseth's* vessel crew will also assist in detecting marine mammals, when practicable. Visual observers will have access to reticle binoculars (7×50 Fujinon), and big-eye binoculars (25×150), optical range finders, and night vision devices.

##### Exclusion Zones

- b. **Shallow Water (<=100 m):** Establish a 180-dB and 190-dB exclusion zone (with 3-dB buffer) before starting the airgun subarray (6,600 in<sup>3</sup> or smaller); and a 180-dB and 190-dB exclusion zone (with buffer) for the single airgun (40 in<sup>3</sup>). Observers will use the predicted radius distance for the 180-dB and 190-dB exclusion zones (with buffer) for mitigation shown in Table 2 (attached).

**Intermediate and Deep Water (>100 m):** Establish a 180-dB and 190-dB exclusion zone before starting the airgun subarray (6,600 in<sup>3</sup> or smaller); and a 180-dB and 190-dB exclusion zone for the single airgun (40 in<sup>3</sup>). Observers will use the predicted radius distance for the 180-dB and 190-dB exclusion zones for mitigation shown in Table 2 (attached).

### **Visual Monitoring at the Start of Airgun Operations**

- c. Monitor the entire extent of the relevant exclusion zones for at least 30 minutes (day or night) prior to the ramp-up of airgun operations, including after a shutdown.
- d. Delay airgun operations if the visual observer sees a cetacean within the 180-dB exclusion zone (with buffer as defined in Table 2) in shallow water or within the 180-dB exclusion zone in intermediate or deep water (as defined in Table 2) until the marine mammal(s) has left the area.

Delay airgun operations if the visual observer sees a pinniped within the 190-dB exclusion zone (with buffer as defined in Table 2) in shallow water or within 190-dB exclusion zone in intermediate or deep water (as defined in Table 2) until the marine mammal(s) has left the area.

- i. If the visual observer sees a marine mammal that surfaces, then dives below the surface, the observer shall wait 30 minutes. If the observer sees no marine mammals during that time, he/she should assume that the animal has moved beyond the relevant exclusion zone (as defined in Table 2).
- ii. If, for any reason the visual observer cannot see the full relevant exclusion zone (as defined in Table 2) for the entire 30 minutes (*i.e.*, rough seas, fog, darkness), or if marine mammals are near, approaching, or within zone, the *Langseth* may not resume airgun operations.
- iii. If one airgun is already running at a source level of at least 180 dB re: 1  $\mu$ Pa, the *Langseth* may start the second gun—and subsequent airguns—without observing relevant exclusion zones for 30 minutes, provided that the observers have not seen any marine mammals near the relevant exclusion zones (in accordance with Condition 6(b)).

### **Passive Acoustic Monitoring**

- e. Utilize the passive acoustic monitoring (PAM) system, to the maximum extent practicable, to detect and allow some localization of marine mammals around the *Langseth* during all airgun operations and during most periods when airguns are not operating. One visual observer and/or bioacoustician will monitor the PAM at all times in shifts no longer than 6 hours. A bioacoustician shall design and set up the PAM system and be present to operate or oversee PAM, and available when technical issues occur during the survey.
- f. Do and record the following when an observer detects an animal by the PAM:
  - i. Notify the visual observer immediately of a vocalizing marine mammal so a power-down or shut-down can be initiated, if required;
  - ii. Enter the information regarding the vocalization into a database. The data to be entered include an acoustic encounter identification number, whether it was linked with a visual sighting, date, time when first and last heard and whenever any additional information was recorded, position, and water depth when first detected, bearing if determinable, species or species group (*e.g.*, unidentified dolphin, sperm whale), types and nature of sounds heard (*e.g.*, clicks, continuous, sporadic, whistles, creaks, burst pulses, strength of signal, etc.), and any other notable information.

## **Ramp-Up Procedures**

- g. Implement a “ramp-up” procedure when starting the airguns at the beginning of seismic operations or any time after the entire array has been shutdown for 8 minutes or longer, which means start the smallest gun first and add airguns in a sequence such that the source level of the array will increase in steps not exceeding approximately 6 dB per 5-minute period. During ramp-up, the observers will monitor the exclusion zones, and if the observers sight marine mammals, the *Langseth* will implement a course/speed alteration, power-down, or shutdown as though the full array were operational.

