CENTRAL COASTAL CALIFORNIA SEISMIC IMAGING PROJECT

REQUEST FOR AN INCIDENTAL HARASSMENT AUTHORIZATION TO ALLOW THE INCIDENTAL TAKE OF MARINE MAMMALS DURING A MARINE GEOPHYSICAL SURVEY

Submitted to:

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LIST OF ACRONYMS

2D	Two Dimensional Seismic Survey
3D	Three Dimensional Seismic Survey
24/7	24 hours per day/7 days per week
^{o}C	degrees centigrade
^{o}F	degrees Fahrenheit
AAC	Active Acoustic Monitoring
ACOE/Corps	U.S. Army Corps of Engineers
AMS	Applied Marine Sciences
APCD	Air Pollution Control District
AWD	Accelerated Weight Drop
bar-m	Bar per meter pressure measurement
BOEMRE	Bureau of Ocean Energy Management, Regulation and Enforcement
CAA	Clean Air Act
CCCSIP	Central Coastal California Seismic Imaging Project
CD	Compact Disc
CDFG	California Department of Fish and Game
cm	Centimeters
CPA	Closest Point of Approach
CPFV	Commercial Passenger Fishing Vessels
CSLC	California State Lands Commission
CW	Continuous wave
dB	Decibel
dB re 1µPa	Decibels in reference to 1 micro Pascal
DCPP	Diablo Canyon Power Plant
DPS	Distinct Population Segments
DOD	Department of Defense
EFH	Essential Fish Habitat
EFHA	Essential Fish Habitat Assessment
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
ESA	Endangered Species Act
FB	Fish Block
FESA	Federal Endangered Species Act

LIST OF ACRONYMS

FM	Frequency Modulation
FMP	Fishery Management Plan
ft	Feet
Ftm	Fathom (six feet)
GPS	Global Positioning System
GIS	Geographic Information Systems
HAPC	Habitat Areas of Particular Concern
HESS	High Energy Seismic Survey
HESST	High Energy Seismic Survey Team
HFZ	Hosgri Fault Zone
hp	Horsepower
Hz	Hertz
IAGS	International Association of Geophysical Contractors
IHA	Incidental Harassment Authorization
in	Inch(es)
IWC	International Whaling Commission
in^2	Square inch(es)
in^3	Inches cubed
kg	Kilogram
kHz	Kilohertz
KM	Kilometer Marks
km	Kilometer(s)
km^2	Square kilometers
kPa	Kilopascal
kt	Knot (Nautical Miles per Hour)
L-DEO	Lamont-Doherty Earth Observatory
l	Liter(s)
lbs	Pounds
LOA	Letter of Authorization
m	Meter
m^2	Square meter
MBES	MultiBeam EchoSounder
MBNMS	Monterey Bay National Marine Sanctuary
MBTA	Migratory Bird Treaty Act

LIST OF ACRONYMS

mi	Mile
mi^2	Square mile
min	Minute
µPa	Micro Pascal
MLLW	Mean Lower Low Water
MMPA	Marine Mammal Protection Act
MMS	United States Minerals Management Service
MPA	Marine Protected Areas
ms	Millisecond
MSA	Magnuson-Stevens Fishery Conservation and Management Act
MWCP	Marine Wildlife Contingency Plan
M/V	Motor Vessel
NAAQS	National Ambient Air Quality Standards
NCCOS	National Centers for Coastal Ocean Science
NEPA	National Environmental Policy Act
NGO	Non-governmental Organization
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NSF	National Science Foundation
nT	NanoTesla
OBIS-SEAMAP	Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations
OEIS	Operational Environmental Impact Statement
OHWM	Ordinary High Water Mark
OSPR	California State Office of Oil Spill Prevention and Response
OWCN	Oiled Wildlife Care Network
PAM	Passive Acoustic Monitoring
PEIS	Programmatic Environmental Impact Statement
PFMC	Pacific Fishery Management Council
PG&E	Pacific Gas and Electric Company
pk-pk	Peak to Peak
Project	Central Coastal California Seismic Imaging Project
PSO	Protected Species Observer
psi	Pounds Per Square Inch

LIST OF ACRONYMS

PTS	Permanent Threshold Shift
RMS	Root Mean Squared
ROV	Remotely Operated Vehicle
rpm	Revolutions Per Minute
R/V	Research Vessel
SACLANT	Supreme Allied Commander, Atlantic
SBP	Sub-Bottom Profiler
SCB	Southern California Blight
sec	Second
SEL	Sound Exposure Levels
SERDP	Strategic Environmental Research and Development Program
SFZ	Shoreline Fault Zone
SMCA	State Marine Conservation Area
SML	Seafloor Mapping Lab
SMR	State Marine Reserve
SPL	Sound Pressure Level (RMS)
TTS	Temporary Threshold Shift
TWTT	Two-Way Travel Time
Uhl	Michael Uhl
USB	Universal Serial Bus
USCG	United States Coast Guard
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WERC	Western Ecological Research Center
WS	Withering Syndrome

1.0 OPERATIONS TO BE CONDUCTED

A detailed description of the specific activity or class of activities that can be expected to result in incidental taking of marine mammals.

The following updated project description was prepared by Pacific Gas and Electric Company (PG&E) in support of the proposed Offshore Central Coastal California Seismic Imaging Project (Project). This update reflects revisions to the project that have resulted as part of the permitting process and particular the recent California State Lands Commission project approval which resulted in the elimination of portions of the originally planned survey area and the expansion of the project to a two year work window. All Project related activities will occur within the central area of San Luis Obispo County, California (Figure 1). The following summarizes the proposed offshore deep seismic data collection survey operations proposed for 2012.

1.1 PROJECT PURPOSE

The purpose of the proposed survey is to conduct a High Energy Seismic Survey (HESS) in the vicinity of the Diablo Canyon Power Plant (DCPP) and known offshore fault zones near DCPP (Figure 1). The Project as proposed by Lamont-Doherty Earth Observatory (L-DEO), a part of Columbia University, in cooperation with PG&E consists of deploying seismic or sound sources and receivers at onshore and offshore locations to generate data that can be used to improve imaging of major geologic structures and fault zones in the vicinity of the DCPP.

The details of the proposed seismic studies are outlined in a Science Plan submitted to the National Science Foundation (NSF) by L-DEO, University of Nevada and Scripps Institution of Oceanography. NSF, as owner of the survey vessel *Marcus G. Langseth (R/V Langseth)*, will serve as the lead federal agency and will ensure the approval of the proposed Science Plan is in compliance with the National Environmental Policy Act (NEPA) of 1969.

These seismic studies would provide additional insights of any relationships or connection between the known faults as well as enhance knowledge of offshore faults in proximity to the Central California Coast and DCPP. The proposed deep (10 to 15 kilometers [km] or 6 to 9 miles [mi]), HESS (energy >2 kilo joule) would complement a previously completed shallow (<1 km [<0.6 mi]), low energy (<2 kilo joule) three dimensional (3D) seismic reflection survey.

The objectives of the proposed high energy 3D seismic survey are to:

- Record high resolution two dimensional (2D) and 3D seismic reflection profiles of major geologic structures and fault zones in the vicinity of the Central California Coast and DCPP.

- Obtain high-resolution deep-imaging (>1 km [>0.6 mi]) of the Hosgri and Shoreline fault zones in the vicinity of the DCPP to constrain fault geometry and slip rate (Scheduled for 2013 survey activities) .
- Obtain high-resolution deep-imaging (>1 km [>0.6 mi] depth) of the intersection of the Hosgri and Shoreline fault zones near Point Buchon.
- Obtain high-resolution deep-imaging (>1 km [>0.6 mi] depth) of the geometry and slip rate of the Los Osos fault, as well as the intersection of the Hosgri and Los Osos fault zones in Estero Bay.
- Augment the current regional seismic database for subsequent use and analysis through the provision of all data to the broader scientific and safety community.

The resulting data will provide significant societal benefit. The observations will be interpreted in the context of a global synthesis of observations bearing on earthquake rupture geometries, earthquake displacements, fault interactions, and fault evolution. Estimating the limits of future earthquake ruptures is becoming increasingly important as seismic hazard maps are based on geologists' maps of active faults and, locally, the Hosgri Fault strikes adjacent to one of California's major nuclear power plants.

The studies require the collection of data over a long period of time. However, the Project timeframe is limited to fall months due to whale and fish migration as well as nesting bird constraints. The current Project scope has been designed to minimize environmental impacts to the greatest extent feasible. PG&E is proposing to conduct the studies 24 hours per day, 7 days per week (24/7). This schedule is designed to reduce overall air emissions, length of time for operation in the water thereby reducing impacts to marine wildlife, commercial fishing, and other area users. PG&E will work with environmental agencies to appropriately address the balancing of public health and safety and environmental concerns during the conduct of these studies.

1.2 SURVEY DETAILS

The proposed survey involves both marine and some limited onshore activities. The offshore components consist of operating a geophysical survey vessel and support/monitoring vessels within the areas shown in Figure 1 and transiting between the two different survey box areas extending between the Santa Maria River mouth and Estero Bay. The geophysical survey vessel would tow a series of sound-generating air guns and sound-recording hydrophones along pre-determined shore-parallel and shore-perpendicular transects to conduct deep (10 to 15 km [6 to 9 mi]) seismic reflection profiling of major geologic structures and fault zones in the vicinity of DCPP.

The nearshore actions include the placement of a limited number of seafloor geophones (e.g., Fairfield Z700 nodal units) into nearshore waters. Detailed descriptions of the proposed actions for each component are provided below.

