Draft Environmental Analysis of a Low-Energy Marine Geophysical Survey by the R/V *Roger Revelle* in the Tropical Western Pacific Ocean, September-October 2013

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ABSTRACT

The Scripps Institution of Oceanography (SIO), with funding from the U.S. National Science Foundation (NSF), plans to conduct low-energy seismic and sediment coring surveys at 10 sites in the tropical western Pacific Ocean in September-October 2013. The seismic survey would use a pair of low-energy Generator-Injector (GI) airguns with a total discharge volume of ~90 in^3. The seismic survey would take place in water depths 450–3000 m in International Waters and in the Exclusive Economic Zones (EEZs) of the Federated States of Micronesia, the Independent State of Papua New Guinea, the Republic of Indonesia, and the Republic of the Philippines. On behalf of SIO, the U.S. State Department will seek authorization from those nations for clearance to work in their EEZs.

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 a NSF program priority. It would provide data necessary to extend the record of millennial climate variability in the Western Pacific Warm Pool back to the mid Miocene.

The Draft 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. SIO 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 issue regarding whether the Marine Mammal Protection Act applies to U.S. activities occurring within the Exclusive Economic Zones of foreign States remains unsettled as a matter of law. Therefore, the submission of the IHA application to the National Marine Fisheries Service does not constitute a waiver or adoption of any position regarding that issue. 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 Draft 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 (NSF-USGS 2011) and Record of Decision (NSF 2012), referred to herein as the PEIS.

Numerous species of marine mammals inhabit the tropical western Pacific Ocean. Several of these species are listed as ***endangered*** under the U.S. Endangered Species Act (ESA): the sperm, humpback, sei, fin, and blue whales. Other ESA-listed species that could occur in the area are the ***endangered*** leatherback, hawksbill, green, and olive ridley turtles and the Christmas Island frigatebird, and the ***threatened*** loggerhead turtle and Heinroth's shearwater.

Potential impacts of the seismic survey on the environment would be primarily a result of the operation of the pair of GI airguns. A multibeam echosounder and a sub-bottom profiler would also be operated. Impacts would be associated with increased underwater noise, which could result in avoidance behavior by marine mammals, sea turtles, seabirds, and fish, and other forms of disturbance. An integral part of the planned survey is a monitoring and mitigation program designed to minimize potential impacts

of the proposed activities on marine animals present during the proposed research, and to document as much as possible the nature and extent of any effects. Injurious impacts to marine mammals, sea turtles, and seabirds have not been proven to occur near airguns including high-energy airgun arrays, and also are not likely to be caused by the other types of sound sources to be used. Even given the low levels of sound emitted by a pair of GI 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; and shut downs when marine mammals or sea turtles are detected in or about to enter designated exclusion zones. SIO 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
EAM	East Asian Monsoon
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
ENSO	El Niño Southern Oscillation
ESA	(U.S.) Endangered Species Act
EZ	Exclusion Zone
FAO	Food and Agriculture Organization of the United Nations
GI	Generator-Injector
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
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for the Conservation of Nature
kHz	kilohertz
km	kilometer
kt	knot
L-DEO	Lamont-Doherty Earth Observatory of Columbia University
m	meter
MBES	multibeam echosounder
MCS	multi-channel seismic
min	minute
MMPA	(U.S.) Marine Mammal Protection Act
ms	millisecond
n.mi.	nautical mile
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
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
SBP	sub-bottom profiler
SIO	Scripps Institution of Oceanography
SST	sea surface temperature
TTS	Temporary Threshold Shift
UNEP	United Nations Environment Programme
U.S.	United States of America
USC	United States Code
USCG	U.S. Coast Guard
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
USIO	U.S. Implementing Organization
USN	U.S. Navy
μPa	microPascal
vs.	versus
WCMC	World Conservation Monitoring Centre
WPWP	Western Pacific Warm Pool

I. PURPOSE AND NEED

The purpose of this Draft Environmental Analysis (EA) is to provide the information needed to assess the potential environmental impacts associated with the use of pair of 45-in^3 Generator-Injector (GI) airguns and sediment corers during the proposed seismic surveys. The Draft EA was prepared under Executive Order 12114, "Environmental Effects Abroad of Major Federal Actions". This Draft EA tiers to the Final Programmatic Environmental Impact Statement (EIS)/Overseas Environmental Impact Statement (OEIS) for Marine Seismic Research funded by the National Science Foundation or Conducted by the U.S. Geological Survey (NSF and USGS 2011) and Record of Decision (NSF 2012), referred to herein as the PEIS. The Draft 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 Draft EA will also be used in support of an application submitted by SIO 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 surveys by SIO in the tropical western Pacific Ocean during September-October 2013. The issue regarding whether the Marine Mammal Protection Act applies to U.S. activities occurring within the Exclusive Economic Zones of foreign States remains unsettled as a matter of law. Therefore, the submission of the IHA application to the National Marine Fisheries Service does not constitute a waiver or adoption of any position regarding that issue.

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. High-resolution multi-channel seismic (MCS) profiles and sediment cores would be collected in the heart of the Western Pacific Warm Pool (WPWP). The proposed survey sites would fill gaps in equatorial Pacific data sets, namely the lack of high-resolution records from the eastern part of the WPWP, to better understand climate variability and the controls on the hydrologic cycle in the WPWP, and a limited meridional coverage to test hypotheses related to the Plio-Pleistocene evolution of the WPWP. Survey data would also be included in a research proposal submitted to the Integrated Ocean Drilling Program (IODP) for funding consideration to extend the record of millennial climate variability in the western equatorial Pacific Ocean back to the mid Miocene. Survey and site characterization data would assist the IODP in determining the viability of the sites for potential future drilling. A Programmatic Environmental Impact Statement was prepared for IODP drilling activities (IODP-USIO 2008) and an NSF

Record of Decision was issued (NSF 2008). Should IODP consider funding a future proposal, it would evaluate if any additional environmental analysis were warranted. The proposed low-energy seismic and sediment coring 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 Draft 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 Draft EA, three alternatives are evaluated: (1) the proposed seismic surveys and issuance of an associated IHA, (2) corresponding seismic surveys 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 SIO's planned seismic surveys are described in the following subsections.

(1) Project Objectives and Context

SIO plans to conduct low-energy seismic and sediment coring surveys at 10 sites in the tropical western Pacific Ocean (Fig. 1). The proposed surveys would fill gaps in equatorial Pacific data sets, namely the lack of high-resolution records from the eastern part of the Western Pacific Warm Pool (WPWP) to better assess the controls on the hydrologic cycle in the WPWP, and a limited meridional coverage to test hypotheses related to the Plio-Pleistocene evolution of the WPWP. To achieve the project's goals, the Principal Investigators (PIs), Drs. Y. Rosenthal and G. Mountain (Rutgers University) propose to collect low-energy, high-resolution multi-channel seismic (MCS) profiles and sediment cores in the heart of the WPWP. As noted previously, survey data would be included in a research proposal submitted to the IODP for funding consideration to extend the record of millennial climate variability the western equatorial Pacific Ocean back to the mid Miocene. Survey and site characterization data would assist the IODP in determining the viability of the sites for potential future drilling.

(2) Proposed Activities

(a) Location of the Activities

The proposed survey sites are located between ~4°S–8°N and ~126.5–144.5°E in the tropical western Pacific Ocean (Fig. 1). Water depths in the survey area are 450–3000 m. The seismic surveys would be conducted in International Waters and in the EEZs of the Federated States of Micronesia (Micronesia), the Independent State of Papua New Guinea (Papua New Guinea), the Republic of

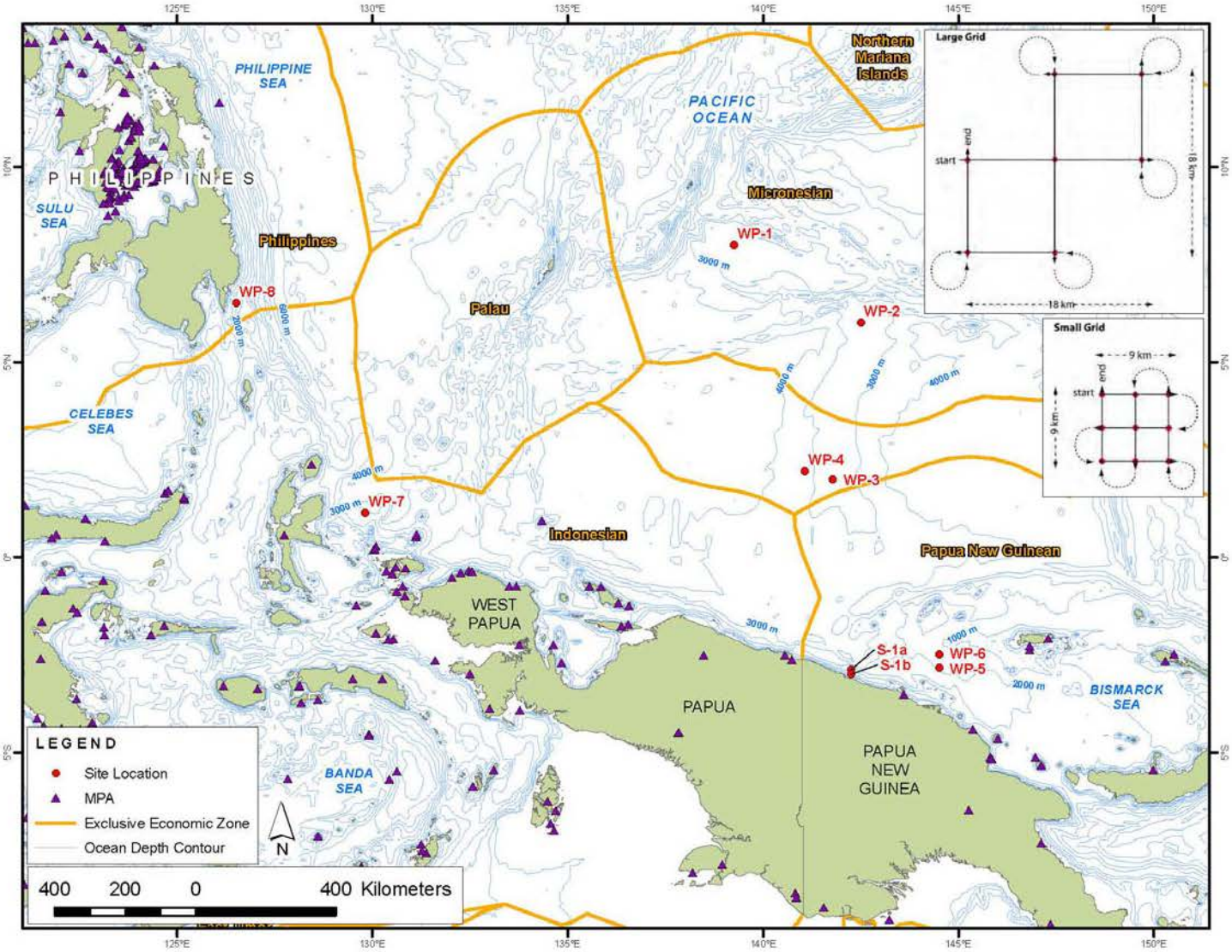

FIGURE 1. Locations of the proposed low-energy seismic survey sites in the tropical western Pacific Ocean during September–October 2013, and marine protected areas in the survey area.

Indonesia (Indonesia), and the Republic of the Philippines (the Philippines), and are scheduled to occur for 14–20 h at each of the 10 sites during 6 September-1 October 2013.

(b) Description of the Activities

The procedures to be used for the surveys would be similar to those used during previous seismic surveys by SIO and would use conventional seismic methodology. The surveys would involve one source vessel, the R/V *Roger Revelle*. The *Revelle* would deploy a pair of 45-in^3 GI airguns as an energy source with a total volume of ~90 in^3. The receiving system would consist of one 600-m hydrophone streamer. As the airguns are towed along the survey lines, the hydrophone streamer would receive the returning acoustic signals and transfer the data to the on-board processing system.

Straight survey lines whose lengths and orientations have been chosen by the anticipated complexity of subseafloor geologic features at each site would be collected in a grid of intersecting lines. Seven sites (see Table 1) would be centered in 'small' 9 x 9 km grids of six intersecting lines (see inset in upper right of Figure 1.) One site warrants slightly longer lines and would be surveyed in a 'large' 18 x 18 km grid of six intersecting lines (see inset in upper right of Figure 1.) Finally, Sites S-1a and S-1b are close enough that efficiency in ship use would be achieved by covering both with a single grid of intersecting lines in a 30 x 26 km area. Individual survey lines in this grid would be 5–10 km apart. The total track distance of survey data, including turns, would be 1033 km. Barring re-organization because of weather considerations or results that develop from data analyzed as sites are completed, sites would be surveyed in the order summarized in Table 1.

TABLE 1. Survey patterns and lengths at each proposed survey site in the tropical western Pacific Ocean during September-October 2013.