## **Recording Visual Detections**

- h. Visual observers must record the following information when they detect a marine mammal:
  - i. Species, group size, age/size/sex categories (if determinable), behavior when first sighted and after initial sighting, heading (if consistent), bearing and distance from seismic vessel, sighting cue, apparent reaction to the airguns or vessel (*e.g.*, none, avoidance, approach, paralleling, etc., and including responses to ramp-up), and behavioral pace; and
  - ii. Time, location, heading, speed, activity of the vessel (including number of airguns operating and whether in state of ramp-up or shut-down), Beaufort sea state and wind force, visibility, cloud cover, and sun glare; and
  - iii. The data listed under 6(f)(ii) at the start and end of each observation watch and during a watch whenever there is a change in one or more of the variables.

## **Speed or Course Alteration**

- i. Alter speed or course during seismic operations if a marine mammal, based on its position and relative motion, appears likely to enter the relevant exclusion zone. If speed or course alteration is not safe or practicable, or if after alteration the marine mammal still appears likely to enter the relevant exclusion zone, Lamont-Doherty will implement further mitigation measures, such as a power-down or shutdown.

## **Power-Down Procedures**

- j. Power down the airguns if a visual observer detects a marine mammal within, approaching, or entering the relevant exclusion zone (as defined in Table 2). A power-down means reducing the number of operating airguns to a single operating 40 in<sup>3</sup> airgun. This would reduce the relevant exclusion zone to the degree that the animal(s) is/are outside of that zone. When appropriate or possible, power-down of the airgun array shall also occur when the vessel is moving from the end of one trackline to the start of the next trackline. Following a power-down, if the marine mammal approaches the smaller exclusion zone (as defined in Table 2), then the *Langseth* must completely shut down the airguns.

## **Resuming Airgun Operations after a Power-Down**

- k. Airgun activity will not resume until the observer has visually observed the marine mammal(s) exiting the exclusion zone and is not likely to return, or the observer has not seen the animal within the relevant exclusion zone for 15 minutes for species with shorter

dive durations (*i.e.*, small odontocetes); or 30 minutes has passed for mysticetes and large odontocetes (including pygmy sperm, dwarf sperm, and killer whales); and 60 minutes has passed for sperm and beaked whales which can have longer dive durations.

- l. Following a power-down and subsequent animal departure, the *Langseth* may resume airgun operations at full power. Initiation requires that the observers can effectively monitor the full exclusion zones described in Condition 6(b). If the observer sees a marine mammal within or about to enter the relevant zones then the *Langseth* will implement a course/speed alteration, power-down, or shutdown.

### **Shutdown Procedures**

- m. Shutdown the airgun(s) if a visual observer detects a marine mammal within, approaching, or entering the relevant exclusion zone (as defined in Table 2). A shutdown means that the *Langseth* turns off all operating airguns.
- n. If an observer visually detects a North Atlantic right whale (*Eubalaena glacialis*), the *Langseth* will shut-down the airgun array regardless of the distance of the animal(s) to the sound source. The array will not resume firing until 30 minutes after the last documented North Atlantic right whale visual sighting.

### **Resuming Airgun Operations after a Shutdown**

- o. Following a shutdown, if the observer has visually confirmed that the animal has departed the relevant exclusion zone within a period of less than or equal to 8 minutes after the shutdown, then the *Langseth* may resume airgun operations at full power.
- p. Else, if the observer has not seen the animal depart the relevant exclusion zone (as defined in Table 2), the *Langseth* shall not resume airgun activity until 15 minutes has passed for species with shorter dive times (*i.e.*, small odontocetes and pinnipeds); 30 minutes has passed for mysticetes and large odontocetes (including pygmy sperm, dwarf sperm, and killer whales); and 60 minutes has passed for sperm and beaked whales which can have longer dive durations. The *Langseth* will follow the ramp-up procedures described in Conditions 6(g).