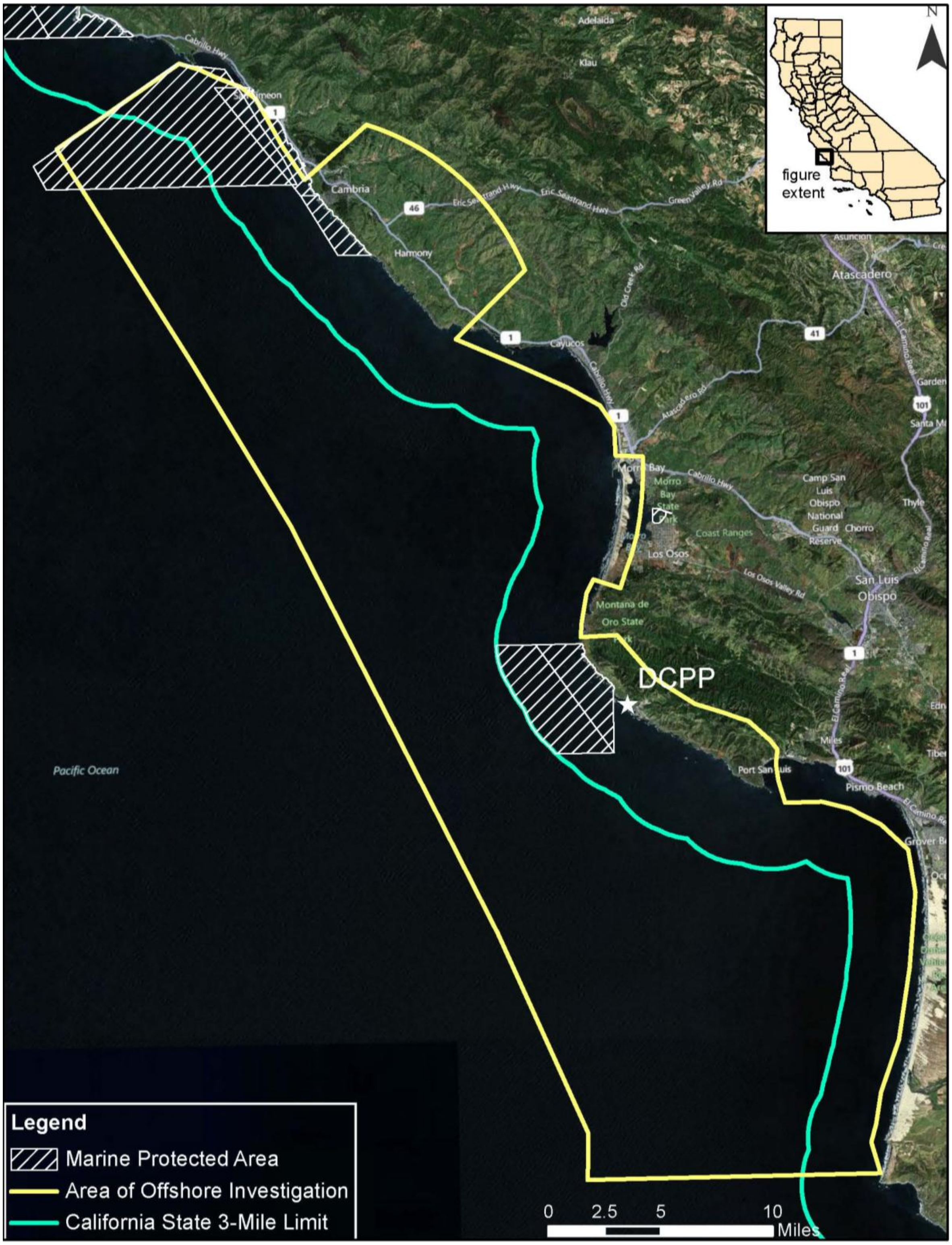

Figure 1. Proposed Project Survey Area

1.3. VESSEL MOVEMENTS

The 3D seismic survey race tracks will encompasses an area of approximately 740.52 km^2 (285.9 mi^2). The 2012 Project area is divided into the two "primary target areas," (Boxes 2 and 4) are described below and are shown on Figure 2. The offshore (vessel) survey would be conducted in both federal and state waters and water depths within the proposed survey areas ranging from 0 to over 400 m (1,300 ft). The State Three-Mile Limit is identified in Figure 1. The Point Buchon Marine Protected Area (MPA) lies within portions of the survey area. In addition, the Monterey Bay National Marine Sanctuary (MBNMS), a federally-protected marine sanctuary that extends northward from Cambria to Marin County, is located to the north and outside of the Project area.

Survey Box 2. (Survey area from Estero Bay to offshore Santa Maria River Mouth)

- Area: = 406.04 km^2 (156.77 mi^2)
- Total survey line length is 2,148.2 km (1,334.8 mi)
- Strike line surveys along the Hosgri fault zone and Shoreline, Hosgri and Los Osos fault intersections

Survey Box 4. (Estero Bay)

- Area: 334.48 km^2 (129.14 mi^2)
- Total survey line length is 1,417.6 km (880.9 mi)
- Dip line survey across the Hosgri and Los Osos fault zones in Estero Bay

Figure 2 depicts the proposed survey transit lines. These lines depict the survey lines as well as the turning legs. The full seismic array is firing during the straight portions of the track lines as well as the initial portions of the run out sections and later portions of run in sections. During turns and most of the initial portion of the run ins, there will only be one air gun firing (mitigation air gun). Assuming a daily survey rate of approximately 8.3 km/hr (4.5 knots for 24/7 operations), Survey Box 2 approximately 14 days, and Survey Box 4 approximately 9.25 days. When considering mobilization, demobilization, equipment maintenance, weather, marine mammal activity, and other contingencies, the proposed survey is expected to be completed in 49.25 days. For a more detailed discussion, refer to Section 2.1 - Project Schedule.

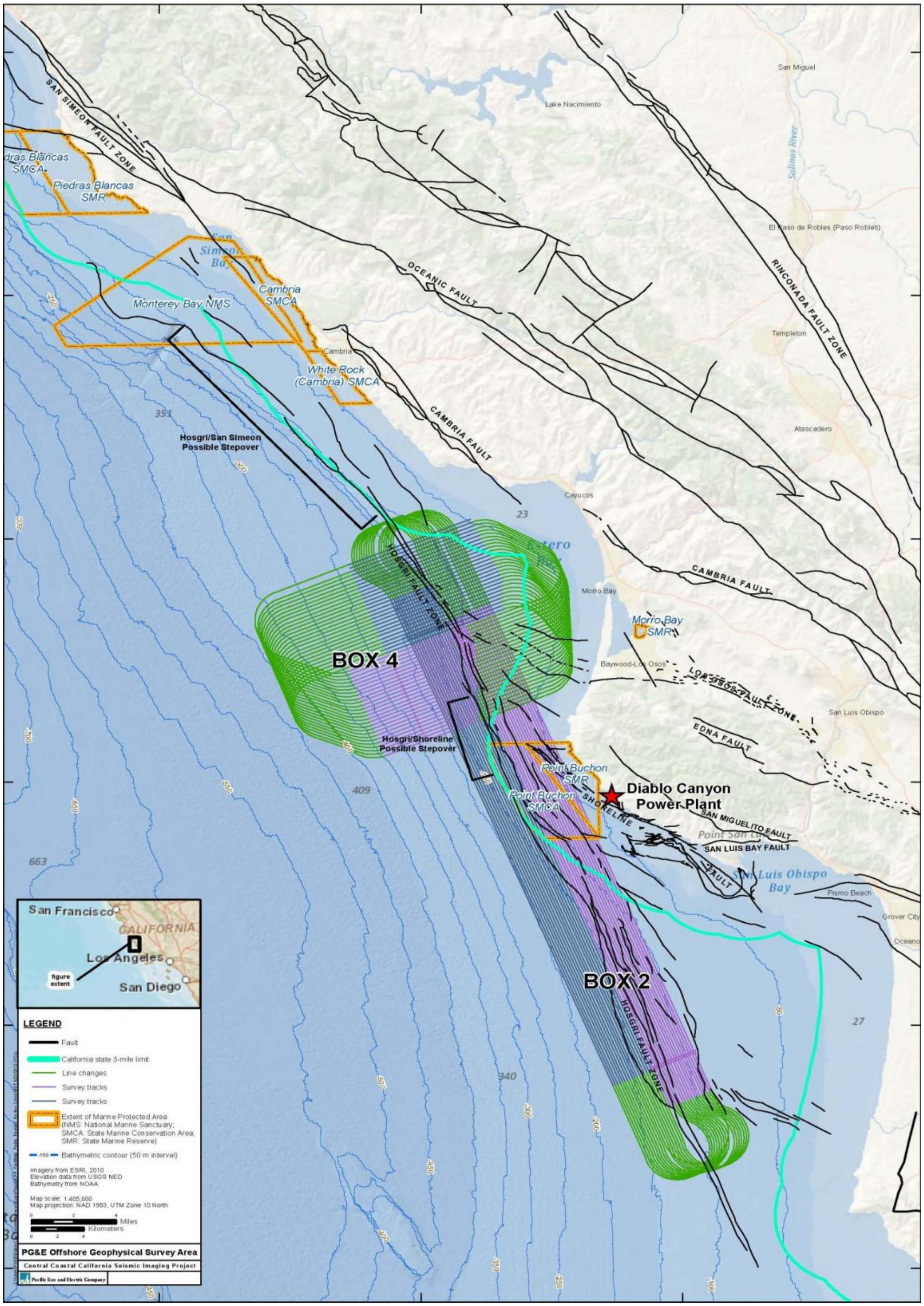

Figure 2. Proposed 2012 Project Survey Track Line Map

The nearshore actions include the placement of seafloor geophones (e.g., Fairfield Z700 nodal units) in nearshore water areas. Detailed descriptions of the proposed actions for each component are provided below.

1.3.1 Mobilization and Demobilization

The offshore 3D marine survey equipment and vessels are highly specialized and typically no seismic vessels are located in California. The proposed seismic survey vessel (*R/V Langseth*) is currently operating on the west coast and is available to conduct the proposed survey work.

The *R/V Langseth* would transit south prior to the start of survey operations (October 15 through December 31, 2012 with active air gun surveys starting November 1). Once the vessel has arrived in the Project area, the survey crew, any required equipment, and support provisions would be transferred to the vessel. Larger equipment, if required, would need to be loaded onboard the vessel at either Port of San Francisco/Oakland or Port Hueneme. The proposed survey vessel is supported by a chaseboat (*R/V Sea Trek or equivalent*) and scout/shore support boat (M/V *Dolphin II or equivalent*). Any additional scout/monitoring vessels required for the Project will be drawn from local vessel operators. Upon completion of the offshore survey operations, the survey crew would be transferred to shore and the survey vessel would transit out of the Project area.

Nearshore operations would be conducted using locally available vessels such as the *M/V Michael Uhl (Uhl).* Equipment, including the geophones and cables, would be loaded aboard the *M/V Uhl* in Morro Bay Harbor and transferred to the offshore deployment locations. Following deployment and recovery of the geophones and cables, they would be transferred back to Morro Bay Harbor for transport offsite.

Receiver line equipment would be deployed by foot-based crews supported by four-wheel drive vehicles or small vessel. Once the Project has been completed, the equipment would demobilize from the area by truck.