Survey site[1]	Survey pattern (km)	Survey length (km)
WP-5	9 x 9	82.2
WP-6	9 x 9	82.2
S-1a, S-1b	30 x 26	349.5
WP-3	9 x 9	82.2
WP-4	9 x 9	82.2
WP-2	9 x 9	82.2
WP-1	9 x 9	82.2
WP-7	9 x 9	82.2
WP-8	18 x 18	108.0
Total		1032.9

[1] Sites are listed in the intended order in which they would be conducted

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 *Revelle* continuously throughout the cruise between the first and last survey site. All planned geophysical data acquisition activities would be conducted by SIO with on-board assistance by the scientists who have proposed the study. The vessel would be self-contained, and the crew would live aboard the vessel for the entire cruise.

(c) Schedule

The *Revelle* would depart from Lae, Papua New Guinea, on 6 September and transit to Manila, Philippines, after the last survey to arrive on 1 October (see Table 1 for proposed order of survey sites). Seismic operations would take 14–20 h at each of the 10 sites, and total transit time to the first site, between all sites, and from the last site would be 13 days. The remainder of the time, ~6 days, would be spent collecting sediment cores at the 10 sites, for a total of 26 operational days.

(d) Vessel Specifications

The R/V *Roger Revelle* has a length of 83 m, a beam of 16.0 m, and a maximum draft of 5.2 m. The ship is powered by two 3,000 hp Propulsion General Electric motors and a 1180 hp azimuthing jet bow thruster. An operation speed of 9.3 km/h (5 kt) would be used during seismic acquisition. When not towing seismic survey gear, the *Revelle* cruises at 22.2–23.1 km/h (12–12.5 kt) and has a maximum speed of 27.8 km/h (15 kt). It has a normal operating range of ~27,780 km.

The *Revelle* would also serve as the platform from which vessel-based marine mammal observers would watch for marine mammals and sea turtles before and during airgun operations. The characteristics of the *Revelle* that make it suitable for visual monitoring are described in § II(3)(a).

Other details of the *Revelle* include the following:

Owner:	U.S. Navy
Operator:	Scripps Institution of Oceanography of the University of California
Flag:	United States of America
Date Built:	1996
Gross Tonnage:	3180
Compressors for Air Guns:	Price Air Compressors, 300 cfm at 1750 psi
Accommodation Capacity:	22 crew plus 37 scientists

(e) Airgun Description

The *Revelle* would tow a pair of 45-in^3 GI airguns and a 600-m streamer containing hydrophones along predetermined lines. Seismic pulses would be emitted at intervals of ~10 seconds (25 m). At a speed of 5 knots (11.1 km/h), the 6–10 s spacing would correspond to a shot interval of ~18.5–31 m.

The generator chamber of each GI gun, the one responsible for introducing the sound pulse into the ocean, is 45 in^3. The larger (105 in^3) injector chamber injects air into the previously generated bubble to maintain its shape, and does not introduce more sound into the water. The two 45 in^3 GI guns would be towed 8 m apart side by side, 21 m behind the *Revelle*, at a depth of 2 m.

<u>GI Airgun Specifications</u>

Energy Source	Two GI guns of 45 in^3
Source output (downward)	0-peak is 3.4 bar-m (230.6 dB re 1 μPa·m); peak-peak is 6.2 bar-m (235.8 dB re 1 μPa·m)
Towing depth of energy source	2 m
Air discharge volume	Approx. 90 in^3
Dominant frequency components	0–188 Hz
Gun positions used	Two side by side guns 8 m apart
Gun volumes at each position (in^3)	45, 45

As the airguns are towed along the survey lines, the towed hydrophone array in the 600-m streamer would receive the reflected signals and transfers the data to the on-board processing system. Given the relatively short streamer length behind the vessel, the turning rate of the vessel with gear deployed would be much higher than the limit of 5º per minute for a seismic vessel towing a streamer of more typical length (>>l km), ~20º. Thus, the maneuverability of the vessel would not limited much during operations.

The nominal downward-directed source levels indicated above do not represent actual sound levels that can be measured at any location in the water. Rather, they represent the level that would be found 1 m from a hypothetical point source emitting the same total amount of sound as is emitted by the combined GI airguns. The actual received level at any location in the water near the GI airguns would not exceed the source level of the strongest individual source. In this case, that would be about 224.6 dB re 1μPa-m peak, or 229.8 dB re 1μPa-m peak-to-peak. Actual levels experienced by any organism more than 1 m from either GI airgun would be significantly lower.

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

(f) Piston Core, Gravity Core, and Multicore Description and Deployment

The piston corer to be used on the *Revelle* consists of (1) a piston core with a 10-cm diameter steel barrel up to ~18 m long with a 2300-kg weight and (2) a trigger core with a 10-cm diameter PVC plastic barrel 3 m long with a 230-kg weight, which are lowered concurrently into the ocean floor with 1.4-cm diameter steel cables.

The gravity corer consists of a 6-m long core pipe that takes a core sample ~10 cm in diameter, a head weight ~45 cm in diameter, and a stabilizing fin. It is lowered to the ocean floor with 1.4-cm diameter steel cable at 100 m/min speed.

The multicorer consists of an outer 8-legged cone-shaped frame and a weighted inner frame that holds up to 8 plastic core sampling tubes 80 cm long and ~10 cm in diameter. The outer frame is lowered to the bottom, and the inner frame is then released to allow the sampling tubes to penetrate the sediment.

At each of the 10 sites, one of each type of core would be collected.

(g) Multibeam Echosounder and Sub-bottom Profilers

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

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[1] The rms (root mean square) pressure is an average over the pulse duration.

(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.

SIO's mitigation measures are described in § 2.4.1.1 of the PEIS. Included are

- monitoring by protected species visual observers (PSVOs) for marine mammals and sea turtles;
- PSVO data and documentation; and
- mitigation during operations (speed or course alteration; shut-down and ramp-up procedures).

(a) Proposed Exclusion Zones

Received sound levels have been modeled by Lamont-Doherty Earth Observatory of Columbia University (L-DEO) for a number of airgun configurations, including two 45-in^3 Nucleus G. Guns, in relation to distance and direction from the airguns (Fig. 2). The model does not allow for bottom interactions, and is most directly applicable to deep water.

Empirical data on the 180- and 160-dB distances have been acquired for various airgun arrays based on measurements during acoustic verification studies conducted by L-DEO in the northern Gulf of Mexico in 2003 (6-, 10-, 12-, and 20-airgun arrays, and 2 GI airguns; Tolstoy et al. 2004) and 2007–2008 (18- and 36-airgun arrays; Tolstoy et al. 2009; Diebold et al. 2010). The empirical data for the 6-, 10-, 12-, and 20-airgun arrays indicate that, for deep water (>1000 m), the L-DEO model tends to overestimate the received sound levels at a given distance (Tolstoy et al. 2004). Measurements were not made for the 2 GI airguns in deep water, but we propose to use the "Safety Zone" radii predicted by L-DEO's model for the proposed GI airgun operations in deep water, although they are likely conservative given the empirical results for the other arrays.

The data also showed that radii around the airguns where the received level would be 180 dB re 1 μPa (rms), the safety criterion applicable to cetaceans (NMFS 2000), varies with water depth. Correction factors were developed for water depths 100–1000 m and <100 m. The proposed surveys would occur in depths 450–3000 m, so only the correction factor for intermediate water depths is relevant here. The only empirical measurements made for ***intermediate depths*** (100–1000 m) were for the 36-aigun array in 2007–2008 (Diebold et al. 2010). 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]).

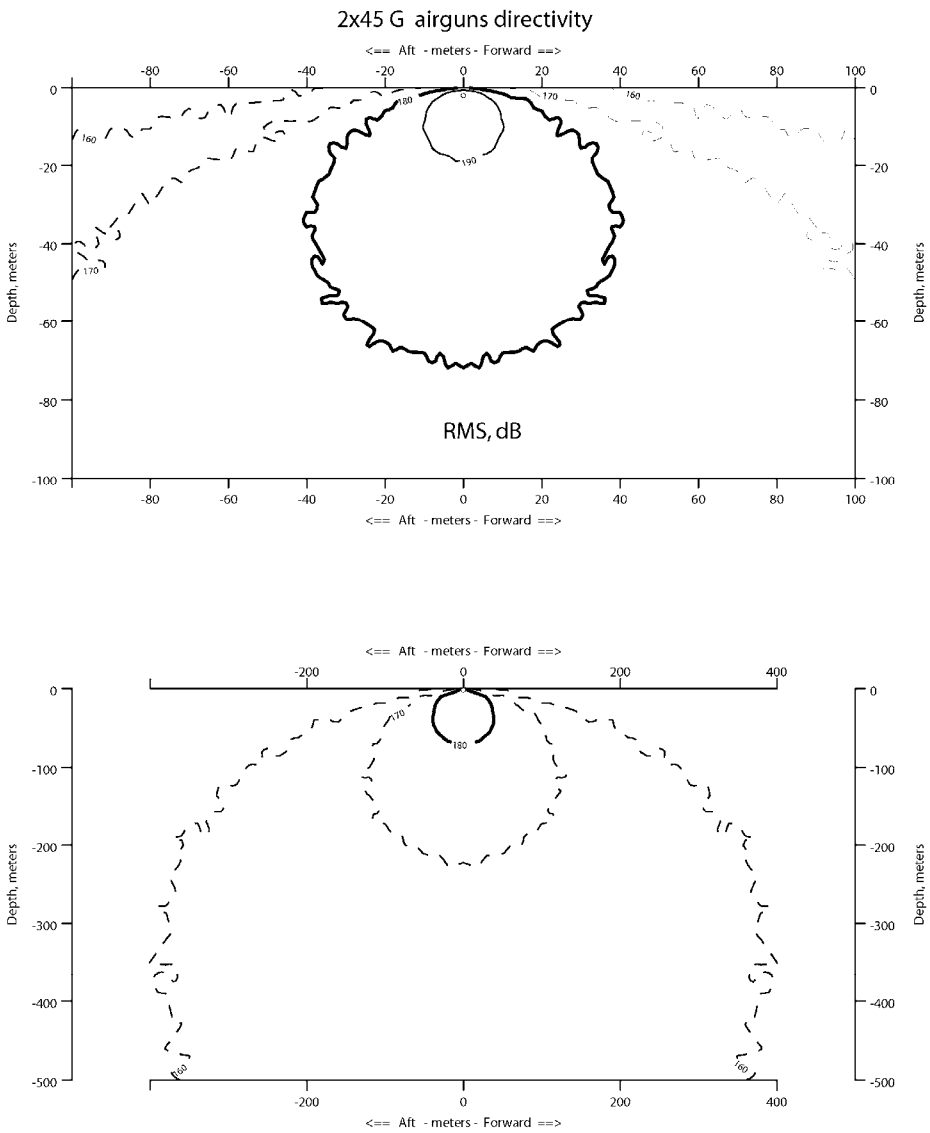

FIGURE 2. Modeled received sound levels from two 45-in^3 G. Guns, similar to the two 45-in^3 GI airguns that would be used during the SIO surveys in the tropical western Pacific Ocean during September-October 2013. Model results were provided by L-DEO.

The PEIS defined a low-energy source as any towed acoustic source whose received level is ≤180 dB at 100 m, including any single or any two GI airguns and a single pair of clustered airguns with individual volumes of ≤250 in^3. In § 2.4.2 of the PEIS, Alternative B (the Preferred Alternative) conservatively applied a 100-m exclusion zone (EZ) for all low-energy acoustic sources in water depths >100 m. Consistent with the PEIS, that approach is used here for the pair of 45-in^3 GI airguns. A fixed full mitigation zone, or 160 dB "Safety Zone" was not defined in the PEIS for the same suite of low-energy sources, therefore, L-DEO model results for 45-in^3 G Guns are used here to determine the 160 dB radius for the pair of 45-in^3 GI airguns.

Table 2 shows the 180-dB EZ for the pair of 45-in^3 GI guns based on the PEIS and the L-DEO modeled measurements for the 160-dB safety zone, the distances at which the rms sound levels are expected to be received in >1000-m and 100–1000 m water. Because the model results are for G Guns,

TABLE 2. Predicted distances to which 160 dB re 1 μPa_{rms} sound levels could be received from two 45-in^3 G guns, similar to the two 45-in^3 GI guns that would be used during the seismic surveys in the tropical western Pacific Ocean during September-October 2013 (model results provided by L-DEO). Distances to which 180 dB re 1 μPa_{rms} sound levels could be received are based on the standard EZ established in the PEIS.

Water depth	Predicted or established distances at received levels	
	180 dB	160 dB
>1000 m	100 m	400 m
100–1000 m	100 m	600 m

which have more energy than GI airguns of the same size, the distances are overestimated. 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., 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 in or about to enter the appropriate EZ, the airguns would be shut down immediately.

Southall et al. (2007) made detailed recommendations for new science-based noise exposure criteria. Currently, NMFS is using those proposed levels as a starting point to revise the current acoustic criteria, but they have not yet been finalized (NMFS 2013). 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 September-October 2013 is the most suitable time logistically for the *Revelle* 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 *Revelle* 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 conduct the proposed surveys to fill gaps in equatorial Pacific data sets, namely the lack of high-resolution records from the eastern part of the WPWP, to better understand climate variability and the controls on the hydrologic cycle in the WPWP, and a limited meridional coverage to test hypotheses related to the Plio-Pleistocene evolution of the WPWP. The methodology to achieve this goal would be to collect low-energy, high-resolution MCS profiles and sediment cores in the heart of the WPWP. Survey data would also be included in a research proposal

submitted to the IODP for funding consideration to extend the record of millennial climate variability in the western equatorial Pacific Ocean back to the mid Miocene.