### **Survey Operations**

- q. The *Langseth* may continue marine geophysical surveys into night and low-light hours if the Holder of the Authorization initiates these segment(s) of the survey when the observers can view and effectively monitor the full relevant exclusion zones (as defined in Table 2).
- r. This Authorization does not permit the Holder of this Authorization to initiate airgun array operations from a shut-down position at night or during low-light hours (such as in dense fog or heavy rain) when the visual observers cannot view and effectively monitor the full relevant exclusion zones (as defined in Table 2).
- s. To the maximum extent practicable, the Holder of this Authorization should schedule seismic operations (*i.e.*, shooting the airguns) during daylight hours.
- t. To the maximum extent practicable, the *Langseth* will conduct the seismic survey (especially when near land) from the coast (inshore) and proceed towards the sea (offshore) in order to avoid trapping marine mammals in shallow water.



## Mitigation Airgun

- u. The *Langseth* may operate a small-volume airgun (*i.e.*, mitigation airgun) during turns and maintenance at approximately one shot per minute. The *Langseth* would not operate the small-volume airgun for longer than three hours in duration during turns. During turns or brief transits between seismic tracklines, one airgun would continue to operate.

## Special Procedures for Large Whale Concentrations

- v. The *Langseth* will power-down the array and avoid concentrations of humpback (*Megaptera novaeangliae*), sei (*Balaenoptera borealis*), fin (*Balaenoptera physalus*), blue (*Balaenoptera musculus*), and/or sperm whales (*Physeter macrocephalus*) if possible (*i.e.*, exposing concentrations of animals to 160 dB re: 1  $\mu$ Pa). For purposes of the survey, a concentration or group of whales will consist of six or more individuals visually sighted that do not appear to be traveling (*e.g.*, feeding, socializing, etc.). The *Langseth* will follow the procedures described in Conditions 6(k) for resuming operations after a power down.

## 7. Reporting Requirements

This Authorization requires the Holder of this Authorization to:

- a. Submit a draft report on all activities and monitoring results to the Office of Protected Resources, National Marine Fisheries Service, within 90 days of the completion of the *Langseth's* cruise. This report must contain and summarize the following information:
  - i. Dates, times, locations, heading, speed, weather, sea conditions (including Beaufort sea state and wind force), and associated activities during all seismic operations and marine mammal sightings;
  - ii. Species, number, location, distance from the vessel, and behavior of any marine mammals, as well as associated seismic activity (number of shutdowns), observed throughout all monitoring activities.
  - iii. An estimate of the number (by species) of marine mammals with known exposures to the seismic activity (based on visual observation) at received levels greater than or equal to 160 dB re: 1  $\mu$ Pa and/or 180 dB or 190-dB re: 1  $\mu$ Pa for cetaceans and pinnipeds, respectively and a discussion of any specific behaviors those individuals exhibited.
  - iv. An estimate of the number (by species) of marine mammals with estimated exposures (based on modeling results) to the seismic activity at received levels greater than or equal to 160 dB re: 1  $\mu$ Pa and/or 180 dB or 190-dB re: 1  $\mu$ Pa with a discussion of the nature of the probable consequences of that exposure on the individuals.
  - v. A description of the implementation and effectiveness of the: (A) Terms and Conditions of the Biological Opinion's Incidental Take Statement; and (B) mitigation measures of the Incidental Harassment Authorization. For the Biological Opinion, the report will confirm the implementation of each Term and Condition, as well as any conservation recommendations, and describe their effectiveness, for minimizing the adverse effects of the action on Endangered Species Act listed marine mammals.



- b. Submit a final report to the Chief, Permits and Conservation Division, Office of Protected Resources, National Marine Fisheries Service, within 30 days after receiving comments from us on the draft report. If we decide that the draft report needs no comments, we will consider the draft report to be the final report.

## **8. Reporting Prohibited Take**

In the unanticipated event that the specified activity clearly causes the take of a marine mammal in a manner not permitted by the Authorization, such as an injury, serious injury, or mortality (*e.g.*, ship-strike, gear interaction, and/or entanglement), Lamont-Doherty shall immediately cease the specified activities and immediately report the take to the Chief, Permits and Conservation Division, Office of Protected Resources, NMFS, at 301-427-8401 and/or by email to [Jolie.Harrison@noaa.gov](mailto:Jolie.Harrison@noaa.gov) and [ITP.Cody@noaa.gov](mailto:ITP.Cody@noaa.gov).