1.3.2 Offshore Survey Operations

The proposed offshore seismic survey would be conducted with geophysical vessels specifically designed and built to conduct such surveys. PG&E has selected the R/V *Langseth*, which is operated by the L-DEO (Columbia University). The following outlines the general specifications for the *R/V Langseth* geophysical survey vessel and the support vessels needed to complete the offshore survey.

In water depths from 30 to 305 m (100 to >1,000 ft), the *R/V Langseth* will tow four hydrophone streamers with a length of approximately 6 km (3.7 mi). The intended tow depth is approximately 10 m (32.8 ft). Flotation is provided on each streamer as well as Streamer Recovery Devices (SRD). The SRD is activated when the streamer sinks to a pre-determined depth (e.g. 50 m [164 ft]) to aid in recovery.

- Primary vessel - The*. R/V Langseth is* 71.5 m [235 ft.] in length and is outfitted to deploy/retrieve hydrophone streamers and air gun arrays, air compressors for the air gun array, and survey recording facilities.
- Chase boat - *R/V Sea Trek* is 38.7 m (127 ft.) in length and will be deployed in front of the *R/V Langseth* to observe potential obstructions, conduct additional marine mammal monitoring and support deployment of seismic equipment.
- Third vessel - *M/V Dolphin II* is approximately 20 m [65 ft.] in length and would act as a scout boat and support vessel for the *R/V Langseth*.
- Nearshore work vessel (approximately 50 m [150 ft.] in length) would be used to deploy/retrieve seafloor geophones in the shallow water (0-20 m) zone (e.g. *M/V Uhl]*).
- Monitoring Aircraft - Partenavia P68-OBS “Observer”, a high-wing, twin-engine plane or equivalent. The aircraft would be used to perform aerial surveys of marine mammals.

1.3.3 Survey Vessel Specifications

The *R/V Langseth* is proposed as the seismic survey vessel. The *R/V Langseth* would tow both the air gun and hydrophone streamer array along predetermined lines (Figure 2). When the *R/V Langseth* is towing the air gun array as well as the hydrophone streamers, the vessel would “fly” the appropriate USCG-approved day shapes (mast head signals used to communicate with other vessels) and display the appropriate lighting to designate the vessel has limited maneuverability. The turning radius is limited to 3 degrees per minute (2.5 km [1.5 mi]). Thus, the maneuverability of the vessel is limited during operations with the streamers.

The *R/V Langseth* has a length of 71.5 m (235 ft), a beam of 17.0 m (56 ft), and a maximum draft of 5.9 m (19.4 ft). The *R/V Langseth* was designed as a seismic research vessel, with a propulsion system designed to be as quiet as possible to avoid interference with the seismic signals. The ship is powered by two Bergen BRG-6 diesel engines, each producing 3,550 hp, which drive the two propellers directly. Each propeller has four blades, and the shaft typically rotates at 750 revolutions per minute (rpm). The vessel also has an 800 hp bowthruster, which is not used during seismic acquisition. The operation speed during seismic data acquisition is typically 7.4 to 9.3 km/h (4.6 to 5.7 miles/h). When not towing seismic survey gear, the *R/V Langseth* typically cruises at 18.5 km/h (11.5 miles/h).

Other details of the *R/V Langseth* include the following:

- Owner: National Science Foundation
- Operator: Lamont-Doherty Earth Observatory of Columbia University
- Flag: United States of America
- Date Built: 1991 (Refitted in 2006)
- Gross Tonnage: 3834
- Accommodation Capacity: 55 including ~35 scientists

1.3.4 Air Gun Description

The survey will be shot using two tuned air gun arrays, consisting of two sub-arrays with 1,650 cubic inches (in^3). The array would consist of a mixture of Bolt 1500LL and Bolt 1900LLX air guns. The subarrays would be configured as two identical linear arrays or "strings" (Figure 3). Each string would have ten air guns; the first and last air guns in the strings are spaced 16 m (52.5 ft) apart. Nine air guns in each string would be fired simultaneously (for a total volume of approximately 3,300 in^3), whereas the tenth is kept in reserve as a spare, to be turned on in case of failure of another air gun. The subarrays would be fired alternately during the survey. Each of the two subarrays would be towed approximately 140 m (459 ft) behind the vessel and would be distributed across an area of approximately 12 by 16 m (40 by 50 ft) behind the primary vessel, offset by 75 m (250 ft). Discharge intervals depend on both the ship's speed and Two Way Travel Time (TWTT) recording intervals. For a 16-second TWTT, air guns will be discharged approximately every 37.5 meters (123 ft) based on an assumed boat speed of 4.5 knots. The firing pressure of the subarrays is 1,900 pounds per square inch (psi). During firing, a brief (~0.1 sec) pulse of sound is emitted. The air guns would be silent during the intervening periods.

The tow depth of the air gun array would be 9 m (29.5 ft). Because the actual source is a distributed sound source (9 air guns) rather than a single point source, the highest sound levels measurable at any location in the water would be less than the nominal single point source level. In addition, the effective (perceived) source level for sound propagating in near-horizontal directions would be substantially lower than the nominal omni-directional source level because of the directional nature of the sound from the air gun array (i.e. sound is directed downward).

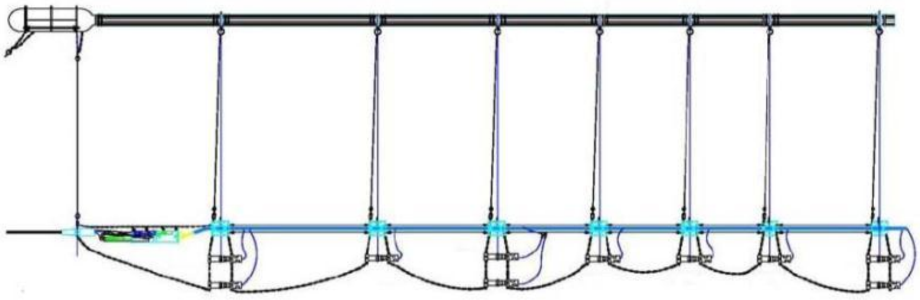

Figure 3. One Linear Air Gun Array or String with Ten Air Guns, Nine of Which Would be Operating

Details regarding the proposed 18-air gun air gun array (2 strings) specifications are as follows:

- Energy source: Eighteen, 2,000 psi Bolt air guns of 40 to 360 in^3 each
- Source output (downward): 0- peak (pk) is 42 bar-m (252 dB re 1 µPa at 1 m); pk-pk is 87 bar-m (259 dB)
- Towing depth of energy source: 9 m (29.5 ft.)

- Air discharge volume: ~3,300 in^3
- Dominant frequency components: 0-188 Hertz (Hz)

Ropes are used to keep the air guns at a depth of 9 m (29.5 ft) and the vessel speed during data collection would range from 7.4 to 9.3 km/h (4 to 5 nautical miles per hour [knots}). The sound source would be generated by the discharge of the air guns approximately every 37.5 m (123 ft) (Figure 4), which is based on an assumed vessel speed of 8.3 km/h (4.5 knots). The expected timing of the shots is once every 15 to 20 seconds.

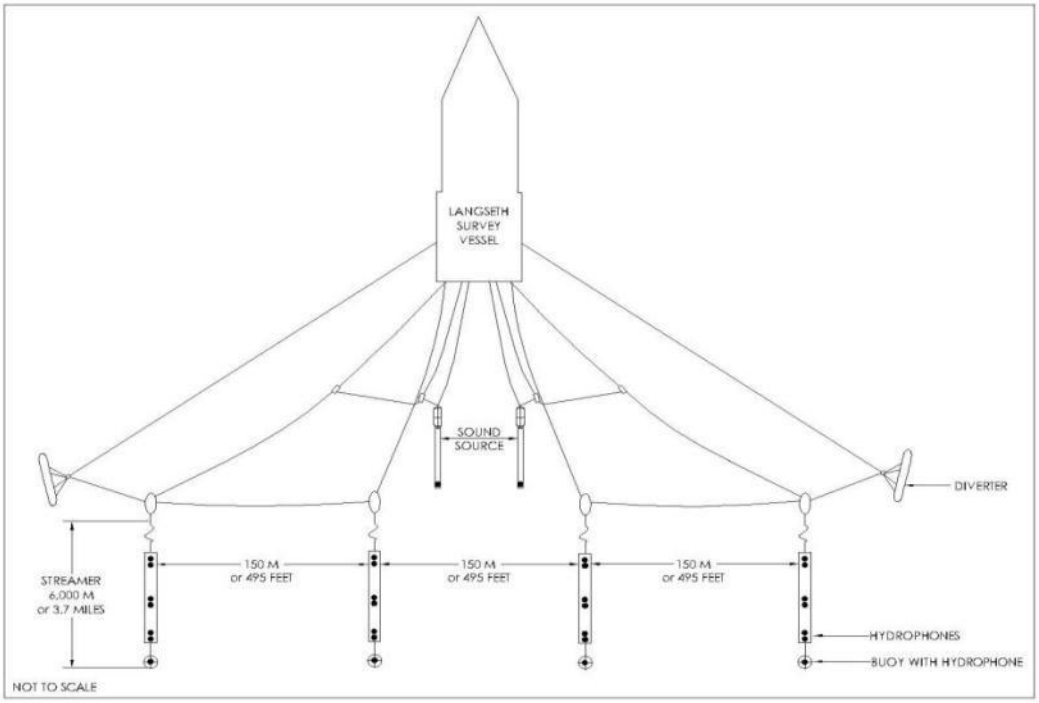

Figure 4. ***R/V Langseth*** **Air gun and Streamer Deployment**

1.3.5 Hydrophone Streamer Description

Acoustic signals will be recorded using a system array of four hydrophone streamers, which would be towed behind the *R/V Langseth*. Each streamer would consist of Sentry Solid Streamer Sercel cable approximately 6 km (3.7 mi) long. The streamers are attached by floats to a diverter cable, which keeps the streamer spacing at approximately 100 to 150 m (328 to 492 ft) apart.

Seven hydrophones will be present along each streamer for acoustic measurement. The hydrophones will consist of a mixture of Sonardyne Transceivers. Each streamer will contain three groups of paired hydrophones, with each group approximately 2,375 m (7,800 ft) apart. The hydrophones within each group will be approximately 300 m (984 ft) apart. One additional hydrophone will be located on the tail buoy attached to the streamer cable. In addition, one Sonardyne Transducer will be attached to the air gun array. Compass Birds will be used to keep the streamer cables and hydrophones at a depth of approximately 10 m (33 ft). One compass bird will be placed at the front end of each streamer. Figure 4 depicts the configuration of both the streamer and air gun array used by the *R/V Langseth*.