The "No Action" alternative could also, in some circumstances, result in significant delay of other studies that would be planned on the *Revelle* 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. Effects of this Alternative Action are evaluated in § IV.

Alternatives Considered but Eliminated from Further Analysis

(1) Alternative E1: Alternative Location

The survey locations have been specifically selected as key locations for studying oceanographic and climate variability of the western equatorial Pacific during the Pleistocene. These sites are strategically located to address questions related to the relationships between millennial-scale variability in the tropical Pacific and in the northern Atlantic; the controls on tropical Pacific sea surface temperature (SST) and SST gradient on various time scales; the response of the hydrologic cycle on those time scales and mechanisms controlling these variations; the evolution of the WPWP from the middle Miocene to the present; and the relationships between changes in the equatorial Pacific mean climate state and dynamical processes (e.g., El Niño Southern Oscillation or ENSO) and how do they relate to the Plio-Pleistocene transitions. The survey locations proposed also have been specifically selected to help inform possible drilling sites for a pending IODP proposal.

The proposal includes low sedimentation-rate, deep-sea sites selected to reconstruct secular trends and orbital scale variability in WPWP and sites from rapidly accumulating sediments closer to continental margins, selected to assess centennial to millennial climate variability. To our knowledge, no other sites can address all the research objectives' requirements, i.e., climatically appropriate locations with sedimentation rates that provide the needed resolution. Obtaining 2-D seismic data would assess whether the proposed sites are suitable for IODP drilling, which is the only means possible for providing long climate records from this important region. Furthermore, the proposed research underwent the NSF merit review process, and the science, including the survey site locations, 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 marine geophysical research. At the present time, these technologies are still not feasible, commercially viable, or appropriate to meet the Purpose and Need.

Table 3 provides a summary of the proposed action, alternatives, and alternatives eliminated from further analysis.

TABLE 3. Summary of Proposed Action, Alternatives Considered, and Alternatives Eliminated

Proposed Action	Description/Analysis
Proposed Action: Conduct marine geophysical surveys and associated activities in the tropical western Pacific Ocean	Under this action, the use of a low-energy seismic source and sediment coring are proposed. When considering mobilization, demobilization, refueling, equipment maintenance, weather, marine mammal activity, and other contingencies, the proposed activities would be expected to be completed in ~26 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 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, SIO 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 whereas some migrate north in summer, 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 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 millennial climate variability the western equatorial Pacific 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 locations are in key locations for studying oceanographic and climate variability of the western equatorial Pacific during the Pleistocene. To our knowledge, no other sites can address all the requirements for our research objectives, namely, climatically appropriate locations with sedimentation rates that provide the needed resolution. Furthermore, the proposed science underwent the NSF merit review process, and the science, including the site location, was determined to be meritorious. The survey locations proposed also have been specifically selected to help inform possible drilling sites for a pending IODP proposal.
Alternative E2: Alternative Survey Techniques	Under this alternative, SIO would use alternative survey techniques, e.g., 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.

III. AFFECTED ENVIRONMENT

As described in the PEIS, Chapter 3, the description of the affected environment focuses only on those resources potentially subject to impacts. Accordingly, the discussion of the affected environment (and associated analyses) has focused mainly on those related to marine biological resources, as the proposed short-term activities have the potential to impact marine biological resources within the Project area. These resources are identified in Section III, and the potential impacts to these resources are discussed in Section IV. Initial review and analysis of the proposed Project activities determined that the following resource areas did not require further analysis in this Draft EA:

- *Transportation*—Only one vessel, the *Revelle*, would be used during the marine seismic and sediment coring surveys. 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 displacement and removal of a small amount of seafloor sediments through the collection of sediment cores. 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.

Protected Areas

There are a number of marine protected areas (MPAs) in Micronesia, Papua New Guinea, Indonesia, and the Philippines identified by Wood (2007); Protected Planet (2012); and SAUP (2012); see Figure 1. The closest MPA to any drill site is 80 km from Site WP-7 in the EEZ of Indonesia.

Marine Mammals

Twenty-six species of marine mammals, including 19 odontocetes and 7 mysticetes, could occur at or near the proposed survey sites in the western tropical Pacific Ocean (Table 4). Five of the 26 species are listed under the U.S. Endangered Species Act (ESA) as ***Endangered***: the humpback, blue, fin, sei, and sperm whales. In addition, there are four species known to occur in coastal waters of the study area: the Australian snubfin dolphin (*Orcaella heinsohni*), Indo-Pacific humpback dolphin (*Sousa chinensis*), Indo-Pacific bottlenose dolphin (*Tursiops aduncus*), and the dugong (*Dugong dugon*). However, these species do not occur in slope or deep, offshore waters where the proposed activities would take place. No pinnipeds are known to occur in the proposed 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 PEIS. One of the qualitative analysis areas (QAAs) defined in the PEIS, the Marianas, is located ~800 km to the north of the proposed study area, at 17ºN, 145ºE. The general distribution of mysticetes and odontocetes in the western North Pacific Ocean is discussed in § 3.6.3.7 and § 3.7.3.7 of the PEIS, respectively. The rest of this section deals specifically with species distribution in the proposed survey area in the western tropical Pacific.

Few systematic surveys have been conducted in the western tropical Pacific Ocean, and none have taken place during September–October. Borsa and Nugroho (2010) conducted 1561 km of surveys of Raja Ampat waters, including the Halmahera Sea, in West Papua during November–December 2007. Visser (2002 *in* Visser and Bonoccorso 2003) conducted preliminary surveys in Kimbe Bay, New Britain, Papua New Guinea. Miyazaki and Wada (1978) surveyed 11,249 km in the wider tropical Pacific, including Micronesia, and the waters off Papua New Guinea and the Solomon Islands during January–March 1976. Shimada and Miyashita (2001) conducted 8721 km of surveys in Micronesia, the Solomon Islands, and north of Papua New Guinea during February–March from 1999–2001. Oremus (2011) described 4523 km of surveys in the Solomon Islands during November of 2009 and 2010. Dolar et al. (2006) surveyed the waters of the central Philippines, including the Sulu Sea, during May–June 1994 and 1995; 2747 km were covered. In May 1996, Dolar et al. (1997) surveyed 825 km in the southern Sulu Sea. Another survey of relevance to the proposed survey area is one that took place during January–April 2007 in the waters of Guam and the Commonwealth of the Northern Mariana Islands; a total of 11,033 km were surveyed in the area 10–18°N and 142–148°E (SRS-Parsons 2007; Fulling et al. 2011). The aforementioned surveys took place in shallow coastal waters as well as deeper offshore waters. Records from the Ocean Biogeographic Information System (OBIS) database hosted by Rutgers and Duke University (Read et al. 2009) were also included.

TABLE 4. The habitat, regional abundance, and conservation status of marine mammals that could occur in or near the proposed survey sites in the western tropical Pacific.

Species	Occurrence near survey sites	Habitat	Abundance in the Pacific	ESA[1]	IUCN[2]	CITES[3]
Mysticetes						
Humpback whale	Uncommon	Mainly nearshore waters and banks	3520[4]	EN	LC	I
Common minke whale	Uncommon	Coastal, offshore	25,000[5]	NL	LC	I
Bryde's whale	Common–Uncommon	Coastal, offshore	21,000[6]	NL	DD	I
Omura's whale	Common–Uncommon	Coastal, offshore	N.A.	NL	DD	I
Sei whale	Uncommon	Mostly pelagic	7260–12,620[7]	EN	EN	I
Fin whale	Uncommon	Slope, mostly pelagic	13,620–18,680[8]	EN	EN	I
Blue whale	Rare	Coastal, shelf, pelagic	N.A.	EN	EN	I
Odontocetes						
Sperm whale	Common–Uncommon	Usually deep pelagic, steep topography	29,674[9]	EN	VU	I
Pygmy sperm whale	Uncommon	Deep waters off shelf	N.A.	NL	DD	II
Dwarf sperm whale	Uncommon	Deep waters off shelf	11,200[10]	NL	DD	II
Cuvier's beaked whale	Common–Uncommon	Slope and pelagic	20,000[10]	NL	LC	II
Longman's beaked whale	Rare	Pelagic	N.A.	NL	DD	II
Ginkgo-toothed beaked whale	Rare	Pelagic	25,300[11]	NL	DD	II
Blainville's beaked whale	Uncommon	Pelagic	25,300[11]	NL	DD	II
Rough-toothed dolphin	Common–Uncommon	Pelagic	107,633[12]	NL	LC	II
Common bottlenose dolphin	Common–Uncommon	Coastal, shelf, pelagic	168,792[13]	NL	LC	II
Pantropical spotted dolphin	Common–Uncommon	Coastal, pelagic	438,064[13]	NL	LC	II
Spinner dolphin	Common	Coastal, pelagic	734,837[14]	NL	DD	II
Striped dolphin	Common–Uncommon	Off continental shelf	570,038[13]	NL	LC	II
Fraser's dolphin	Common–Uncommon	Pelagic	289,300[10]	NL	LC	II
Risso's dolphin	Common–Uncommon	Shelf, slope, seamounts	83,289[13]	NL	LC	II
Melon-headed whale	Common–Uncommon	Pelagic	45,400[10]	NL	LC	II
Pygmy killer whale	Common–Uncommon	Pelagic	38,900[10]	NL	DD	II
False killer whale	Common–Uncommon	Pelagic	16,668[13]	NL	DD	II
Killer whale	Common–Uncommon	Coastal, widely distributed	8500[10]	NL	DD	II
Short-finned pilot whale	Common–Uncommon	Mostly pelagic, high-relief	53,608[13]	NL	DD	II

N.A. Not available or not assessed.
[1] U.S. Endangered Species Act: EN = Endangered, NL = Not listed (ECOS 2013)
[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] Oceania (Constantine et al. 2010)
[5] Northwest Pacific and Okhotsk Sea (IWC 2013)
[6] Western North Pacific (IWC 2013)
[7] North Pacific (Tillman 1977)
[8] North Pacific (Ohsumi and Wada 1974)
[9] Western North Pacific (Whitehead 2002)
[10] Eastern Tropical Pacific or ETP (Wade and Gerrodette 1993)
[11] ETP; all *Mesoplodon* spp. (Wade and Gerrodette 1993)
[12] ETP (Gerrodette et al. 2008)
[13] Western North Pacific (Miyashita 1993)
[14] Whitebelly stock in ETP (Gerrodette et al. 2008)

(1) Mysticetes

Humpback Whale (*Megaptera novaeangliae*)

Humpback whales occur throughout most of the Pacific, but are rare in the equatorial region (Jefferson et al. 2008). In the western North Pacific, humpback whales are known to winter and calve around Ogasawara and Ryukyu Islands in southern Japan, Taiwan, and the Babuyan Islands in Luzon Strait in the northern Philippines (Perry et al. 1999; Acebes and Lesaca 2003; Acebes et al. 2007; Calambokidis et al. 2008). Singing humpbacks have been detected in both deep and shallow waters of the Mariana Islands, suggesting a small wintering population in the region (SRS-Parsons et al. 2007). However, Shimada and Miyashita (2001) did not report any sightings of humpback whales during February–March surveys of the Mariana Islands or Micronesia.

There are several distinct breeding grounds in the South Pacific Ocean, including eastern Australia and Oceania (Anderson et al. 2010; Garrigue et al. 2011a). Although genetic evidence also indicates several discrete breeding grounds within Oceania, including New Caledonia, Tonga, and French Polynesia (Olavarría et al. 2003, 2007), some movement has been shown between breeding areas within Oceania (Garrigue et al. 2002, 2011a; Clapham et al. 2008) and between Oceania and eastern Australia (Anderson et al. 2010; Garrigue et al. 2011b). Constantine et al. (2010) noted that Oceania is the least abundant breeding ground in the Southern Hemisphere, with an estimated population size of 3520.

During surveys in February–March 1999–2001, Shimada and Miyashita (2001) did not report any sightings of humpback whales north of Papua New Guinea or near the Solomon Islands. However, there are records of humpback whales for Papua New Guinea (SPREP 2012) and unconfirmed records for the Solomon Islands (Miller 2007). There is one OBIS record for humpback whales in the proposed survey area, off western Papua New Guinea; there are an additional two records for the Solomon Islands (IOC 2013). The occurrence of humpback whales in Indonesia is unconfirmed; there has been a possible sighting in the Celebes Sea (Rudolph et al. 1997).

The available evidence suggests that humpback whales would be uncommon throughout the proposed survey area. However, it is possible that some individuals could be encountered off Papua New Guinea. Encounters in other parts of the study area, particularly north of the equator would be unlikely, as most humpbacks would be on higher-latitude feeding grounds during the time of the proposed surveys.

Minke Whale (*Balaenoptera* spp.)