Lamont-Doherty must also contact the NMFS Greater Atlantic Region Marine Mammal Stranding Network at 866-755-6622 ([Mendy.Garron@noaa.gov](mailto:Mendy.Garron@noaa.gov)), and the NMFS Southeast Region Marine Mammal Stranding Network at 877-433-8299 ([Blair.Mase@noaa.gov](mailto:Blair.Mase@noaa.gov) and [Erin.Fougeres@noaa.gov](mailto:Erin.Fougeres@noaa.gov)).

The report must include the following information:

- Time, date, and location (latitude/longitude) of the incident;
- Name and type of vessel involved;
- Vessel's speed during and leading up to the incident;
- Description of the incident;
- Status of all sound sources used in the 24 hours preceding the incident;
- Water depth;
- Environmental conditions (*e.g.*, wind speed and direction, Beaufort sea state, cloud cover, and visibility);
- Description of all marine mammal observations in the 24 hours preceding the incident;
- Species identification or description of the animal(s) involved;
- Fate of the animal(s); and
- Photographs or video footage of the animal(s) (if equipment is available).

Lamont-Doherty shall not resume its activities until we are able to review the circumstances of the prohibited take. We shall work with Lamont-Doherty to determine what is necessary to minimize the likelihood of further prohibited take and ensure MMPA compliance. Lamont-Doherty may not resume their activities until notified by us via letter, email, or telephone.

## **9. Reporting an Injured or Dead Marine Mammal with an Unknown Cause of Death**

In the event that Lamont-Doherty discovers an injured or dead marine mammal, and the lead visual observer determines that the cause of the injury or death is unknown and the death is relatively recent (*i.e.*, in less than a moderate state of decomposition as we describe in the next section), Lamont-Doherty will immediately report the incident to the Chief, Permits and Conservation Division, Office of Protected Resources, NMFS, at 301-427-8401 and/or by email to [Jolie.Harrison@noaa.gov](mailto:Jolie.Harrison@noaa.gov) and [ITP.Cody@noaa.gov](mailto:ITP.Cody@noaa.gov).

Lamont-Doherty must also contact the NMFS Greater Atlantic Region Marine Mammal Stranding Network at 866-755-6622 ([Mendy.Garron@noaa.gov](mailto:Mendy.Garron@noaa.gov)), and the NMFS Southeast Region Marine Mammal Stranding Network at 877-433-8299 ([Blair.Mase@noaa.gov](mailto:Blair.Mase@noaa.gov) and [Erin.Fougeres@noaa.gov](mailto:Erin.Fougeres@noaa.gov)).

The report must include the same information identified in Condition 8. Activities may continue while we review the circumstances of the incident. We would work with Lamont-Doherty to determine whether modifications in the activities are appropriate.

#### **10. Reporting an Injured or Dead Marine Mammal Unrelated to the Activities**

In the event that Lamont-Doherty discovers an injured or dead marine mammal, and the lead visual observer determines that the injury or death is not associated with or related to the authorized activities (*e.g.*, previously wounded animal, carcass with moderate to advanced decomposition, or scavenger damage), Lamont-Doherty would report the incident to the Chief, Permits and Conservation Division, Office of Protected Resources, NMFS, at 301-427-8401 and/or by email to [Jolie.Harrison@noaa.gov](mailto:Jolie.Harrison@noaa.gov) and [ITP.Cody@noaa.gov](mailto:ITP.Cody@noaa.gov).

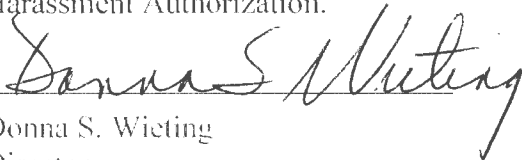
Lamont-Doherty must also contact the NMFS Greater Atlantic Region Marine Mammal Stranding Network at 866-755-6622 ([Mendy.Garron@noaa.gov](mailto:Mendy.Garron@noaa.gov)), and the NMFS Southeast Region Marine Mammal Stranding Network at 877-433-8299 ([Blair.Mase@noaa.gov](mailto:Blair.Mase@noaa.gov) and [Erin.Fougeres@noaa.gov](mailto:Erin.Fougeres@noaa.gov)).