Details regarding the proposed hydrophone streamer and acoustic recording equipment specifications are included in Table 1 below.

Table 1. Summary of Offshore Streamer Features

Hydrophone Type	Sonardyne XSRS Transceiver 7885 (Standard)
Length of Individual Unit (approximate)	85.8 cm (33.8 in)
Diameter of Individual Unit (approximate)	7.5 cm (3.0 in)
Weight of Individual Unit in Air (approximate)	7.3 kg (16.0 lbs)
Number of Units per String	5
Hydrophone Type	**Sonardyne XSRS Transceiver 8005 (Long Life)**
Length of Individual Unit (approximate)	91.1 cm (35.9 in)
Diameter of Individual Unit (approximate)	8.9 cm (3.5 in)
Weight of Individual Unit in Air (approximate)	10.4 kg (22.9 lbs)
Number of Units per String	2
Hydrophone Type	**Sonardyne HGPS Transducer 7887 (Right Angle)**
Length of Individual Unit (approximate)	56.3 cm (22.2 in)
Diameter of Individual Unit (approximate)	9.4 cm (3.7 in)
Weight of Individual Unit in Air (approximate)	9.6 kg (21.2 lbs)
Number of Units per String	1
Depth Sensor	**ION Model 5011 Compass Bird**
Length of Individual Unit (approximate)	120 cm (48.2 in)
Weight of Individual Unit in Air (approximate)	8.32 kg (18.3 lbs)
Number of Units per Streamer (approximate)	4
Streamer Type	**Thompson Marconi Sentry**
Streamer Depth (approximate)	10 m (33 ft.)
Group Interval (approximate)	12.5 m (41 ft.)
Group Length (approximate)	12.5 m (41 ft.)
Number of Groups	468
Length of Streamer	6 km (3.7 mi)

Source: Columbia University

1.3.6 Acoustic Measurements

The strengths of the air gun pulses can be measured in a variety of ways, but National Marine Fisheries Service (NMFS) commonly uses “root mean square” (in dB re 1µPa [rms]), which is the level of the received air gun pulses averaged over the duration of the pulse. The rms value for a given air gun pulse is typically 10 dB lower than the peak level, and 16 dB lower than the pk-pk level (McCauley *et al*., 1998, 2000 a,b).

The noise modeling for the proposed 3D seismic survey is based on the results of mathematical modeling conducted by Greeneridge Sciences, Inc. (2011). The model results are based upon the air gun specifications provided for the *R/V Langseth* and seafloor characteristic available for the Project area. Safety and Exclusion Zone dimensions are based on NMFS definitions for Incidental Harassment Authorizations (IHA). The Safety Zone is the distance within which received sound levels are modeled to be greater than 160 dB and the Exclusion Zone is the distance within which received sound levels are modeled to be greater than 180 dB. Distances to received levels of 120, 154, 160, 170, 180, 187, and 190 dB re 1µPa (rms) are also provided (Table 5 in Section 6.4 below).

1.3.7 Multibeam Echosounder and Sub-bottom Profiler

Along with the air gun operations, two additional acoustical data acquisition systems will be operated from the *R/V Langseth* continuously during the survey. The ocean floor will be mapped with a Kongsberg EM-122 multibeam echosounder (MBES) and a Knudsen 320B sub-bottom profiler (SBP).

The Kongsberg EM-122 MBES operates at 10.5-13 (usually 12) kHz and is hull-mounted on the *R/V Langseth*. The transmitting beam width is 1 or 2 degrees fore-aft and 150 degrees athwartship. The maximum source level is 242 dB re 1 µPa m_{rms}. Each "ping" consists of 8 (in water >1,000 m [3,300 ft] deep) or 4 (<1,000 m [3,300 ft]) successive fan-shaped transmissions, each ensonifying a sector that extends 1 degree fore-aft. Continuous-wave (CW) pulses increase from 2 to 15 (milliseconds) ms long in water depths up to 2,600 m (8,350 ft), and frequency-modulated (FM) chirp pulses up to 100 ms long are used in water >2,600 m (8,350 ft). The successive transmissions span an overall cross-track angular extent of about 150 degree, with 2 ms gaps between the pulses for successive sectors (see Table 2).

The Knudsen 320B SBP is normally operated to provide information about the sedimentary features and the bottom topography that is being mapped simultaneously by the MBES. The beam is transmitted as a 27-degree cone, which is directed downward by a 3.5-kHz transducer in the hull of the *R/V Langseth*. The maximum output is 1,000 watts (204 dB), but in practice, the output varies with water depth. The pulse interval is 1 second (sec), but a common mode of operation is to broadcast five pulses at 1-sec intervals followed by a 5-sec pause.

Table 2. *R/V Langseth* Sub-bottom Profiler Specifications

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

Both the Kongsberg EM-122 MBES and Knudsen 320B SBP are operated continuously during survey operations. Given relatively shallow water depths of the survey area (20 to 300 m [66 to 984 ft]), the number of 'pings' or transmissions would be reduced from 8 to 4, and the pulse durations would be reduced from 100 ms to 2 to 15 ms for the Kongesberg EM-122.

Power levels of both instruments would be reduced from maximum levels to account for water depth. Actual operating parameters will be established at the time of the survey.

1.3.8 Gravimeter

The *R/V Langseth* will employ a Bell Aerospace BGM-3 gravimeter system (Figure 5) to measure very tiny fractional changes in the Earth's gravity caused by nearby geologic structures, the shape of the Earth, and by temporal tidal variations. The BGM-3 has been specifically designed to make precision measurements in a high motion environment. Precision gravity measurements are attained by the use of the highly accurate Bell Aerospace Model XI inertial grade accelerometer.

Figure 5. Bell BMG Marine Gravity Meter

1.3.9 Magnetometer

The *R/V Langseth* will employ a Bell Aerospace BGM-3 geometer, which contains a model G-882 cesium-vapor marine magnetometer (Figure 6). Magnetometers measure the strength and/or direction of a magnetic field, generally in units of nanotesla (nT) in order to detect and map geologic formations. These data would enhance earlier marine magnetic mapping conducted by the United States Geological Survey (USGS) (Sliter *et al*., 2009).

Figure 6. Geometrics G-882 Magnetometer

The G-882 is designed for operation from small vessels for shallow water surveys as well as for the large survey vessels for deep tow applications (4,000 psi rating, telemetry over steel coax available to 10 km [6.2 mi]). Power may be supplied from a 24 to 30 VDC battery power or a 110/220 VAC power supply. The standard G-882 tow cable includes a Vectran strength member and can be built to up to 700 m (2,297 ft) (no telemetry required). The shipboard end of the tow cable is attached to a junction box or on-board cable. Output data are recorded on a computer with an RS-232 serial port.

Both the gravimeter and magnetometers are “passive” instruments and do not emit sounds, impulses, or signals, and are not expected to adversely affect marine mammals.

1.3.10 Nearshore and Onshore Survey Operations

To collect deep seismic data in water depths that are not accessible by the *R/V Langseth* (less than 25 m [82 ft]), seafloor geophones and both offshore and onshore seismic sources will be used. The currently proposed locations for the seafloor geophone lines between Point Buchon and Point San Luis are shown in Figure 7.

One dozen (12) Fairfield Z700 marine nodes would be placed on the seafloor along two nearshore survey routes as a pilot test prior to the full deployment of 600 nodes scheduled for 2013. The northern route (Crowbar Beach) traverses the Point Buchon MPA north of DCPP. The southern route (either Green Peak or Deer Canyon) is located south of DCPP. The approximate locations of the proposed nodal routes are depicted below on Figure 7. Six nodes would be placed at 500 m intervals along each route for a total length of 3 km. Maximum water depth ranges from 70 m (Crowbar) to 30 m (Deer Canyon). Marine nodes would be deployed using a vessel and (in some locations) divers and will be equipped with acoustic releases to facilitate recovery.

The seafloor equipment will be in place for the duration of the 2012 offshore 3D HESS plus deployment and recovery time. Node deployment will be closely coordinated with offshore survey operations to ensure survey activities are completed before the projected battery life of 45 days is exceeded. PG&E anticipates using a locally available vessel to deploy and retrieve the geophones. The vessel would be a maximum of 150 feet (50 meters) in length. The M/V *Uhl*, which is locally available, or a vessel of equivalent size and engine specification, is proposed for this purpose.