There are two species of minke whale, the common minke whale (*B. acutorostrata*) and the Antarctic minke whale (*B. borealis*). In the North Pacific, the common minke whale occurs from tropical to polar waters (Reeves et al. 2002); its distribution in the South Pacific is not well known (Jefferson et al. 2008). Antarctic minke whales are found between 55°S and the ice edge during the austral summer; in the austral winter, they are mainly found between 10°S and 30°S and between 170°E and 100°W (Perrin and Brownell 2009). A smaller form (unnamed subspecies) of the common minke whale, known as the dwarf minke whale, occurs in the Southern Hemisphere where its distribution overlaps with that of the Antarctic minke whale (Perrin and Brownell 2009). Only the common minke whale could be encountered during the proposed surveys.

In the North Pacific, three stocks of minke whales are currently recognized: the Sea of Japan/East China Sea, the rest of the western Pacific, and the remainder of the Pacific (Donovan 1991). For the western Pacific stock, one group is thought to breed near the Bonin-Japan Trench during winter (Smith et al. 2003). Minke whales that occur in Southeast Asia are likely from the same population that winters off

the coast of Japan (see Parsons et al. 1995). Minke whales are known to occur in the Yellow, East China, and South China seas (Parsons et al. 1995). There are only unconfirmed records of minke whales for Indonesia (Rudolph et al. 1997). During January–April 2007 surveys of the waters of Guam and the Northern Mariana Islands, minke whales were the baleen whale species most frequently detected acoustically (SRS-Parsons et al. 2007). There are also unconfirmed records of minke whales for Palau (Miller 2007). Minke whales have not been reported for Papua New Guinea (Miller 2007; SPREP 2012). However, there are OBIS records of common minke whales for the Solomon Islands and to the east of the study area at ~160°E (IOC 2013). Minke whales are likely to be uncommon throughout the proposed survey area.

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

Bryde's whale's distribution is circumglobal, but it generally occurs in tropical and subtropical areas. A small form is known to occur in southwestern Japan, Hong Kong/Macau, and Australia, but this form has not been distinguished from the common Bryde's whale (Jefferson et al. 2008). Nonetheless, Wada et al. (2003) and Sasaki et al. (2006) suggested that smaller *B. edeni* (the pygmy Bryde's or Eden's whale) could be a distinct species from the larger *B. brydei* or Bryde's whale. However, here we follow Kato and Perrin (2009) in recognizing the uncertainty and using *B. edeni/brydei*. Also, whales in the East China Sea and coastal waters of Kochi, Japan, differ from the whales in offshore waters of the western North Pacific, perhaps at the subspecific level (Yoshida and Kato 1999). However, the reclassification of Bryde's whale remains unresolved (Jefferson et al. 2008).

Ohizumi et al. (2002) reported that Bryde's whales occur throughout the western North Pacific during winter, including the Mariana, Ogasawara, Kazan, and Philippine islands. Bryde's whales were also sighted during surveys of the central Philippines, including northern Mindanao, by Dolar et al. (2006), and Bryde's whales where marked off eastern Mindanao during 1972–1987 (Kishiro 1996). Bryde's-like whales are known to occur in Palau (SPREP 2012) as well as in Indonesia (Rudolph et al. 1997; Kahn and Pet 2003). Kishiro (1996) reported that Bryde's whales were available for marking during Japanese marking operations off West Papua, Papua, as well as Papua New Guinea, and strandings have also been reported for West Papua (Wild and Science 2013). Miyazaki and Wada (1978) reported Bryde's whale sightings for January–March surveys in 1976 north of Papua New Guinea and in the Solomon Islands. Miyazaki et al. (1996) sighted Bryde's whales during January–March 1993–1995 surveys off eastern Mindanao, Philippines. Bryde's whale sightings were also made during surveys in February–March 1999–2001 north of Papua New Guinea, the Federated States of Micronesia, and the Solomon Islands, and near the Mariana Islands (Shimada and Miyashita 2001). Bryde's whales were also taken in the Philippine fishery in the 1980s near the Caroline Islands of the Federated Sates of Micronesia (Perrin 2006). Bryde's whales are considered the most common baleen whale in the Marianas region, typically occurring from May to July and possibly August (Eldredge 2003; Kishiro 1996; Miyashita et al. 1996). During January–April 2007 surveys in the waters of Guam and the Northern Mariana Islands, Bryde's and sei whales were the most frequently encountered baleen whales (SRS-Parsons et al. 2007; Fulling et al. 2011). Ohsumi (1978) reported high densities of Bryde's whales along the equator between 130°W and 180°W.

There are no records of Bryde's whales in or near the proposed survey area in the OBIS database (IOC 2013). Nonetheless, this is the most likely baleen whale species that would be encountered during the proposed surveys according to other available information.

Omura's Whale (*Balaenoptera omurai*)

Omura's whale was first described in 2003 from records from the eastern Indian Ocean, Indonesia, the Philippines, the Sea of Japan, and the Solomon Islands (Wada et al. 2003). Aragones et al. (2010) reported two strandings of this species in the Philippines between 1998 and 2009. Wada and Numachi (1991) and Yoshida and Kato (1999) had noted that whales in the Solomon Islands were distinct from Bryde's whales from offshore waters of the western North Pacific and the East China Sea. In fact, this species is not as closely related to Bryde's, Eden's, or sei whales as previously thought (Sasaki et al. 2006). Omura's whale mostly occurs over the continental shelf in nearshore waters, and is generally seen alone or in pairs (Jefferson et al. 2008).

There are no records of this species in the OBIS database (IOC 2013), but it could occur in the proposed survey area.

Sei Whale (*Balaenoptera borealis*)

In the western North Pacific, the sei whale can be found across the Bering Sea and off the coasts of Japan and Korea in summer. Its occurrence in the South China Sea is unconfirmed (Rudolph and Smeenk 2009), although Chou (2004) reported on records for this species in Taiwan. Its winter distribution is concentrated at ~20°N. During January–April surveys of the Mariana Islands, Bryde's and sei whales were the most frequently encountered baleen whales (SRS-Parsons et al. 2007; Fulling et al. 2011). No breeding grounds have been identified for sei whales anywhere in its range; however, calving is thought to occur from September to March. Sei whales have not been reported for Palau (SPREP 2012).

Sei whales are generally not found north of 30ºS in the southern hemisphere, but could occasionally visit the southern portion of the proposed study area during the austral winter (Reeves et al. 1999). There are sei whale records for Papua New Guinea and New Caledonia, but they have not been reported for the Solomon Islands (Miller 2007; SPREP 2012). Although there are records of sei whales for Indonesia, no recent sightings have been made (Rudolph et al. 1997).

There are no records of sei whales within or near the proposed survey area in the OBIS database (IOC 2013). In addition, the range of the sei whale indicated by Jefferson et al. (2008) does not include the area where the proposed surveys would take place. Although sei whales are known to occur in the Mariana Islands, it is unlikely that they would occur in Micronesia during the time of the proposed surveys, as they prefer colder temperature waters during summer. It is possible, although unlikely, that sei whales could be encountered off Papua New Guinea.

Fin Whale (*Balaenoptera physalus*)

Northern and southern fin whale populations are distinct, and are sometimes recognized as different subspecies (Aguilar 2009). The current distribution of fin whales in the western North Pacific is largely unknown. Fin whales migrate in the open oceans and their winter breeding areas are mostly uncertain; however, they are known to winter in the Yellow, East China, and South China seas (Parsons et al. 1995; Rudolph and Smeenk 2002). Fin whales could be resident in the East China Sea (Jefferson et al. 2008). De Boer (2000) reported one fin whale sighting during surveys of the South China Sea. There are also a few records for Indonesia (Rudolph et al. 1997).

A recent review of fin whale distribution in the North Pacific noted the lack of sightings across the pelagic waters between eastern and western winter areas (Mizroch et al. 2009). No fin whales were sighted or detected acoustically during the January–April 2007 survey in the waters of the Mariana

Islands (SRS-Parsons et al. 2007; Fulling et al. 2011). There are no records for Palau, Micronesia, Papua New Guinea, or the Solomon Islands (Miller 2007; SPREP 2012). In addition, there are no OBIS records of fin whales within or near the proposed survey area (IOC 2013). It is unlikely that fin whales would be encountered during the proposed surveys.

Blue Whale (*Balaenoptera musculus*)

The North Pacific stock of blue whales is thought to winter off Taiwan, Japan, and Korea. There have also been blue whale calls recorded off Midway and Oahu, Hawaii, suggesting that blue whales occur within several hundred kilometers of these islands (NMFS 1998). Blue whale calls monitored from the U.S. Navy Sound Surveillance System (SOSUS) and other offshore hydrophones suggest that separate populations occur in the eastern and western North Pacific (Stafford et al. 1999, 2001, 2007; Watkins et al. 2000; Stafford 2003). Moore et al. (2002) reported that blue whale calls are received in the North Pacific year-round. The current distribution of blue whales in the western North Pacific is largely unknown, and little information is available on blue whale wintering areas (Perry et al. 1999). However, few blue whales have been reported recently in the western North Pacific (Sears and Perrin 2009).

The blue whale is also considered rare in the Southern Hemisphere (Sears and Perrin 2009). However, there have been confirmed sightings in Indonesia (Rudolph et al. 1997; Kahn and Pet 2003) and the Solomon Islands (Miller 2007; SPREP 2012). There are no records of blue whales in or near the proposed survey area in the OBIS database (IOC 2013).

(2) Odontocetes

Sperm Whale (*Physeter macrocephalus*)

The sperm whale is known to occur in Southeast Asia, including the South China Sea (De Boer 2000), Indonesia (Rudolph et al. 1997; Kahn and Pet 2003), and the Philippines (Acebes and Lesaca 2003; Dolar et al. 2006). Miyazaki et al. (1996) reported sperm whales during January–March surveys off eastern Mindanao, Philippines, during 1993–1995. During surveys off northern West Papua, Indonesia, Borsa and Nugroho (2010) reported five sightings of sperm whales and an encounter rate of 0.005 whales/km, but none of the sightings were made in the Halmahera Sea. Strandings have also been reported for Papua and West Papua (Wild And Science 2013).

The sperm whale is the most common large cetacean (except perhaps for Bryde's whale) in the Pacific Islands region (Reeves et al. 1999), and the most widespread cetacean species in that area (SPREP 2007). Sperm whales were sighted in and near the proposed study area during surveys in February–March 1999–2001 in Micronesia, north of Papua New Guinea, and the Solomon Islands (Shimada and Miyashita 2001). Miyazaki and Wada (1978) also reported sperm whale sightings during surveys in January–March 1976 north of Papua New Guinea and in the Solomon Islands. The Bismarck Sea in Papua New Guinea appears to be an important breeding ground for sperm whales; mother/calf pairs and mature males have been seen in this area (Madsen et al. 2002).

The sperm whale was the most frequently sighted cetacean during surveys in January–April 2007 in the Marianas (SRS-Parsons et al. 2007; Fulling et al. 2011); historically, they occurred there year-round (Townsend 1935). There are also known to occur in Palau (SPREP 2012). In the OBIS database, there is one sperm whale record at 13.5°N, 144°E, north of the proposed survey area, two records off northeastern Papua New Guinea, and three records for the Solomon Islands (IOC 2013). Thus, sperm whales are likely to be sighted during the proposed surveys.

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

Although there are few useful estimates of abundance for pygmy or dwarf sperm whales anywhere in their range, they are thought to be common in some areas. They are known to occur in tropical and warm temperate areas of the western Pacific. In Southeast Asia, pygmy sperm whales are known to occur in the South China Sea (Parsons et al. 1995), and there have been stranding reports for the Philippines (Aragones et al. 2010). Dwarf sperm whales have been sighted during surveys of the Sulu Sea and central Philippines, including northern Mindanao (Dolar et al. 1997, 2006). Dolar et al. (2006) provided density and abundance estimates of 0.01 whales/km^2 and 326 dwarf sperm whales, respectively, for the Sulu Sea. There are also records for pygmy and dwarf sperm whales for Indonesia, including West Papua (Rudolph et al. 1997; Kahn and Pet 2003).

Kogia spp. are known to occur in Papua New Guinea, but there are no records for Palau, Micronesia, or the Solomon Islands (Miller 2007; SPREP 2012). However, there are strandings records for Guam, including five strandings of dwarf sperm whales and one stranding of a pygmy sperm whale (Kami and Lujan 1976; Eldredge 1991, 2003; Reeves et al. 1999). There are no records of *Kogia* sp. in or near the proposed survey area in the OBIS database (IOC 2013). Nonetheless, *Kogia* spp. could be encountered during the proposed surveys.

Cuvier's Beaked Whale (*Ziphius cavirostris*)

Cuvier's beaked whale occurs throughout the deep waters of the western Pacific. In Southeast Asia, it is known to occur in Indonesia, including West Papua (Rudolph et al. 1997; Kahn and Pet 2003), and the Philippines (Rudolph and Smeenk 2002; Perrin et al. 2005). Dolar et al. (1997) reported one Cuvier's beaked whale sighting in the Sulu Sea, and Dolar et al. (2006) reported an unidentified ziphiid whale sighting in the Sulu Sea. Cuvier's beaked whale has also been sighted in the Mariana Islands (Masaki 1972 *in* Eldredge 2003; NMFS 2007). Cuvier's beaked whales were sighted on surveys during January–March 1976 off Papua New Guinea (Miyazaki and Wada 1978). There have been unconfirmed records in Micronesia, Palau, and the Solomon Islands (Miller 2007).