Lamont-Doherty would provide photographs or video footage (if available) or other documentation of the stranded animal sighting to NMFS.

#### **11. Endangered Species Act Biological Opinion and Incidental Take Statement**

Lamont-Doherty must comply with the Terms and Conditions of the Incidental Take Statement corresponding to the Endangered Species Act Biological Opinion issued to the National Science Foundation and NMFS' Office of Protected Resources, Permits and Conservation Division.

A copy of this Authorization and the Incidental Take Statement must be in the possession of all contractors and protected species observers operating under the authority of this Incidental Harassment Authorization.

  
Donna S. Wieting  
Director,  
Office of Protected Resources  
National Marine Fisheries Service

SEP 12 2014

\_\_\_\_\_  
Date

**Table 1 – Authorized Level B harassment take numbers for each marine mammal species during Lamont-Doherty’s marine seismic survey in the Atlantic Ocean September 15, 2014 to October 31, 2014.**

<b>Mysticetes</b>	<b>Authorized Level B Take</b>
<b>North Atlantic right whale</b>	5
<b>Blue whale</b>	3
Bryde’s whale	21
<b>Fin whale</b>	19
<b>Humpback whale</b>	44
Minke whale	2
<b>Sei whale</b>	98
<b>Odontocetes</b>	<b>Authorized Level B Take</b>
<b>Sperm whale</b>	104
Dwarf sperm whale	39
Pygmy sperm whale	39
Cuvier's beaked whale	19
Gervais' beaked whale	19
Blainville's beaked whale	19
True's beaked whale	19
Rough-toothed dolphin	18
Bottlenose dolphin (offshore)	3,829
Bottlenose dolphin (SMC)	778
Bottlenose dolphin (NNCE)	7
Bottlenose dolphin (NNCE)	23
Pantropical spotted dolphin	830
Atlantic spotted dolphin	5,239
Spinner dolphin	74
Striped dolphin	112
Clymene dolphin	398
Short-beaked common dolphin	1,519
Atlantic white-sided-dolphin	0
Fraser's dolphin	114
Risso’s dolphin	100
Melon-headed whale	114
Pygmy killer whale	57
False killer whale	18
Killer whale	7
Long-finned pilot whale	903
Short-finned pilot whale	903
Harbor porpoise	0
Harbor Seal	5

**Table 2 –Exclusion Zones**

Source and Volume (in <sup>3</sup> )	Tow Depth (m)	Water Depth (m)	Predicted RMS Distances <sup>1</sup> (m)				
			190 dB with Buffer	190 dB	180 dB with Buffer	180 dB	160 dB
Single Bolt airgun (40 in <sup>3</sup> )	6 or 9	< 100	37 <sup>3</sup>	27 <sup>3</sup>	121 <sup>3</sup>	86 <sup>3</sup>	938 <sup>3</sup>
		100-1,000	-	-	100	100	582 <sup>2</sup>
		> 1,000	-	-	100	100	388 <sup>1</sup>
18-Airgun array (3,300 in <sup>3</sup> )	6	< 100	436 <sup>4</sup>	294 <sup>4</sup>	1,628 <sup>4</sup>	1,097 <sup>4</sup>	15,280 <sup>4</sup>
		100-1,000	-	-	-	675 <sup>2</sup>	5,640 <sup>2</sup>
		> 1,000	-	-	-	450 <sup>1</sup>	3,760 <sup>1</sup>
36-Airgun array (6,600 in <sup>3</sup> )	9	< 100	877 <sup>3</sup>	645 <sup>3</sup>	2,838 <sup>3</sup>	2,060 <sup>3</sup>	22,600 <sup>3</sup>
		100-1,000	-	-	-	1,391 <sup>2</sup>	8,670 <sup>2</sup>
		> 1,000	-	-	-	927 <sup>1</sup>	5,780 <sup>1</sup>

<sup>1</sup> Based on Lamont-Doherty modeling results.

<sup>2</sup> Predicted distances based on model results with a 1.5 correction factor between deep and intermediate water depths.

<sup>3</sup> Predicted distances based on empirically-derived measurements in the Gulf of Mexico with scaling factor applied to account for differences in tow depth.

<sup>4</sup> Predicted distances based on empirically-derived measurements in the Gulf of Mexico.