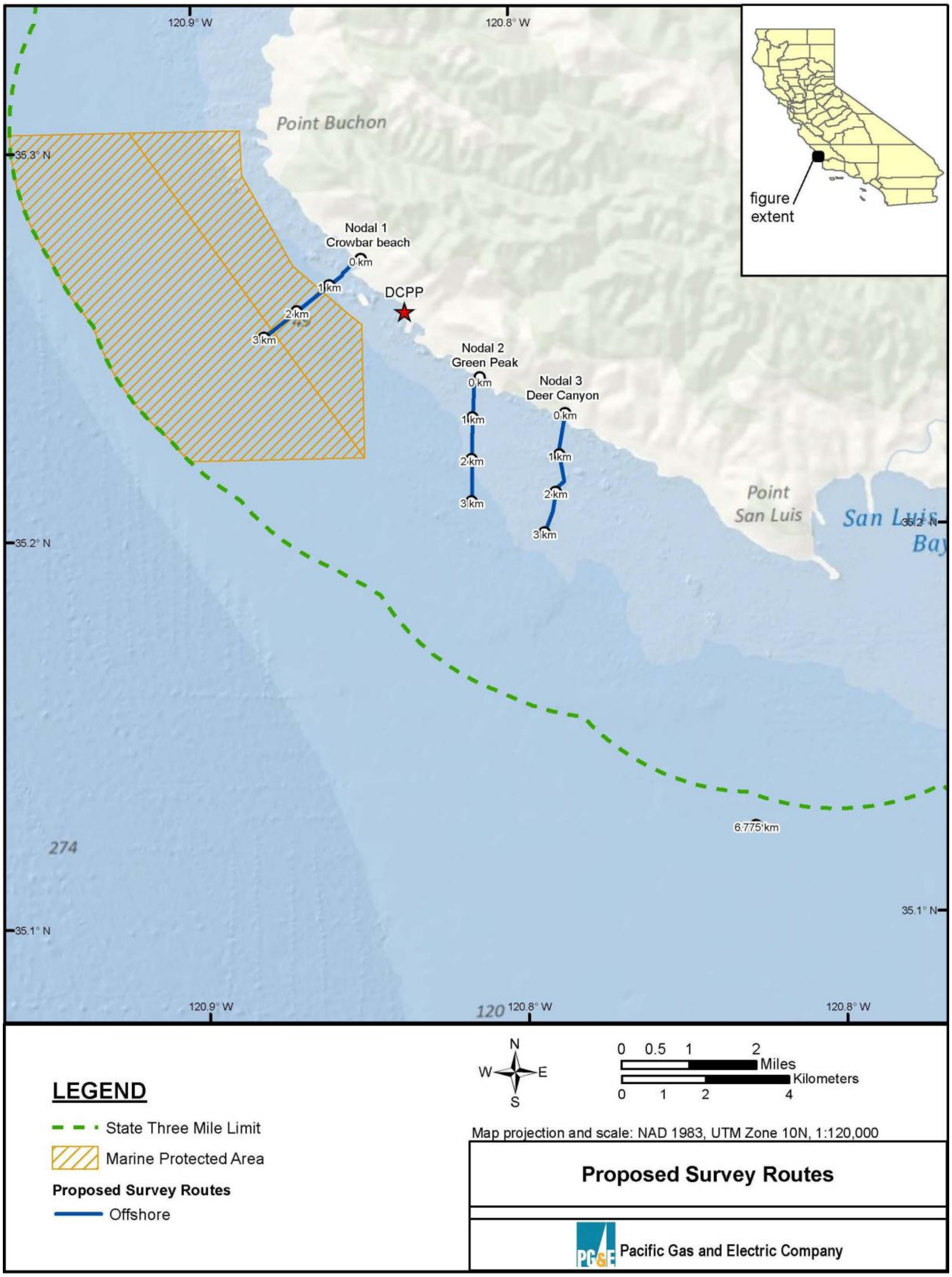

Figure 7. Proposed Seafloor Geophone Lines near Diablo Canyon Power Plant

Figure 8 shows an example of a Fairfield Z700 seafloor geophone and Table 3 summarizes its features.

Figure 8. Fairfield Z700 Seafloor Geophone

Table 3. Summary of Nearshore Geophone Features

Feature	Description
Geophone Model	Fairfield Z700
Height of Individual Unit	15 cm (6 in)
Diameter of Individual Unit	38 cm (15 in)
Weight of Individual Unit	29 kg (65 lbs) when wet
Number of Units per String	Crowbar Beach: 6 Green Peak: 6 or Deer Canyon: 6
Length of Overall Receiver String (approximate)	Crowbar Beach: 3 km (1.9 mi) Green Peak: 3 km (1.9 mi) or Deer Canyon: 3 km (1.9 mi)

Onshore, a linear array of ZLand nodals will be deployed along a single route on the Morro Strand to record onshore sound transmitted from the offshore air gun surveys. Route location is shown in Figure 9. Ninety nodes would be placed at 100 m (328 ft) intervals along the Strand for a total route length of ~ 9 km (5.6 mi). The autonomous, nodal, cable-less recording devices (Figure 9) would be deployed by foot into the soil adjacent to existing roads, trails and beaches. The nodal systems are carried in backpacks and pressed into the ground at each receiver point. Each nodal would be removed following completion of the data collection. PG&E estimates that the onshore receiver activities would be conducted over a 2 to 3-day period, concurrent with the offshore surveys. Figure 10 depicts the area of proposed onshore receivers along the Morro Strand.

Figure 9. Example of an Autonomous Wireless Nodal Land Recording System* - Fairfield ZLand

*Includes a 5-inch spike, is 6 inches high, 5 inches in diameter, and weighs 5 lbs.

Deployment Operations. PG&E estimates that the onshore seismic source activities would be conducted over a 2 to 3-day period, concurrent with the offshore surveys. . The sources would be activated as described above at each survey point, the responses would be recorded.

1.4 EQUIPMENT REQUIREMENTS

The following vessels and equipment are proposed for use in the offshore survey.

- R/V. *Langseth*
  - Four hydrophone streamers;
  - Two air gun arrays
  - Multi Beam Echo Sounder and Sub Bottom Profiler; gravity and magnetic sensors
- Chase boat - *R/V Sea Trek* or equivalent
- Support vessel - *M/V Dolphin II* or equivalent
- *M/V Uhl* or equivalent
- Monitoring aircraft - Partenavia P68-OBS “Observer” (or equivalent aircraft)
- Marine geophones (approximately 12 geophones with acoustic releases)
- Canoe/kayak

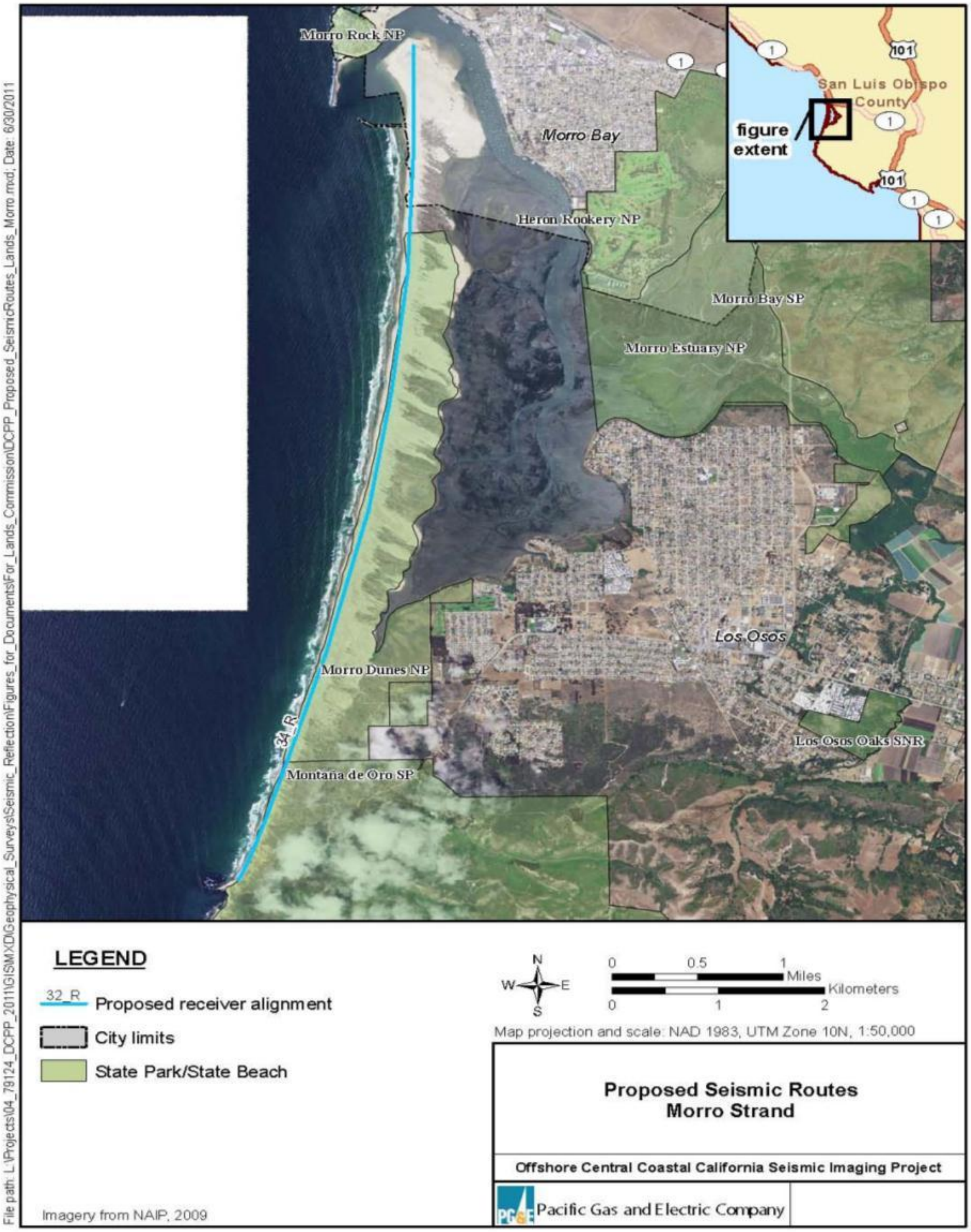

Figure 10. Proposed Onshore Seismic Lines, Morro Strand

The following is a preliminary estimate of anticipated onshore vehicle and equipment needs for the proposed seismic surveys.

- 1 to 2 vans for data recording/processing.

1.5 PERSONNEL REQUIREMENTS

It is estimated that 89 personnel would be required for the proposed offshore survey program, which include:

- *R/V Langseth* crew: 55 (Base on Coast Guard registration)
- *R/V Sea Trek* 12
- *M/V Dolphin II* 6
- *M/V Uhl* crew: 5
- Support divers: 3
- Partenavia P68-OBS "Observer" or equivalent 5
- Administrative/computer support: 3

Onshore survey operations are expected to require approximately 6 crew members. In addition, biological and cultural resource monitors would accompany each team. These teams would operate at intervals of 0.8 to 4.8 km (0.5 to 3 mi) throughout the proposed Project area.

2.0 DATES, DURATION, AND REGION OF ACTIVITY

The date(s) and duration of such activity and the specific geographical region where it will occur.

2.1 2012 PROJECT SCHEDULE

Project duration is 49.25 operational days (see below). Mobilization will initiate on October 15, with active air gun surveys taking place from November 1 through December 31, 2012. Below is an estimated schedule for the Project based on the use of the *R/V Langseth* as the primary survey vessel.

- Mobilization to Project Site - 6 days
- Initial Equipment Deployment - 3 days (offshore geophone deployment also)
- Pre-activity marine mammal surveys - 5 days (concurrent to equipment mobilization and deployment)
- Onshore geophone deployment - 2-3 days (concurrent with offshore deployment activities)
- Equipment Calibration and Sound Check - 5 days
- Seismic Survey - 23.25 days (Per the direction of the NMFS Box 4 will be surveyed first followed by Box 2)
  - Survey Box 4 (Survey area within Estero Bay) - 9.25 days
  - Survey Box 2 (Survey area from Estero Bay to offshore Santa Maria River Mouth) - 14 days
- Streamer and air gun preventative maintenance - 2 days
- Additional shut downs (marine mammal presence, crew changes, and unanticipated weather delays) - 4 days
- Demobilization - 6 days

TOTAL: 49.25 days (for 24/7 operation). Note that the total of 49.25 days is based on adding the above non-concurrent tasks.