There are no OBIS sightings of Cuvier's beaked whale in or near the proposed survey area (IOC 2013). Nonetheless, this species could be encountered during the proposed surveys.

Longman's Beaked Whale (*Indopacetus pacificus*)

Sightings of Longman's beaked whale have occurred at many locations in tropical waters of the Indo-Pacific region (Rudolph and Smeenk 2002; Jefferson et al. 2008). In Southeast Asia, records for this species include the Philippines (Acebes et al. 2005; Aragones et al. 2010). A possible sighting was made in the Sulu Sea during surveys of the central Philippines in 1994 (Dolar et al. 2006). There are no records of this species for Palau, Micronesia, Papua New Guinea, or the Solomon Islands, and there are no OBIS sightings of Longman's beaked whale in or near the proposed survey area (IOC 2013). It is unlikely that this species could be encountered during the proposed surveys.

Ginkgo-toothed Beaked Whale (*Mesoplodon ginkgodens*)

The ginkgo-toothed whale is hypothesized to occupy tropical and warm temperate waters of the Indian and Pacific oceans (Pitman 2009). However, this species is mainly known from stranding records (Mead 1989; Jefferson et al. 2008). There is a report of a juvenile ginkgo-toothed whale that was caught near the proposed study area by a Taiwanese longliner in Micronesia at 4.43°N, 152.20°E (Dalebout et al. 2008). The species' occurrence has been confirmed in the Yellow and East China seas (Perrin et al.

2005). Sixteen unidentified *Mesoplodon* sp. sightings were made in the Sulu Sea during surveys of the central Philippines in May–June 1994 and 1995 (Dolar et al. 2006). However, there are no confirmed sightings for Palau, Papua New Guinea (Miller 2007; SPREP 2012), or Indonesia (Rudolph et al. 1997). There are no OBIS sightings in or near the proposed survey area (IOC 2013).

Blainville's Beaked Whale (*Mesoplodon densirostris*)

Blainville's beaked whale occurs in temperate and tropical waters of the western Pacific. In Southeast Asia, sighting and stranding records exist for the Philippines (Perrin et al. 2005; Aragones et al. 2010) but there are no records for Indonesia (Rudolph et al. 1997). A Blainville's beaked whale sighting was made in the Sulu Sea during surveys of the central Philippines during May–June 1994 and 1995 (Dolar et al. 2006). There have been unconfirmed records of Blainville's beaked whales for Papua New Guinea and the Solomon Islands, but there are no records for Micronesia or Palau (Miller 2007).

There are no OBIS sightings of Blainville's beaked whale in or near the proposed survey area (IOC 2013). Nonetheless, this species could be encountered during the proposed surveys.

Rough-toothed Dolphin (*Steno bredanensis*)

In the western Pacific, the rough-toothed dolphin occurs from northern Japan to Australia. In Southeast Asia, it is known to occur in the South China Sea (Perrin et al. 2005). The rough-toothed dolphin is the most commonly encountered species during surveys in the Babuyan Islands, off northern Philippines (Perrin et al. 2005), and has been sighted during surveys of the central Philippines (Dolar et al. 2006). There are also records for Indonesia (Rudolph et al. 1997; Khan and Pet 2003).

Sightings of rough-toothed dolphins have also been made during surveys in January–April 2007 in the Mariana Islands (SRS-Parsons et al. 2007; Fulling et al. 2011), but there are no records for Palau or Micronesia (Miller 2007; SPREP 2012). A possible sighting of rough-toothed dolphin was made in the Bismarck Sea off Papua New Guinea (Visser 2007), and they are known to occur in the Solomon Islands (Miller 2007; SPREP 2012).

There are no OBIS sightings of rough-toothed dolphin in or near the proposed survey area (IOC 2013). Nonetheless, this species could be encountered during the proposed surveys.

Common Bottlenose Dolphin (*Tursiops truncatus*)

In the western Pacific, the bottlenose dolphin is distributed from Japan to Australia and New Zealand. Bottlenose dolphins are found throughout the East and South China seas (Perrin et al. 2005), and have been sighted during surveys of the Sulu Sea and central Philippines, including northern Mindanao (Dolar et al. 1997, 2006). Dolar et al. (2006) provided density and abundance estimates of $0.11/km^2$ and 2628 for the Sulu Sea. Bottlenose dolphins are also known to occur in Indonesia (Rudolph et al. 1997). During surveys off northern West Papua, Indonesia, Borsa and Nugroho (2010) reported a sighting of 12 bottlenose dolphins, and an encounter rate of 0.013 dolphins/km, but this sighting was not made in the Halmahera Sea. Bottlenose dolphins have also been sighted during surveys in January–April 2007 in the Mariana Islands (SRS-Parsons et al. 2007; Fulling et al. 2011). Trianni and Kessler (2002) also reported that bottlenose dolphins are seen in coastal waters of Guam.

Bottlenose dolphins are also known to occur in Micronesia, and there are unconfirmed records for Palau (Miller 2007). Sightings have also been made in Papua New Guinea, including the Bismarck Sea (Miyazaki and Wada 1978; Visser 2007), and during surveys in the Solomon Islands (Miyazaki and Wada

1978; Oremus 2011). There are two OBIS records of bottlenose dolphins in the Bismarck Sea, Papua New Guinea (IOC 2013).

Pantropical Spotted Dolphin (*Stenella attenuata*)

In the western Pacific Ocean, the pantropical spotted dolphin occurs from Japan south to Australia. They are found throughout the East and South China seas, including the Philippines (Parsons et al. 1995; Perrin et al. 2005) and Indonesia (Rudolph et al. 1997; Khan and Pet 2003). Pantropical spotted dolphins have been sighted during surveys of the Sulu Sea and central Philippines, including northern Mindanao (Dolar et al. 1997, 2006). Dolar et al. (2006) provided density and abundance estimates of 0.65/km^2 and 14,930 for the Sulu Sea. They have also been sighted during surveys in January–April 2007 in the Mariana Islands (SRS-Parsons et al. 2007; Fulling et al. 2011). During surveys in January–March 1976, Miyazaki and Wada (1978) reported sightings of pantropical spotted dolphins near Micronesia, and in the EEZs of Papua New Guinea and the Solomon Islands. There are also unconfirmed records for Palau (Miller 2007). Oremus (2011) also reported sightings of pantropical spotted dolphins in the Solomon Islands.

There are no OBIS sightings of pantropical spotted dolphin within or near the proposed survey area (IOC 2013). Nonetheless, this species could be encountered during the proposed surveys.

Spinner Dolphin (*Stenella longirostris*)

Two subspecies of spinner dolphin occur in the western Pacific: the widespread, offshore spinner dolphin (*Stenella longirostris longirostris*) and the dwarf spinner dolphin (*S. l. roseiventris*). There is little or no genetic interchange between the two subspecies (Dizon et al. 1991). *S. l. longirostris* is pantropical, occurring from Japan, through to the Philippines, and south to Australia; *S. l. roseiventris* only inhabits the shallow waters of inner Southeast Asia (Perrin et al. 1999). The spinner dolphin has been sighted during surveys of the Sulu Sea and central Philippines, including northern Mindanao; it is the most abundant marine mammal species in the area (Dolar et al. 1997, 2006). Dolar et al. (2006) provided density and abundance estimates of 1.37/km^2 and 31,512 for the Sulu Sea. Miyazaki et al. (1996) reported spinner dolphins during surveys off eastern Mindanao, Philippines, in January–March 1993–1995. During surveys off northern West Papua, Indonesia, the spinner dolphin was the most common cetacean species sighted, with encounter rates of 0.137–0.388/km (Borsa and Nugroho 2010). During those surveys, 19 sightings of spinner dolphins were made, 11 of which were reported for the Halmahera Sea.

The spinner dolphin is expected to occur throughout the Mariana Islands (Trianni and Kessler 2002; Jefferson et al. 2008), but only one sighting was made during a January–April 2007 survey in the area (SRS-Parsons et al. 2007; Fulling et al. 2011). Spinner dolphins are also known to occur in Micronesia and Palau (SPREP 2012). They have also been sighted in Papua New Guinea during surveys by Visser and Bonoccorso (2003) and Visser (2007); sometimes they were seen in association with killer whales (Visser and Bonoccorso 2003). Miyazaki and Wada (1978) also reported sightings of spinner dolphins in the EEZ of Papua New Guinea, and there were two sightings near the proposed survey sites WP-3 and WP-4. Spinner dolphins have also been sighted during surveys in the Solomon Islands (Miyazaki and Wada 1978; Oremus 2011).

There are three OBIS records of spinner dolphins in or near the proposed study area: one off northwestern Papua New Guinea, one near west New Britain, Papua New Guinea, and one in the Solomon Islands (IOC 2013).

Striped Dolphin (*Stenella coeruleoalba*)

The striped dolphin occurs in temperate and tropical regions of the western Pacific, ranging from Russian waters south to Australia and New Zealand. Striped dolphins are not considered common in Southeast Asia, but they are known to occur in the South China Sea, including the Philippines (Parsons et al. 1995; Perrin et al. 2005). Its presence in Indonesia is not confirmed (Rudolph et al. 1997; Perrin et al. 2005).

Striped dolphins were sighted during surveys in January–April 2007 in the Mariana Islands (SRS-Parsons et al. 2007; Fulling et al. 2011) and during surveys in Micronesia (Miyazaki and Wada 1978). Striped dolphins are also known to occur in Palau and the Solomon Islands, but there are no records for Papua New Guinea (Miller 2007; SPREP 2012). There are no OBIS sightings of striped dolphins in or near the proposed survey area (IOC 2013).

Fraser's Dolphin (*Lagenodelphis hosei*)

In Asia, Fraser's dolphin is known to occur in the East and South China seas (Parsons et al. 1995; Perrin et al. 2005). It was sighted during surveys of the Sulu Sea and central Philippines, including northern Mindanao (Dolar et al. 1997, 2006). Dolar et al. (2006) provided density and abundance estimates of 0.58/km^2 and 13,518 for the Sulu Sea. Miyazaki et al. (1996) also reported Fraser's dolphins during surveys off eastern Mindanao, Philippines, during January–March 1993–1995. Sightings have also been made off West Papua and other provinces throughout Indonesia (Rudolph et al. 1997; Kahn and Pet 2003).

Fraser's dolphins have also been sighted in the EEZs of Micronesia and Papua New Guinea during surveys by Miyazaki and Wada (1978). Fraser's dolphins are also known to occur in the Solomon Islands, and there are unconfirmed records for Palau (Miller 2007). There are no OBIS sightings of Fraser's dolphin in or near the proposed survey area (IOC 2013).

Risso's Dolphin (*Grampus griseus*)

In the western Pacific Ocean, Risso's dolphin ranges from the Kuril Islands to New Zealand and Australia. They are known to occur in the East and South China seas (Parsons et al. 1995; Perrin et al. 2005) and have been sighted in the Philippines (Perrin et al. 2005) and Indonesia (Rudolph et al. 1997; Khan and Pet 2003). Risso's dolphins have been sighted during surveys of the Sulu Sea and central Philippines, including northern Mindanao (Dolar et al. 1997, 2006). Dolar et al. (2006) provided density and abundance estimates of 0.03/km^2 and 1514 for the Sulu Sea. During surveys off northern West Papua, Indonesia, Borsa and Nugroho (2010) reported two Risso's dolphin sightings, with an encounter rate of 0.016/km, but this sighting was not made in the Halmahera Sea (Borsa and Nugroho 2010). Sightings have also been made off Papua New Guinea, including the Bismarck Sea (Miyazaki and Wada 1978; Visser 2007). In addition, Risso's dolphin has been sighted during surveys in the Solomon Islands (Miyazaki and Wada 1978; Oremus 2011). No Risso's dolphins were sighted during the January–April 2007 survey in the Mariana Islands (SRS-Parsons et al. 2007), but Miyazaki and Wada (1978) reported a sighting within the EEZ of Guam. There are unconfirmed records for Palau, but no records for Micronesia (Miller 2007).

There are no OBIS sightings of Risso's dolphin in or near the proposed survey area (IOC 2013). Nonetheless, this species could be encountered during the proposed surveys.

Melon-headed Whale (*Peponocephala electra*)

The range of the melon-headed whale in the western Pacific includes the waters from Japan to Australia. In Southeast Asia, it is known to occur in the South China Sea, including the Philippines (Perrin et al. 2005) and Indonesia (Rudolph et al. 1997; Khan and Pet 2003). Strandings have also been reported for Indonesia, including West Papua (Wild And Science 2013). Melon-headed whales were sighted during surveys of the central Philippines, including northern Mindanao, with an estimated density of 0.04/km^2 and an abundance of 921 for the Sulu Sea (Dolar et al. 2006).