Placement of the onshore receiver lines would be completed prior to the start of offshore survey activities and would remain in place until the offshore survey can be completed.

2.2 REGION OF ACTIVITY

The proposed survey area is located offshore of central California. See Figures 1 and 2 in Section 1.0 for a depiction of the Project area.

3.0 SPECIES AND NUMBERS OF MARINE MAMMALS IN AREA

The species and numbers of marine mammals likely to be found within the activity area.

The marine mammal species under the jurisdiction of NMFS and United States Fish and Wildlife Service (USFWS) that are known to or may occur in the seismic survey area include 18 cetacean species, 6 species of pinnipeds, and 1 fissiped species. Six cetacean species (fin whale, humpback whale, blue whale, northern right whale, sei whale, and sperm whale) are listed as Endangered under the Federal Endangered Species Act (FESA). Two pinniped species (Guadalupe fur seal and Steller sea lion) and 1 fissiped species (southern sea otter) are listed as Threatened under FESA.

Fin, sei, north Pacific right, and sperm whale sightings are uncommon in the area, and have a low likelihood of occurrence during the seismic survey. Similarly, the Project area is generally north of the range of the Guadalupe fur seal.

Table 4 below details the marine mammal species possibly occurring in the Project area, along with protected status and population estimates and trends by stock. Section 4.0 provides information on the numbers of species observed in the general Project area.

Table 4. Marine Mammal Protection Status and Population Estimates and Trends by Stock

Common Name ***Scientific Name***	**Protected Status[1]**	**Minimum Population Estimate**	**Current Population Trend**
Mysticeti			
California gray whale *Eschrichtius robustus*	M	18,017 (Eastern North Pacific Stock)	Fluctuating annually
Fin whale *Balaenoptera physalus*	FE, M	2,624 (California/Oregon/Washington Stock)	Increasing off California
Humpback whale *Megaptera novaeangliae*	FE, M	1,878 (California/Oregon/Washington Stock)	Increasing
Blue whale *Balaenoptera musculus*	FE, M	2,046 (Eastern North Pacific Stock)	Unable to determine
Minke whale *Balaenoptera acutorostrata*	M	202 (California/Oregon/Washington Stock)	No long-term trends suggested
North Pacific right whale *Eubalaena japonica*	FE, M	17 (based on photo-identification) (Eastern North Pacific Stock)	No long-term trends suggested
Sei whale *Balaenoptera borealis*	FE, M	83 (Eastern North Pacific Stock)	No long-term trends suggested
Odonteceti			
Short-beaked common dolphin *Delphinus delphis*	M	343,990 (California/Oregon/Washington Stock)	Unable to determine
Long-beaked common dolphin *Delphinus capensis*	M	17,127 (California Stock)	Unable to determine
Harbor porpoise *Phocoena phocoena*	M	1,478 (Morro Bay Stock)	Unable to determine
Dall's porpoise *Phocoenoides dalli*	M	32,106 (California/Oregon/Washington Stock)	Unable to determine
Pacific white-sided dolphin *Lagenorhynchus obliquidens*	M	21,406 (California/Oregon/Washington Stock)	No long-term trends suggested
Risso's dolphin *Grampus griseus*	M	4,913 (California/Oregon/Washington Stock)	No long-term trends suggested
Northern right whale dolphin *Lissodelphis borealis*	M	6,019 (California/Oregon/Washington Stock)	No long-term trends suggested

Common Name *Scientific Name*	**Protected Status**[1]	**Minimum Population Estimate**	**Current Population Trend**
Striped dolphin *Stenella coeruleoalba*	M	8,231 (California, Oregon, Washington)	No long term trend due to rarity
Baird's beaked whale *Berardius bairdii*	M	615 (California, Oregon, Washington)	No long term trend due to rarity
Mesoplodont beaked whales	M	576 (California, Oregon, Washington	No long term trend due to rarity
Bottlenose dolphin *Tursiops truncatus*	M	684 (California/Oregon/Washington Offshore Stock) 290 (California Coastal Stock)	No long-term trends suggested
Sperm whale *Physeter macrocephalus*	FE, M	751 (California/Oregon/Washington Stock)	No long-term trends suggested
Dwarf sperm whale *Kogia sima*	M	Unknown (California, Oregon, Washington)	No long term trend due to rarity
Short-finned pilot whale *Globicephala macrorhynchus*	M	465 (California/Oregon/Washington Stock)	No long-term trends suggested
Killer whale *Orcinus orca*	M	162 (Eastern North Pacific Offshore Stock) 354 (West Coast Transients)	No long-term trends suggested
Pinnipeds			
California sea lion *Zalophus californianus*	M	153,337 (U.S. Stock)	Unable to determine; increasing in most recent three year period
Northern elephant seal *Mirounga angustirostris*	M	74,913 (California Breeding Stock)	Increasing
Pacific harbor seal *Phoca vitulina richardsi*	M	26,667 (California Stock)	Stable
Northern fur seal *Callorhinus ursinus*	M	5,395 (San Miguel Island Stock)	Increasing
Guadalupe fur seal *Arctocephalus townsendi*	FT, M	3,028 (Mexico Stock) Undetermined in California	Increasing
Northern (Steller) sea lion *Eumetopias jubatus*	FT, M	42,366 (Western U.S. Stock)	Decreasing

Common Name ***Scientific Name***	**Protected Status[1]**	**Minimum Population Estimate**	**Current Population Trend**
Fissipeds			
Southern sea otter *Enhydra lutris nereis*	FT, M	2,711*	Unable to determine

Source: NMFS, 2011; NMFS,2012

[1]Protected Status Codes:

FE	Federally listed Endangered Species
FT	Federally listed Threatened Species
M	Protected under Marine Mammal Protection Act

4.0 STATUS, DISTRIBUTION AND SEASONAL DISTRIBUTION OF AFFECTED SPECIES OR STOCKS OF MARINE MAMMALS

A description of the status, distribution, and seasonal distribution (when applicable) of the affected species or stocks of marine mammals likely to be affected by such activities.

The marine mammal species under the jurisdiction of the NMFS and the USFWS most likely to occur in the seismic survey area include: four mysticeti species (gray whale, blue whale, minke whale, and humpback whale); six odontoceti species (Dall's porpoise, harbor porpoise, Pacific white-sided dolphin, Risso's dolphin, common dolphin, and bottlenose dolphin); four pinniped species (California sea lion, harbor seal, Steller sea lion, and northern fur seal); and, one fissiped species (southern sea otter). These species are described in detail below. A number of other species have a low probability of occurring in the Project area during the seismic survey Project, but are also described below.

4.1 ODONTOCETES (TOOTHED WHALES)

Odontocetes, or toothed whales, that are commonly found in the central California waters, include: sperm whale, several species of dolphins, porpoises, and at least six species of beaked whale. With the exception of killer whales, which are the top predators in the ocean and feed on a wide variety of fishes, squid, seabirds, sea turtles. pinnipeds, and cetaceans, odontocetes generally feed on schooling fishes and squid (Bonnell and Dailey, 1993). Major fish prey species include anchovy, mackerel, lanternfish, smelt, herring, and rockfishes. Octopus and crustaceans are also eaten on occasion.

Due to the offshore nature of the proposed Project, several of the odontocetes that exist within central California waters have the potential to occur within the Project area, or to be encountered by vessels traveling to the Project area. The species with the highest potential to be encountered during Project activities are discussed below.

4.1.1 Common Dolphin

Common dolphins are found worldwide and are the most abundant cetaceans in California waters (Bonnell and Dailey, 1993). Two recognized species of common dolphin are found in central California waters. The long-beaked common dolphin is commonly found within about 90 km (55 mi) from the coastline. Its relative abundance changes both seasonally and inter-annually, with the highest densities observed during warm water events (Heyning and Perrin, 1994). A recent population estimate for this species is about 17,127 (NMFS, 2011). The more numerous short-beaked common dolphin ranges from the coast to 550 km (340 mi) offshore. The most recent estimates indicate the California-Washington population of this species to be 343,990 individuals making it the most abundant cetacean off California (NMFS, 2011). California common dolphins are very gregarious and are frequently encountered in herds of 1,000 or more. Because populations tend to vary with water temperature, no long-term population trends have been determined at this time (NMFS, 2011). Common dolphins were observed regularly from late summer through winter of 2010 during marine mammal monitoring events within or near Project area waters (Padre, 2010, 2011a).

4.1.2 Dall's Porpoise

Dall's porpoise is one of the most abundant small cetaceans in the North Pacific and are found in shelf, slope, and offshore waters throughout their range (Koski *et al*., 1998). The Dall's porpoise is found year-round throughout the Project area (NCCOS, 2007). The most recent population estimates indicate that at least 32,106 individuals are known to occur off California, Oregon, and Washington (NMFS, 2011). The population trend for this species has not yet been determined (NMFS, 2011). Ten Dall's porpoises were observed from late summer through winter of 2010 during marine mammal monitoring events within Project area waters (Padre, 2011a). Tenera Environmental (2007) reported approximately 21 Dall's porpoises during marine mammal monitoring conducted in November 2007 within the Project area.

4.1.3 Harbor Porpoise

Harbor porpoise are found in coastal and inland waters from Point Conception, California to Alaska and across to the Kamchatka Peninsula and Japan. The harbor porpoise occurs year-round off of central California, mostly in the coastal ocean, and occasionally in bays, harbors, and estuaries (NCCOS, 2007). The most recent population estimates for the Morro Bay harbor porpoise stock indicate that at least 1,478 individuals occur between Cambria and Point Conception, and the population trend is increasing (NMFS, 2011). Harbor porpoises were observed regularly while transiting to the Project area in the late summer and winter of 2010 (Padre, 2010, 2011a).

Genetic testing in the early 1990s identified differences between the central coast population and the other populations along the west coast of the harbor porpoise, which ultimately led to the splitting of the central coast population into its own species stock. More recent genetic findings from Chivers *et al.*, (2002, 2007), found that there are six distinct harbor porpoise populations along the west coast and four genetically different populations along the California coast. Based on the threat of population isolation and density separation from aerial flights, what was once the central coast population has been split into the Monterey Bay and Morro Bay stocks. According to the recent 2009 stock assessment for harbor porpoise, the Morro Bay population has averaged a 13% annual growth since 1988, possibly due to dispersal from the Monterey Bay population. According to the recent density data provided by Karin Forney of NMFS (Appendix B), the highest density area of the Morro Bay stock is south of Oceano averaging over two individuals per km^2, with a total area of 504 km^2.