There are also records of this species for the Mariana Islands (Kami and Hosmer 1982; Donaldson 1983; SRS-Parsons et al. 2007; Jefferson et al. 2008; Fulling et al. 2011), and they have been sighted in Micronesia during surveys by Miyazaki and Wada (1978), in Palau (SPREP 2012), and in the Bismarck Sea off Papua New Guinea (Visser 2007). Melon-headed whales are known to occur in the Solomon Islands (Miller 2007; SPREP 2012). There are no OBIS sightings of melon-headed whale in or near the proposed survey area (IOC 2013).

Pygmy Killer Whale (*Feresa attenuata*)

Little is known about the pygmy killer whale in most of its range, but it is sighted frequently in the eastern tropical Pacific, Hawaii, and Japan (Donahue and Perryman 2009). Dolar et al. (2006) made one sighting of pygmy killer whales during surveys of the central Philippines, north of Mindanao. Pygmy killer whales have also been reported for Indonesia (Rudolph et al. 1997; Khan and Pet 2003) and the South China Sea (De Boer 2000).

There was one sighting of a group of six pygmy killer whales during surveys in January–April 2007 in the Mariana Islands (SRS-Parsons et al. 2007; Fulling et al. 2011). They are also known to occur in Palau and Papua New Guinea, but not in Micronesia (SPREP 2012). There are no OBIS sightings of pygmy killer whale in or near the proposed survey area (IOC 2013).

False Killer Whale (*Pseudorca crassidens*)

In the western Pacific, the false killer whale is distributed from Japan south to Australia and New Zealand. In Southeast Asia, the false killer whale is known to occur in the South China Sea, including the Philippines (De Boer 2000; Perrin et al. 2005) and Indonesia (Rudolph et al. 1997; Khan and Pet 2003). During surveys off northern West Papua, Indonesia, Borsa and Nugroho (2010) reported two sightings of false killer whales, one of which was made in the Halmahera Sea (Borsa and Nugroho 2010). The encounter rates in the Halmahera Sea and adjacent waters were 0.006–0.008/km (Borsa and Nugroho 2010).

Sightings have also been reported during surveys in January–April 2007 in the Mariana Islands (SRS-Parsons et al. 2007; Fulling et al. 2011), where there are an estimated 6000 false killer whales (Miyashita 1993). There are also unconfirmed records for Palau, but none for Micronesia (Miller 2007), although one sighting was made near Micronesia at ~4.9°N, 138.6°E (Miyazaki and Wada 1978). Sightings have also been reported for Papua New Guinea, including the Bismarck Sea (Miyazaki and Wada 1978; Visser 2007). False killer whales have also been sighted during surveys in the Solomon Islands (Oremus 2011). In the OBIS database, there are two records of pygmy killer whales near the Manus Islands, Papua New Guinea, and one record off southern Papua New Guinea (IOC 2013).

Killer Whale (*Orcinus orca*)

In Asia, the killer whale is known to occur in the East China Sea and the Philippines (Perrin et al. 2005) as well as Indonesia (Rudolph et al. 1997; Khan and Pet 2003). A killer whale sighting was made during 1994–1995 surveys in the central Philippines (Dolar et al. 2006). There are a few sightings (most unconfirmed) of killer whales off Guam (Eldredge 1991), and there was a badly decomposed killer whale found stranded on Guam in August 1981 (Kami and Hosmer 1982).

Killer whales are also known to occur off Palau and Micronesia (SPREP 2012) and in Papua New Guinea (Visser 2007). Most sighting records are for Kimbe Bay, west New Britain, but sightings have also been made in other parts of the Bismarck Sea, including six sightings near the proposed survey Sites WP-5 and WP-6, and in the Solomon Sea (Visser and Bonoccorso 2003). Killer whales have been reported for 10 months of the year there, with group sizes ranging from one to ~20 (Visser and Bonoccorso 2003). Calves were mostly seen during April (Visser 2007). Killer whales are also known to occur in the Solomon Islands (Miller 2007; SPREP 2012). In the OBIS database, there is one record of a killer whale for the Solomon Islands, but none in the proposed survey area (IOC 2013).

Short-finned Pilot Whale (*Globicephala macrorhynchus*)

The range of the short-finned pilot whale in the western Pacific includes the waters from Sakhalin Island, Russia, south to Australia and New Zealand. In Southeast Asia, it is known to occur in the South China Sea, including the Philippines and Indonesia (Perrin et al. 2005). Short-finned pilot whales were sighted during surveys of the Sulu Sea and central Philippines, including northern Mindanao (Dolar et al. 1997, 2006). Dolar et al. (2006) provided density and abundance estimates of 0.32/km^2 and 7493 for the Sulu Sea. During surveys off northern West Papua, Indonesia, Borsa and Nugroho (2010) reported a sighting of 18 short-finned pilot whales, with an encounter rate of 0.019/km, but this sighting was not made in the Halmahera Sea (Borsa and Nugroho 2010).

Short-finned pilot whales are known to occur in Micronesia (Miller 2007; SPREP 2012) and in the Mariana Islands (Miyashita et al. 1996). There were four sightings of short-finned pilot whales during a January–April 2007 survey in the Mariana Islands (SRS-Parsons et al. 2007; Fulling et al. 2011). There are no records for Palau (Miller 2007; SPREP 2012). Short-finned pilot whales have been sighted during surveys in the Solomon Islands (Oremus 2011), and they were sighted off Papua New Guinea during surveys in January–March 1976 (Miyazaki and Wada 1978). There are no OBIS sightings of short-finned pilot whale in or near the proposed survey area (IOC 2013).

Sea Turtles

Five 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 area. A sixth species, the flatback turtle (*Natator depressus*), is endemic to the continental shelf of Australia and southern New Guinea; this species does not have an oceanic pelagic phase and is not expected to occur in the proposed study area.

General information on the taxonomy, ecology, distribution and movements, and acoustic capabilities of sea turtles are given in § 3.4.1 of the PEIS. The general distribution of sea turtles in the western North Pacific Ocean is discussed in § 3.4.3.7 of the PEIS. The rest of this section deals specifically with their distribution within the proposed survey area in the western tropical Pacific.

(1) Leatherback Turtle (*Dermochelys coriacea*)

In the Pacific Ocean, the leatherback turtle has been reported from 71°N to 42°S (NMFS and USFWS 1998a, 2007a). There are 28 nesting sites in the western Pacific Ocean, with ~5000–9200 nests annually (Dutton et al. 2007). The northwest coast of Papua, Indonesia, is thought to have the largest leatherback nesting area in the Pacific Ocean (Hitipeuw et al. 2007). However, major leatherback turtle nesting areas are also known in Papua New Guinea, the Solomon Islands, and Vanuatu, with fewer nesting in Fiji, Malaysia, and Australia (NMFS and USFWS 2007a). Leatherback turtles are sighted regularly near Hinatuan Bay, northeastern Mindanao, Philippines (Byrne and Hines 2005), and strandings have been reported for southern Mindanao (Lucero et al. 2011).

In West Papua, Indonesia, leatherbacks are distributed from Waigeo Island to Yapen Island (Tomascik et al. 1997 *in* Putrawidjaja 2000). Bird's Head Peninsula, West Papua, Indonesia, is a major nesting site (Putrawidjaja 2000; Shanker and Pilcher 2003). Nesting occurs there year-round, with a peak in nesting activity during May–September at Jamursba-Medi beach and October–March at Wermon beach (Hitipeuw et al. 2007). Feeding leatherbacks have also been seen in Cendrawasih Bay to the east of Bird's Head Peninsula (Putrawidjaja 2000). Leatherbacks have also been sighted in the waters around Raja Ampat Islands, west of Bird's Head Peninsula (Hitipeuw et al. 2007).

In Papua New Guinea, nesting occurs during November–March, with peak activity during December–January (Benson et al. 2007). Along a 2-km stretch at Kamiali, southeast Papua New Guinea, 415 nests were counted in 2004, and 41–71 females were estimated to have nested between 2000/2001 and 2003/2004 (Benson et al. 2007). Satellite-tagged leatherback turtles traveled from nesting beaches in Papua New Guinea to foraging areas in the high latitudes of the South Pacific (Benson et al. 2007).

Leatherback turtles are also known to occur in Palau, but not in Micronesia (SPREP 2012). There are no OBIS sightings of leatherback turtles near the proposed survey area in the western Pacific Ocean (IOC 2013). Nonetheless, leatherbacks could be encountered during the proposed surveys.

(2) Green Turtle (*Chelonia mydas*)

Major nesting sites in the western Pacific include Raine Island off eastern Australia, where ~25,000 females nest, Indonesia, Malaysia, and the Philippines (Shanker and Pilcher 2003; NMFS and USFWS 2007b). Minor sites include China, Taiwan, Japan, Micronesia, Papua New Guinea, and the Solomon Islands (NMFS and USFWS 2007b). Existing nesting sites in China and Taiwan are located on only a few subtropical or tropical beaches, and islands in the South China Sea (Chan et al. 2007). Nesting can occur throughout the year, but peaks during July–August (Cheng 2002).

In Southeast Asia, green turtles are the mostly widely distributed turtle species (Shanker and Pilcher 2003). In Indonesia, the green turtle is the most abundant turtle species; Moosa (2000) reported that more than 25,000 females are estimated to nest in western Indonesia annually. Green turtles are also known to nest on Bird's Head Peninsula, West Papua (Tenguh 2000 *in* Putrawidjaja 2000); Cendrawasih Bay also has nesting habitat for green turtles (Putrawidjaja 2000). In the Tawi-Tawi Turtle Islands in southwestern Mindanao, Philippines, there are an estimated 10,000–20,000 nests (Nasir et al. 1999 and Chan 2001 *in* Shanker and Pilcher 2003) with an annual egg production of 1.4 million (Cruz 2002 *in* NMFS and USFWS 2007b). In Hinatuan Bay, northeastern Mindanao, there are ~15 sea turtle nesting sites (Byrne and Hines 2005), and nesting green turtles have also been reported for southern Mindanao, ~100 km from proposed survey Site WP-8, by Lucero et al. (2011). Green turtles are known to be caught incidentally by fishing vessels off eastern Mindanao (Byrne and Hines 2005).

Green turtles are also known to occur in Palau, Micronesia, and Papua New Guinea (SPREP 2012). Although there are no OBIS sightings of green turtles near the proposed survey area (IOC 2013), these turtles could be encountered during the proposed surveys.

(3) Loggerhead Turtle (*Caretta caretta*)

Loggerhead turtle nesting in the Pacific Ocean is restricted to the western region; the two main nesting stocks in Japan and Australia/New Caledonia have been identified as genetically distinct (NMFS and USFWS 2007c). Telemetry studies, mark-recapture data, demographics, diet analysis, and oceanographic patterns suggest that North Pacific loggerhead turtles, mostly born in southern Japan, are transported as hatchlings and juveniles to the North Pacific by the Kuroshio Current (NMFS 2002). They spend the next 2–6 years moving from west to east, feeding along convergence and frontal zones. Loggerheads arrive at the U.S. west coast as juveniles, and feed along the Baha California coast on pelagic red crabs. When mature, they migrate back to natal beaches in Japan and remain in the western Pacific, migrating annually between nesting beaches and feeding grounds on the continental shelves of the South and East China seas (Nichols et al. 2000; Hatese et al. 2002; Zhu 2002; Nichols 2005; Parker et al. 2005).

Loggerhead turtles are known to occur in Indonesia but do not nest there (Moosa 2000). One loggerhead turtle was reported as bycatch by fishing vessels off eastern Mindanao, Philippines, during 1997–2002 (Byrne and Hines 2005), but none were reported as sighted or stranded for southern Mindanao during 2004–2009 (Lucero et al. 2011). Loggerhead turtles have also been sighted throughout the South Pacific Islands region, including Palau and Papua New Guinea (SPREP 2012), New Caledonia, and the Solomon Islands (Limpus and Limpus 2003 *in* NMFS and USFWS 2007c). There are no OBIS sightings of loggerhead turtles near the proposed survey area (IOC 2013). Nonetheless, loggerhead turtles could be encountered during the proposed surveys.

(4) Hawksbill Turtle (*Eretmochelys imbricata*)

In the western Pacific, major hawksbill turtle nesting areas can be found in Australia, Indonesia, Papua New Guinea, and the Philippines (NMFS and USFWS 2007d). There are ~15 sea turtle (including hawksbill) nesting sites in Hinatuan Bay, northeastern Mindanao, Philippines (Byrnes and Hines 2005), and nests have also been reported for southern Mindanao, ~100 km from proposed survey Site WP-8, by Lucero et al. (2011). In Indonesia, hawksbill turtles are abundant (Moosa 2000). Nesting has been reported for Bird's Head Peninsula and Cendrawasih Bay, West Papua (Putrawidjaja 2000). In total, 1362–3026 nests occur in Indonesia annually (NMFS and USFWS 2007d). In Papua New Guinea, 500–1000 females nest annually, and <500 nest in the Philippines (NMFS and USFWS 2007d). Hawksbill turtles are also known to occur in the Yellow, East China, and South China seas.

The hawksbill turtle is one of the most widespread turtle species in the Pacific Islands region (SPREP 2007). They have been reported to forage around nearly all of the island groups of Oceania, including Palau, Micronesia, and Papua New Guinea (SPREP 2007, 2012). Minor nesting sites are known for the Solomon Islands, Palau, Guam, and Micronesia (NMFS and USFWS 2007d). An estimated 300 females nest in Micronesia annually, and 20–50 nest in Palau (NMFS and USFWS 1998b). There are no OBIS sightings of hawksbill turtles near the proposed survey area off (IOC 2013). Nonetheless, hawksbill turtles could be encountered during the proposed surveys.