4.1.4 Pacific White-sided Dolphin

Pacific white-sided dolphins primarily range along the coasts of California, Oregon, and Washington. This species frequents deep water foraging areas, but may move into nearshore areas in search of prey. Analysis of sighting patterns suggest that Pacific white-sided dolphins make north-south movements, occurring primarily off California in cold water months and moving northward to Oregon and Washington as waters warm in the late spring in summer

(Forney *et al*., 2000; Allen *et al*., 2011). Pacific white-sided dolphin populations are not showing any long-term trend in terms of abundance, but have a current minimum population size of 21,406 off California, Oregon, and Washington (NMFS, 2011). This species was not observed during recent marine mammal monitoring projects in the general Project vicinity (Padre, 2010, 2011a).

4.1.5 Risso's Dolphin

Risso's dolphins are present off central and southern California year-round (Dohl *et al*., 1981, 1983; Bonnell and Dailey, 1993). Risso's dolphins are found off California during the colder water months and are extending their range northward as water temperatures increase (Leatherwood *et al*., 1982; Allen *et al*., 2011). The most recent population estimates indicate that at least 4,913 individuals are known to occur off California, Oregon, and Washington (NMFS, 2011). No long-term population trends have been determined at this time. Risso's dolphins can be observed year-round within the Project area, and were observed regularly from late summer through winter of 2010 during marine mammal monitoring events within or near Project area waters (Padre, 2010, 2011a).

4.1.6 Short-finned Pilot Whale

The short finned pilot whale is a relatively more southern or warm water species. Pilot whales were common off southern California until the early 1980's (Dohl *et al*., 1983), but disappeared from area waters following the 1982-1983 El Nino (Bonnell and Dailey, 1993; Forney *et al*., 2000). Recently, pilot whales have begun reappearing in California waters, possibly in response to long-term changes in oceanographic conditions, but sightings are still rare (Forney *et al*., 2000). The most recent estimates indicate that at least 465 individuals are known to occur off California, Oregon, and Washington (NMFS, 2011). No long-term population trends have been determined at this time. None were observed during recent marine mammal monitoring projects in the general Project vicinity (Padre, 2010, 2011a).

4.1.7 Bottlenose Dolphin

The bottlenose dolphin is probably more widely distributed than any other species of small cetacean in the eastern North Pacific (Leatherwood *et al*., 1982). This species has been tentatively separated into a coastal form and offshore form. The coastal bottlenose dolphin is generally found within 1 km (0.6 mi) of shore and often enters the surf zone, bays, inlets, and river mouths (Leatherwood *et al*., 1987). The California coastal population is estimated at 290 and appears to form small resident groups that range along the coastline (NMFS, 2011). The area of the project site within 1 km from shore includes is 38.1 km^2 for Box 2 and 46.6 km^2 for Box 4.

Offshore bottlenose dolphins are believed to have a more-or-less continuous distribution off the coast of California (Mangels and Gerrodette, 1994). The current minimal population is estimated at 684 individuals off California, Oregon, and Washington (NMFS, 2011). No long-term population trends have been determined at this time (NMFS, 2011). None were observed during recent marine mammal monitoring projects in the general Project vicinity (Padre, 2010, 2011a).

4.1.8 Northern Right Whale Dolphin

The northern right whale dolphins are endemic to temperate waters of the North Pacific, where they range from the Mexican border to British Columbia (Leatherwood and Walker, 1979; Leatherwood *et al*., 1982). They are primarily found over the shelf and slope in U.S. coastal waters and are known to make seasonal north-south movements (Forney *et al*., 2000). Northern right whale dolphins are found primarily off California during colder-water months and shift northward into Oregon and Washington as water temperatures increase in late spring and summer (NCCOS, 2007). The most recent population estimates indicate that at least 6,019 individuals are known to occur off California, Oregon, and Washington (NMFS, 2011). No long-term population trends have been determined at this time (NMFS, 2011). Ten northern right whale dolphins were observed during the winter of 2010 during marine mammal monitoring events within Project area waters (Padre, 2011a).

4.1.9 Killer Whale

The killer whale occurring off the coast of California has been tentatively separated into a transient form, an offshore form, and a resident form. The West Coast Transient form is the most frequently sighted off central California, and has been observed from southern California to Alaska. This form feeds on marine mammals, travels in small groups often over long ranges, and are usually quiet (NCCOS, 2007). It can occur year-round in the Project area, but are most frequently sighted from January-May and from September through November. The most recent population estimate for the transient stock of killer whales is 354 (NMFS, 2011). In January of 2012, 10 transient killer whales were observed off Avila Beach (KSBY, 2012). The Eastern North Pacific Southern Resident form is primarily sighted in more nearshore, areas well north of the Project area. (NMFS, 2011). Offshore killer whales have more recently been identified off the coasts of California, Oregon, and rarely, in Southeast Alaska (Carretta *et al*., 2008). They apparently do not mix with the transient and resident killer whale stocks found in these regions. The offshore type is more vocal, travels in larger groups, and feeds on fishes and squid (NMFS, 2011). The total number of known offshore killer whales along the U.S. West Coast, Canada, and Alaska is 162 animals (NMFS, 2011). Two killer whales were observed in the winter of 2010 during marine mammal monitoring events within Project area waters (Padre, 2011a).

4.1.10 Sperm Whale

The sperm whale is a federally endangered species due to historically intensive commercial whaling. The sperm whale is the largest of the toothed whales and is found predominately in temperate to tropical waters in both hemispheres (Gosho *et al*., 1984). Off California, sperm whales are present in offshore waters year-round, with peak abundance from April to mid-June and again from late August through November (Dohl *et al*., 1981, 1983; Gosho *et al*., 1984; Barlow *et al*., 1997). Sperm whales are primarily pelagic species and are generally found in waters with depths of greater than 1,000 m (3,300 ft) (Watkins, 1977), although their distribution does suggest a preference for continental shelf margins and seamounts, areas of upwelling and high productivity (Leatherwood and Reeves, 1983) The majority of sightings by Dohl *et al*. (1983) in their 3-year study off central and northern California were in waters deeper than 1,800 m (5,900 ft), but near the continental shelf edge. These areas are well offshore of the proposed survey area. The most recent estimates indicate that at least 751 individuals are known to occur off California, Oregon, and Washington (NMFS, 2011). No long-term population trends have been determined at this time (NMFS, 2011). None were observed during recent marine mammal monitoring projects in the general Project vicinity (Padre, 2010, 2011a).

4.1.11 Kogia Species

There are two Kogia spp. that may occur in the project area, the dwarf sperm whale *(Kogia sima)* and pygmy sperm whale *(Kogia breviceps)*. The pygmy sperm whale is more likely to be observed within the project area. Below is a brief description of the pygmy and dwarf sperm whale.

Pygmy sperm whales are distributed worldwide in deep tropical and temperate waters. They are rarely seen at sea due to their deep diving times and inconspicuous nature on the surface. Pygmy sperm whales mostly feed on mid- and deep-water squid, but may also feed on shrimp and various small fish (Allen et al., 2011). The available data is not sufficient enough to distinguish seasonal distribution or stock boundaries (NMFS, 2012c). On occasion, pygmy sperm whales will strand together, reflecting a strong social structure within pods. The most recent estimate indicated that at least 271 individual occur off California, Oregon, and Washington (NMFS, 2012c). No long-term population trend has been determined at this time.

Dwarf sperm whales are distributed throughout deep waters and along the continental slopes of the North Pacific and other ocean basins. According to NMFS, no at-sea sightings of this species have been reported, which may be due to their pelagic distribution, small body size and cryptic behavior (NMFS, 2011). A few sightings of animals identified only as *Kogia* sp. have been reported, and some of these may have been dwarf sperm whales. At least five dwarf sperm whales stranded in California between 1967 and 2000 (NMFS, 2011). They are often observed as an individual or up to 10 individuals (Allen *et al*., 2011). No information is available on the minimum population for dwarf sperm whales off of California, Oregon, and Washington (NMFS, 2011).

4.1.12 Baird's Beaked Whale

The Baird's beaked whale is the largest of the beaked whale family and are distributed along continental slopes and throughout deep waters of the North Pacific (NCCOS, 2007). The Baird's beaked whale range is from the offshore waters of Baja California to as far as the Pribilof Islands. NMFS surveys indicated a seasonal presence of Baird's beaked whales off the west coast of the United States. Most sightings are in summer and fall along the continental slope, and it appears that these whales migrate further offshore in the winter (Allen *et al*., 2011). They are often observed in groups of three to 30 or more individuals. The most recent estimates in 2010 indicate that at least 615 individuals are known to occur off California, Oregon, and Washington (NMFS, 2011). No long-term population trends have been determined at this time (NMFS, 2011).

4.1.13 Striped Dolphin

Striped dolphins are distributed world-wide in tropical and warm-temperate pelagic waters. Striped dolphins are gregarious and are often observed in groups averaging from 28 to 83 individuals (Allen *et al*., 2011). Most sightings of striped dolphins occur within about 185 to 556 km (100 to 300 nautical miles) from the coast. Based on sighting records off California and Mexico, striped dolphins appear to have a continuous distribution in offshore waters of these two regions. The most recent estimates in 2010 indicate that at least 8,231 individuals are known to occur off California, Oregon, and Washington (NMFS, 2011). No long-term population trends have been determined at this time (NMFS, 2011).

4.1.14 Mesoplodont Beaked Whales

Mesoplodont beaked whales are distributed throughout deep waters and along the continental slopes of the North Pacific Ocean. Six species known to occur in this region include: Blainville's beaked whale (*M. densirostris*), Perrin’s beaked whale (*M. perrini*), Lesser beaked whale (*M. peruvianus*), Stejneger's beaked whale (*M. stejnegeri*), Gingko-toothed beaked whale (*M. gingkodens*), and Hubbs' beaked whale (*M. carlhubbsi*) (NMFS, 2011). However, due to the rarity of records and the difficulty in identifying these animals in the field, virtually no species-specific information is available so this species has been grouped to include all in the *Mesoplodon* stocks for this region. The most recent estimates in 2010 indicate that at least 576 individuals are known to occur off California, Oregon, and Washington (NMFS, 2011).