(5) Olive Ridley Turtle (*Lepidochelys olivacea*)

In the western Pacific, olive ridley turtle nesting colonies occur in Australia, Brunei, Malaysia, Indonesia, and Vietnam (Shanker and Pilcher 2003; NMFS and USFWS 2007e). In Indonesia, there is a small nesting site at Bird's Head peninsula with <100 nests (Teguh 2000 *in* Putrawidjaja 2000), and they have also been reported nesting at Jayapura Bay, Papua (Putrawidjaja 2000). There are ~15 sea turtle (including olive ridley) nesting sites in Hinatuan Bay, northeastern Mindanao, Philippines (Byrne and Hines 2005), and nests have been reported for southern Mindanao, ~100 km from proposed survey Site WP-8, by Lucero et al. (2011). Olive ridley turtles are sighted throughout the Pacific Islands region, including Palau (SPREP 2012). There are no records for Micronesia or Papua New Guinea (SPREP 2012).

There are ~9 OBIS sightings of olive ridley turtles in the Halmahera Sea, and numerous other ones near Papua and West Papua, Indonesia (Goyne and Godley 2005 *in* IOC 2013). There are also two olive ridley sightings east of the proposed survey area, at 4.5°N, 154.5°E, in the Solomon Islands, and off southern Papua New Guinea (Goyne and Godley 2005 *in* IOC 2013).

Seabirds

Two ESA-listed seabird species could occur at or near some of the Project study sites (WP-5-, 6-, 7, and -8, S-1a, -1b): The ***Endangered*** Christmas Island frigatebird or Andrew's frigatebird and the ***Threatened*** Heinroth's shearwater. No ESA-listed seabirds would occur at the sites in Micronesia or in International Waters south of there (WP-1, -2, -3, -4). 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) Christmas Island Frigatebird (*Fregata andrewsi*)

The Christmas Island Frigatebird, which breeds only on Christmas Island, is listed as ***Endangered*** under the ESA (USFWS 1976). The species has likely always had a small population and restricted range. The population could have been 6300 breeding pairs historically but was reduced to 1171 by 2003 (BirdLife International 2013a). They begin to form pairs in late February and most young hatch from mid April to late June. The young remain dependant on the adults for over a year, fledging after six months and finally becoming independent nine months after fledging (Hill and Dunn 2004). Non-breeding and juvenile birds wander widely around Southeast Asia, and breeding birds may forage thousands of kilometers from the nest site (BirdLife International 2013a).

Recently, this species has been sighted off the north coast of North Sulawesi, Indonesia (Tebb et al. 2008) and in the Sulu Sea, Philippines, where up to 70 have been observed roosting (Jensen and Tan 2010).

(2) Heinroth's Shearwater (*Puffinus heinrothi*)

Heinroth's shearwater is listed as *Threatened* under the ESA (USFWS 2010). BirdLife International (2013b) estimates the world population is 350–1000. It occurs throughout the Bismarck Sea ranging as far as Madang on the north coast of Papua New Guinea. It may breed on inaccessible mountains in Papua New Guinea, including Watom Island in the Bismarck Sea and Bougainville in the Solomon Sea, but the locations of breeding colonies have not been confirmed (BirdLife International 2013b).

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

There are no ESA-listed fish species in or near the proposed survey areas. There is one species that is a candidate for ESA listing that could occur there, the scalloped hammerhead shark *Sphyrna lewini*, a coastal pelagic species that also occurs offshore to a depth of 1000 m (NOAA 2012). The scalloped hammerhead shark has been reported in Indonesia and the Philippines (Baum et al. 2007). There is no Essential Fish Habitat (EFH) and there are no habitats of particular concern (HAPC) in the proposed survey area.

Fisheries

Information on the commercial fisheries during 2002–2006 described below is from all water depths in the Micronesia EEZ (SAUP 2011a), both inshore and offshore waters of the Papua New Guinea EEZ (SAUP 2011b), the eastern Indonesia EEZ (SAUP 2011c), and the Philippines EEZ (SAUP 2011d). Other sources used here are the Western and Central Pacific Fisheries Commission for the tuna fishery for Micronesia (WCPFC 2009) and Papua New Guinea (Kumoru 2010), the country status report of Indonesia's Indian Ocean tuna fishery (Proctor et al. 2003), and fisheries production data from 2010 made available by the Republic of the Philippines Department of Agriculture Bureau of Fisheries and Aquatic Resources (BFAR 2010). The proposed seismic sites WP-3 and WP-4, located in International Waters between the Micronesia and Papua New Guinea EEZs, are located in deep water of the open ocean, thus are more comparable to the proposed survey sites in Micronesia (WP-1 and WP-2) than those in Papua New Guinea, which include shallow, nearshore sites.

(1) Micronesia

Commercial fishery catches are dominated by tuna, with skipjack, yellowfin, bigeye, and albacore generally comprising the primary target species (Kinch et al. 2010; Harley et al. 2011). The total aggregated catch was 114,627 t during 2002–2006, with catch values 19,680–24,772 t per year. Tuna and billfishes accounted for ~96% of the aggregated catch weight, with most of the rest of the catch being "other fishes and invertebrates" (~4%). Most of the catch by country was dominated by the Marshall Islands (43%), the Solomon Islands (30%), and Micronesia (26%), with minor contributions by Tuvalu (2%) and other countries (0.02%). The most predominant gear type in this area is the purse seine, comprising ~88% of the total catch during 2002–2006, with lesser components (≤5% each) of pole line, longline, gillnets, lines, hooks or gorges, bottom and mid-water trawls, squid hooks, driftnets, and other gear.

The majority of commercial fishing effort for tuna during 2006–2008, particularly via purse seine and longline, was carried out in the eastern and southeastern portion of the Micronesia EEZ (WCPFC 2009), well away from the proposed seismic sites WP-1–WP-4.

(2) Papua New Guinea

The Papua New Guinea commercial fishery primarily targets tuna species, particularly skipjack, yellowfin, and albacore (Kumoru 2010; FAO 2012). The aggregated catch was 1,236,802 t during 2002–2006, with catches 178,759–294,331 t per year (SAUP 2011b). Tuna and billfishes (84%) and "other fishes and invertebrates" (16%) composed the majority of the catch. Most of the catch was taken locally by Papua New Guinea (92%), and most of the rest was taken by the Marshall Islands (3%), the Solomon Islands (2%), and Micronesia (2%). The primary gear types are the purse seine (76%), gillnets (16%), pole line (4%), longline (2%), and hooks or gorges (2%). Purse seines are used by both domestic and

foreign access vessels. The use of longlines and handlines is considered a national activity, and all such vessels fish exclusively in the Papua New Guinea EEZ (Kumoru 2010).

There was a decline in total longline catch from 4000 t in 2006 to 2217 t in 2009, largely a result of reductions in fishing effort (Kumoru 2010). The longline fishery primarily occurs to the east and south-east of Papua New Guinea, far from the proposed seismic sites. Much of the catch and effort in 2008 and 2009 for the domestic purse seine fishery took place in the general vicinity of the proposed seismic sites, although the specific months during which the fishery was conducted were not indicated (Kumoru 2010). The foreign purse seine fishery during 2005–2009 mainly occurred in the deeper waters to the north and northeast of Papua New Guinea, away from the proposed seismic sites with the exception of 2007. In recent years, the vast majority of the purse seine catch has been by foreign vessels (Kumoru 2010).

(3) Indonesia

Indonesia is a major participant in the Indian Ocean fishery, and is considered one of the most important tuna and billfish fishing countries in the region, with principal commercial and artisanal fishery species consisting of yellowfin, bigeye, albacore and southern bluefin tunas, along with black and blue marlin and sailfish (Proctor et al. 2003). The total aggregated catch during 2002–2006 in the eastern EEZ was 10,237,921 t, with catches 1,914,578–2,141,925 t per year (SAUP 2011c). "Perch-likes" (44%), other fishes and invertebrates (22%), and tuna and billfishes (13%) made up the majority of the catch, with lesser contributions of "herring-likes" (8%), anchovies (6%), crustaceans (5%), sharks and rays (2%), and molluscs and flatfishes (< 1% each). This catch was taken almost entirely by Indonesia-flagged vessels (96%) with small amounts taken by the Philippines (4%). Gillnets (25%) and purse seines (21%) were predominantly used, along with mid-water trawls (14%), bottom trawls (11%), other gear (7%), shrimp trawls, set gillnets, troll lines (4%), hooks or gorges (4%), lines (3%), seine nets (2%), and cast nets (1%).

The industrial tuna fishery primarily uses longlines and purse seines, whereas the local artisanal fisheries typically use gillnets, small scale purse seines, troll lines, and seine nets (Merta 2000 *in* Proctor et al. 2003). Indonesia is a world leader as an international tuna supplier (FISHSTAT data and Globefish 2008 *in* SFP 2009); the Food and Agriculture Organization of the United Nations (FAO) suggested that whereas much of the tuna catch in the western central Pacific Ocean is caught within the EEZ, most of the eastern Indian Ocean catch is taken outside of Indonesia's EEZ (FAO n.d. and FAO 2005 *in* SPF 2009). Catch and/or catch per unit effort (CPUE) data could not be located for the proposed seismic area WP-7; however, given the importance of the Indonesian fishery, it is possible that at least some fishing vessels could be present near the site during the proposed surveys.

(4) Philippines

In 2009, the Philippines ranked in sixth place among the top fish producing countries in the world, including production of fish, crustaceans, mollusks, and aquatic plants (FAO website *in* BFAR 2010). The aggregated catch in the Philippines EEZ during 2002–2006 was 8,049,643 t, with catches 1,501,171–1,722,857 t per year (SAUP 2011d). Half of the total aggregated catch consisted of "perch-likes" (51%), while most of the rest consisted of "herring-likes" (18%), tuna and billfishes (15%), other fishes and invertebrates (7%), anchovies (4%), crustaceans (5%), and sharks and rays (0.2%). All of the catch was taken by Philippine vessels. A variety of fishing gear was used, namely mid-water trawls and purse seines (21% each), bottom trawls (13%), gillnets (12%), other gear (10%), and lines, troll lines, boat seines, traps, seine nets, shrimp trawls and set gillnets (≤5% each).

The total commercial fisheries production across all Philippines provincial fisheries management Regions in 2010 was ~1,242,100 t (BFAR 2010). In terms of commercial fisheries production, major species sought and/or used commercially were Indian sardines (21.4%), round scad (15.7%), tuna—including skipjack (14.3%), yellowfin (6.9%), frigate (6.5%), and eastern little tuna (1.9%)—and "other species" (18.4%) (BFAR 2010). According to maps of the Philippines provincial fisheries administrative boundaries (Hibionada, E.M.C. 2012, pers. comm.), the proposed seismic site WP-8 is situated nearest the Management Region XI, which contributed the fourth lowest commercial production value (1.0%) out of all 17 management regions in 2010 (BFAR 2010). The most commercially productive management regions in 2010 (ARMM, IX, and IV-B) are located to the far west and/or northwest of Region XI, thus most commercial fishing activity would likely take place well away from the proposed seismic site.

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 September–October 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 surveys while they are underway, some behavioral disturbance could result, but this would be localized and short-term.

Tolerance.—Numerous studies have shown that pulsed sounds from airguns are often readily detectable in the water at distances of many kilometers. 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 hear airgun sounds and sometimes exhibit localized avoidance (see PEIS). Based on available data, it is likely that sea turtles would 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 surveys. However, those criteria were established before there was any information about minimum received levels of sounds necessary to cause auditory impairment in marine mammals.

Recommendations for science-based noise exposure criteria for marine mammals, frequency-weighting procedures, and related matters were published by Southall et al. (2007). Those recommendations were never formally adopted by NMFS for use in regulatory processes and during mitigation programs associated with seismic surveys, although some aspects of the recommendations have been taken into account in certain environmental impact statements and small-take authorizations. NMFS is currently moving toward adoption of new procedures taking at least some of the Southall et al.

recommendations into account (Scholik-Schlomer 2012; NMFS 2013). The new noise exposure criteria for marine mammals will 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 would 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 surveys would be much less than during the aforementioned studies. Also, recent monitoring studies show that some sea turtles do show localized movement away from approaching airguns. At short distances from the source, received sound level diminishes rapidly with increasing distance. In that situation, even a small-scale avoidance response could result in a significant reduction in sound exposure.

The PSOs stationed on the *Revelle* 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 surveys 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; and 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 GI airguns, as a result of their 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 by ~1030 km of seismic surveys in the tropical western Pacific 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 2). 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.

The only densities reported for the overall proposed survey area are for 8 species sighted during vessel-based surveys in coastal and oceanic waters of the Sulu Sea, Philippines, covering an area of ~23,000 km^2, during May–June 1994 and 1995 (Dolar et al. 2006). To supplement those density data, we used densities for 7 other species expected to occur in the proposed survey area that were sighted during a systematic vessel-based marine mammal survey in Guam and the southern Commonwealth of the Northern Mariana Islands (CNMI) during January–April 2007 (Fulling et al. 2011). The cruise area was defined by the boundaries 10–18°N 142–148°E, encompassing an area ~585,000 km^2. For 5 species not sighted in either survey but expected to occur in the proposed survey area, we also used densities for the "outer EEZ stratum" of Hawaiian waters, covering ~2,240,000 km^2, based on a survey conducted in August–November 2002 (Barlow 2006). All three surveys used standard line-transect protocols

developed by NMFS Southwest Fisheries Science Center (SWFSC). Survey effort was 2313 km in the Sulu Sea, 11,033 km in the CNMI, and 13,500 km in Hawaii.

The densities mentioned above had been corrected, by the original authors, for trackline detection probability bias, and in one of the three areas, for availability bias. Trackline detection probability bias is associated with diminishing sightability with increasing lateral distance from the track line [$f(0)$]. Availability bias refers to the fact that there is less-than 100% probability of sighting an animal that is present along the survey track line, and it is measured by $g(0)$. Dolar et al. (2006) and Fulling et al. (2011) did not correct the CNMI densities for $g(0)$, which, for all but large (>20) groups of dolphins (where $g(0) = 1$), resulted in underestimates of density. 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 5 shows the density estimates 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 surveys if no animals moved away from the survey vessel. The *Requested Take Authorization* is given in the far right column of Table 5. We have included a *Requested Take Authorization* for the mean group size for species for which densities were not available but for which there were sighting records in the proposed survey area, and for species whose calculated takes were less than the mean group size for that species. Mean group sizes used were from the surveys whose densities were used, or from Jefferson et al. (2008) for species not sighted during the surveys.

It should be noted that the following estimates of exposures to various sound levels assume that the proposed surveys 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.

Consideration should be given to the hypothesis that delphinids are less responsive to airgun sounds than are mysticetes, as referenced in both the PEIS and "Summary of Potential Airgun Effects" of this document. The 160-dB (rms) criterion currently applied by NMFS, on which the following estimates are based, was developed based primarily on data from gray and bowhead whales. The estimates of "takes by harassment" of delphinids given below are thus considered precautionary. New criteria for behavioral harassment based on dose-response-type curves or risk functions are being considered by NMFS. Available data suggest that the current use of a 160-dB criterion may be improved upon, as behavioral response may not occur for some percentage of odontocetes and mysticetes exposed to received levels >160 dB, while other individuals or groups may respond in a manner considered as taken to sound levels <160 dB (NMFS 2013). It has become evident that the context of an exposure of a marine mammal to sound can affect the animal's initial response to the sound (NMFS 2013).

TABLE 5. Densities and estimates of the possible numbers of individuals that could be exposed to ≥160 dB re 1 μPa_{rms} during SIO's proposed seismic surveys in the tropical western Pacific during September–October 2013. The proposed sound source is two 45-in^3 GI guns. Species in italics are listed under the ESA. The column of numbers in boldface shows the numbers of Level B "takes" for which authorization is requested.

Species	Reported Density (#/1000 km^2) Fulling et al. (2011)	Barlow (2006)[1]	Dolar et al (2006)	Correction Factor[2]	Estimated Density (#/1000 km^2)	Ensonified Area (km^2)	Calculated Take[3]	% of Regional Pop'n[4]	Requested Level B Take Authorization
Mysticetes									
Humpback whale						*1063.8*	*0*	*0.03*	***1***[5]
Minke whale						1063.8	0	0.01	**3**[5]
Bryde's whale	0.41				0.41	1063.8	0	0.01	**2**[5]
Omura's whale						1063.8	0	N/A	**2**[5]
Sei whale	*0.29*				*0.29*	*1063.8*	*0*	*0.02*	***2***[5]
Fin whale						*1063.8*	*0*	*0.04*	***7***[5]
Blue whale						*1063.8*	*0*	*N/A*	***2***[5]
Odontocetes									
Sperm whale	*1.23*				*1.23*	*1063.8*	*1*	*0.02*	***5***[5]
Pygmy sperm whale		3.19			3.19	1063.8	3	N/A	**3**
Dwarf sperm whale			10.00	0.5	5.00	1063.8	5	0.05	**5**
Cuvier's beaked whale		6.80			6.80	1063.8	7	0.04	**7**
Longman's beaked whale		0.45			0.45	1063.8	0	N/A	**18**[5]
Ginkgo-toothed beaked whale						1063.8	0	0.01	**2**[5]
Blainville's beaked whale		1.28			1.28	1063.8	1	0.01	**2**[5]
Rough-toothed dolphin	0.29				0.29	1063.8	0	0.01	**9**[5]
Bottlenose dolphin			110.00	0.5	55.00	1063.8	59	0.03	**59**
Pantropical spotted dolphin			650.00	0.5	325.00	1063.8	346	0.08	**346**
Spinner dolphin			1370.00	0.5	685.00	1063.8	729	0.10	**729**
Striped dolphin	6.16				6.16	1063.8	7	<0.01	**27**[5]
Fraser's dolphin			430.00	0.5	215.00	1063.8	229	0.08	**229**
Risso's dolphin			30.00	0.5	15.00	1063.8	16	0.02	**16**
Melon-headed whale			40.00	0.5	20.00	1063.8	21	0.07	**31**[5]
Pygmy killer whale	0.14				0.14	1063.8	0	0.02	**6**[5]
False killer whale	1.11				1.11	1063.8	1	0.06	**10**[5]
Killer whale		0.16			0.16	1063.8	0	0.08	**7**[5]
Short-finned pilot whale			320.00	0.5	160.00	1063.8	170	0.32	**170**

[1] Densities calculated from Table 4 of Barlow (2006) using the abundance in the outer EEZ stratum and the surface area of the stratum given on p. 452 of Barlow (2006)

[2] A correction factor of 0.5 was applied to the densities of Dolar et al. (2006) because those densities were from surveys that included coastal waters, and ~50% of the total ensonified area for the proposed surveys is in deep water, far offshore, where marine mammal densities are expected to be lower; see, e.g., densities in Fulling et al. (2011) and Barlow (2006)

[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 (Table 4); 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 in the proposed survey area and for species whose calculated takes were less than group size

(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 surveys, the transect lines are widely spaced relative to the 160-dB distance. Thus, the area including overlap is 1.07 x the area excluding overlap, so a marine mammal that stayed in the survey area during the entire survey could be exposed slightly more than once, 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 2) around each seismic line, and then calculating the total area within the buffers.

Applying the approach described above, ~851 km^2 (~1063.8 km^2 including the 25% contingency) would be within the 160-dB isopleth on one or more occasions during the proposed surveys. Because this approach does not allow for turnover in the mammal populations in the area during the course of the surveys, 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 *Revelle* 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 surveys is 1595 (Table 5). That total includes one cetacean listed as ***Endangered*** under the ESA, the sperm whale (0.03% of the regional population).

In addition, 8 beaked whales (mostly Cuvier's beaked whale) could be exposed during the surveys (Table 5). Most (98.9%) of the cetaceans potentially exposed are delphinids; the spinner dolphin, pantropical spotted dolphin, and Fraser's dolphin are estimated to be the most common delphinid species in the area, with estimates of 729 (0.10% of the regional population), 346 (0.08%), and 229 (0.08%) exposed to ≥160 dB re 1 μPa_{rms}, respectively.

(4) Conclusions for Marine Mammals and Sea Turtles

The proposed seismic project would involve towing a pair of 45-in^3 GI airguns that introduce pulsed sounds into the ocean. Routine vessel operations, other than the proposed seismic operations, are conventionally assumed not to affect marine mammals sufficiently to constitute "taking".

(a) Cetaceans

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 Marianas QAA; that Level A effects were highly unlikely; and that operations were unlikely to adversely affect ESA-listed species.

In this Draft 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 5). 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 olive 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 proposed survey area.

One deployment of each type of core would be made at each of the 10 sites. The core samplers are either piston corers with a 10-cm diameter barrel, gravity corers with a 10-cm diameter barrel, or a multicorer with 8 core sampling tubes ~10 cm in diameter. Although coring operations 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. The cables used to lower the core samplers are under tension, so the possibility of entanglement would be unlikely, if not impossible.

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

(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 surveys 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

Low-energy seismic profiles using a single 40-in^2 airgun were collected across Site WP-1 in 1977 and across Sites WP- and WP-4 in 1967. Low-energy seismic profiles using a single 45-in^2 GI airgun were also collected across and near Sites S1-a and S1-b in 1999. The proposed surveys by the *Revelle* would provide data to be included in a separate proposal submitted to IODP for funding consideration to collect drill core samples to extend the record of millennial climate variability of the western equatorial Pacific Ocean to the mid-Miocene. 2-D seismic characterization is required to determine the viability of the IODP drill sites, thus seismic data collected by the *Revelle* would help inform the viability of future drilling at the sites. A Programmatic Environmental Impact Statement was prepared for IODP-USIO drilling activities (IODP-USIO 2008) and an NSF Record of Decision was issued (NSF 2008). Should IODP consider funding a future proposal, it would evaluate if any additional environmental analysis were warranted.

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 *Revelle* in the foreseeable future. At the present time, the proponents of the surveys are not aware of other similar research activities planned to occur in the proposed survey area during the September–October 2013 timeframe, but research activities planned by other entities are possible, although unlikely.

(b) Vessel noise and collisions

Vessel traffic in and around the proposed seismic sites WP-1 to WP-4 in the Micronesia EEZ and in International Waters would consist of commercial shipping and commercial fishing vessels. These sites

are in the general vicinity of a relatively common shipping route between Papua New Guinea and the Orient. Based on data made available through the Automated Mutual-Assistance Vessel Rescue (AMVER) system managed by the U.S. Coast Guard, up to 14 commercial vessels per month passed near the proposed survey sites during 2007–2012 (USCG 2012). An examination of total vessel traffic in the Pacific Islands region from 2003 similarly indicated a frequency of 100–200 vessels/year around the proposed seismic sites (Anderson et al. 2003 *in* Kinch et al. 2010).

Vessel traffic around the proposed seismic sites in the Papua New Guinea EEZ would be similar to that of the Micronesia EEZ, including commercial shipping and commercial fishery vessels. The northern coastal region is a common shipping area, and sites WP-5 and WP-6 in particular are situated along shipping routes in the region between Papua New Guinea and the Orient. Analysis of the AMVER system indicated that up to 14 vessels/month passed by the sites during 2007–2012, with the exceptions of August 2008, June 2009, and July and August 2010, when 15–49 vessels/month were noted (USCG 2012). Anderson et al. (2003 *in* Kinch et al. 2010) similarly noted shipping traffic upwards of 200 vessels per year near the proposed seismic sites in 2003.

There is relatively little commercial vessel traffic in the area around WP-7 in the Indonesia EEZ. It is likely that commercial and artisanal fishery vessels comprise the majority of vessel traffic in the area. The AMVER system indicated that <4 vessels/month passed by the proposed seismic site during 2007–2012, with the exception of May 2011 during which up to 14 vessels were in the area (USCG 2012). Total vessel traffic was noted at 100–200 vessels/year in the general area in 2003 (Anderson et al. 2003 *in* Kinch et al. 2010).

The proposed seismic site WP-8 is situated in a somewhat common shipping route along the southeastern region of the Philippines, where traffic would consist of both commercial shipping and commercial fishery vessels. Examination of the AMVER system indicated that 5–14 commercial vessels per month passed near the site WP-8 during 2007–2012, with the exception of July 2011, when 15–49 commercial vessels passed through the area (USCG 2012). As of 2007, 89 commercial fishing operators and 269 commercial fishing vessels have been known to operate out of management Region XI, nearest to site WP-8 (BFAR Regulatory and Quarantine Division *in* BFAR 2010).

The total transit distance (~8050 km) by SIO's vessel *Revelle* would be minimal relative to total transit length for vessels operating in the proposed survey area during September–October. Thus, the combination of SIO'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 surveys 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. However, fishing operations at most of the proposed survey sites likely would be limited because of distance from shore (see § III). There may be some localized avoidance by marine mammals of fishing vessels near the proposed seismic survey area. SIO's operations in the proposed survey area are also limited (duration of ~26 days), consisting mostly of transit, and the combination of SIO'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. Proposed survey operations should not impede commercial fishing operations and the *Revelle* would avoid fishing vessels when towing seismic equipment. Operation of the *Revelle*, therefore, 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 Draft EA was prepared by LGL on behalf of SIO 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 SIO to NMFS, under the U.S. MMPA, for "taking by harassment" (disturbance) of small numbers of marine mammals, for this proposed seismic project.

SIO and NSF would coordinate the planned marine mammal monitoring program associated with the seismic surveys with any parties that express interest in this survey activity. SIO 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 SIO, the U.S. State Department will seek authorization from the Federated States of Micronesia, the Independent State of Papua New Guinea, the Republic of Indonesia, and the Republic of the Philippines for clearance to work in their EEZs.

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 (~26 days in September–October) 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 survey area, whereas some migrate north in summer, so altering the timing of the proposed project likely would result in no net benefits for any 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 millennial climate variability the western equatorial Pacific 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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