4.2 MYSTICETES (BALEEN WHALES)

Three families of mysticetes, (baleen whales), along the central California coast. Species include the gray whale, the northern right whale, and members of the rorqual family (Balaenopteridae). Rorquals are characterized as having pleated throats that expand to take in water, which is then strained outward through the baleen. Rorqual species include: blue whale, fin whale, humpback whale, and minke whales.

Although individual species’ patterns vary, baleen whales range widely in the North Pacific, migrating between coldwater summer feeding grounds in the north and winter calving grounds in the south (Bonnell and Dailey, 1993). The mating season generally begins during the fall during the southbound migration and lasts through winter. Most baleen whales feed low on the food chain, eating a variety of swarming, pelagic, shrimp-like invertebrates (Bonnell and Dailey, 1993). Some species also take small schooling fishes and squid. Larger rorquals, such as the blue whale, appear to feed mainly on large pelagic crustaceans, while the diets of smaller baleen whales tend to include more fish.

Due to the offshore nature of the proposed Project, several species of the mysticetes, have the potential to occur within the Project area, or to be encountered by vessels traveling to the Project area. The species with the highest potential to be encountered during Project activities are discussed below:

4.2.1 Gray Whale

The gray whale is the most commonly observed cetacean The gray whale population breeds and calves in lagoons along the west coast of Baja California and in the Gulf of California in the winter (NCCOS, 2007). At the end of the season, the population begins an 8,000 km (5,000 mi) coastal migration to summer feeding grounds to the north. Migrating gray whales generally travel within 3 km (1.86 mi) of the shoreline over most of the route, unless crossing mouths of rivers and straits (Dohl *et al*., 1983). The southward migration generally occurs from December through February and peaks in January. The northward migration in the Project area generally occurs from February through May with a peak in March. The most recent population estimates of eastern North Pacific gray whale indicated approximately 19,126 individuals and a minimum of 18,017 individuals (NMFS, 2011). The gray whale population growth rate was about 3.3 percent per year between 1968 and 1988 (NOAA, 1993), and following 3 years of review, was removed from the endangered species list on June 15, 1994. Gray whales were observed in the winter of 2010 during marine mammal monitoring events within or near Project area waters (Padre, 2011a).

4.2.2 Humpback Whale

The humpback whale is an endangered species due to intensive historical commercial whaling. Humpbacks are distributed worldwide and undertake extensive migration in parts of their range (Leatherwood *et al*., 1982; NMFS, 1991). The population in the Project area is referred to as the eastern northern stock or California/Oregon/Washington stock, which spends the winter/spring months in coastal Central America and Mexico for breeding and calving and migrate to the coast of California to southern British Columbia in summer/fall to feed (NMFS, 2011). In the summer, humpbacks are found in high latitude feeding grounds of the Gulf of Alaska in the Pacific. The humpback whales are distributed mostly over shelf and slope habitats and are more frequently sighted off central California from March through November, with peaks in the summer and fall (NCCOS, 2007). Migrants passing through central California appear to follow a more inshore path than blue or fin whales (Bonnell and Dailey, 1993). The most recent population estimates of humpback whale indicate that at least 1,878 individuals occur off California, Oregon, and Washington (NMFS, 2011). This population estimate is anticipated to be increasing (NMFS, 2011). Humpback whales were observed on multiple occasions from late summer through winter of 2010 during marine mammal monitoring events within or near Project area waters (Padre, 2010, 2011a). Tenera Environmental (2007) reported approximately four humpback whales during marine mammal monitoring conducted in November 2007 within the Project area.

4.2.3 Blue Whale

The blue whale is a federally listed endangered species due to intensive historical commercial whaling. Blue whales are distributed worldwide in circumpolar and temperate waters, and inhabit both coastal and pelagic environments (Leatherwood *et al*, 1982; Reeves *et al*., 1998). Poleward movements in spring allow the whales to take advantage of high zooplankton production in summer (NMFS website [f]). This species is most common from June through November off central and southern California coastal waters where it tends to concentrate near areas of upwelling particularly off the northern Channel Islands. The best available science suggests the gestation period is approximately 10 to 12 months and that calves are nursed for about 6 to 7 months. Most reproductive activity, including births and mating, takes place during the winter (NMFS website [a]). The most recent estimates of the blue whale indicate that a minimum of 2,046 individuals occur off the U.S. west coast (NMFS, 2011). Two blue whales were observed during a marine mammal monitoring event offshore of Point Sal at the limits of the Project survey area in the summer of 2010 (Padre, 2010a).

4.2.4 Minke Whale

Minke whales are a coastal species that are widely distributed on the continental shelf throughout the eastern North Pacific Ocean (Green *et al*., 1989) and occur year-round off the coast of California. This species favors shallow water and venture near shore more often than other baleen whales (Watson, 1981). They seem to be curious about shipping and approach moving vessels. The most recent estimates of minke whales indicate that at least 202 individuals occur off California, Oregon, and Washington, but no long-term trend for the population has been identified at this time (NMFS, 2011). Two minke whales were observed from late summer through winter of 2010 during marine mammal monitoring events within or near Project area waters (Padre, 2010, 2011a).

4.2.5 North Pacific Right Whale

The north Pacific right whale is a federally listed endangered species due to historical intensive historical commercial whaling. Like other baleen whales, right whales appear to migrate from high-latitude feeding grounds toward more temperate waters in the fall and winter, although the location of seasonal migration routes is unknown (Allen *et al.*, 2011). The usual wintering ground of north Pacific right whales extends from northern California to Washington, although sightings have been recorded as far south as Baja California and near the Hawaiian Islands (Allen *et al*., 2011; Gendron *et al*., 1999; Scarff, 1986). Females give birth to their first calf at an average age of 9 to 10 years. Gestation lasts approximately one year. Calves are usually weaned toward the end of their first year. This species feeds from spring to fall, and also in winter in certain areas. The primary food sources are zooplankton, including copepods, euphausiids, and cyprids. Unlike other baleen whales, right whales are skimmers: they feed by removing prey from the water using baleen while moving with their mouth open through a patch of zooplankton (NMFS website [b]). According to the NMFS (2011), the population estimate for the Eastern North Pacific Stock for this species remains low at only 17 individuals. No long-term population trends have been determined at this time (NMFS, 2011). None were observed during recent marine mammal monitoring projects in the general Project vicinity (Padre, 2010, 2011a).

4.2.6 Fin Whale

The fin whale is a federally endangered species due to a severe worldwide population decline due to intensive commercial whaling. Summer distribution is generally offshore and south of the northern Channel Island chain, particularly over the Santa Rosa-San Nicolas Ridge. However, acoustic signals from fin whale are detected year-round off northern California, Oregon, and Washington, with a concentration of vocal activity between September and February (Moore *et al*. 1998 in NMFS, 2011).

Little is known about the social and mating systems of fin whales. Males become sexually mature at 6 to 10 years of age; and females at 7 to 12 years of age. Physical maturity is attained at approximately 25 years for both sexes. Usually mating and birthing occurs in tropical and subtropical areas during midwinter. Fin whales are the second-largest species of whale, with a maximum length of about 22 m (75 ft) in the Northern Hemisphere, and 26 m (85 ft) in the Southern Hemisphere. Fin whales feed on euphasiid shrimp, copepods, and small fish. Although there is no indication of recent population trends, the California coastal waters stock did increase in the 1980s and 1990s (NMFS, 2011). The most recent estimates of the fin whale population indicate that at least 2,624 individuals occur off California, Oregon, and Washington (NMFS, 2011). There is some evidence that recent increases in fin whale abundance have occurred in California waters (Barlow, 1994; Barlow and Gerodette 1996, NMFS, 2011), but these have not been significant (Barlow *et al*., 1997). None were observed during recent marine mammal monitoring projects in the general Project vicinity (Padre, 2010, 2011a).

4.2.7 Sei Whale

The sei whale is a federally listed endangered species. Sei whales were historically abundant off of the California coast and were the fourth most common whale taken by California coastal whalers in the 1950s-1960s. However, due to intensive whaling, they are now considered “extraordinarily” rare (NMFS, 2011; Allen *et al*., 2011). The most recent estimate of the sei whale northern Pacific stock population is at least 83 individuals off California, Oregon, and Washington (NMFS, 2011). Sei whales occur throughout most temperate and subtropical oceans of the world. The northern Pacific stock rarely ventures above 55 degrees N latitude or south of California (Allen *et al*., 2011). Like most baleen whales, they migrate between warmer waters used for breeding and calving in winter and high-latitude feeding grounds where food is plentiful in the summer. The northern Pacific stock ranges almost exclusively in pelagic waters and rarely ventures into coastal waters (Allen *et al*., 2011). None were observed during recent marine mammal monitoring projects in the general Project vicinity (Padre, 2010, 2011a).

4.3 PINNIPEDS

Five of the 36 species of pinnipeds known worldwide occur off the central California coast. Three are eared seals (family Otariidae) and two are earless seals (family Phocidae). The species of Otariidae that may occur in central California waters are: northern fur seal, Steller sea lion, and California sea lion. Two species of Phocidae that are known to occur within the central California coast include the northern elephant seal and Pacific harbor seal.

4.3.1 California Sea Lion

The California sea lion is the most abundant pinniped in California, representing 50 to 93 percent of all pinnipeds on land and about 95 percent of all sightings at sea (Bonnell *et al*., 1981; Bonnell and Ford, 1987). This species ranges from Baja California, Mexico to British

Columbia. The breeding time period and rookery occupancy is mid-May to late July (NCCOS, 2007). In central California, a small number of pups are born on Año Nuevo Island, Southeast Farallon Island, and occasionally at a few other locations; otherwise the central California population is composed of non-breeders. The most recent population estimates for the California sea lion stock indicate that at least 153,337 individuals occur in California (NMFS, 2011). This number is believed to be increasing despite recent drops in pups due to El Niňo events occurring in the late 1990's (NMFS, 2011). California sea lions were observed regularly from late summer through winter of 2010 during marine mammal monitoring events within or near Project area waters (Padre, 2010, 2011a).

4.3.2 Northern Fur Seal

The northern fur seal is the most abundant otariid in the Northern Hemisphere. Most of the population is associated with rookery islands in the Bering Sea and the Sea of Okhotsk, although a small population has existed on San Miguel Island since the late 1950s or early 1960s (NMFS, 2011). Adult females and juveniles migrate to the central California area (and Oregon and Washington) from rookeries on San Miguel Island in the Southern California Bight (SCB) (Carretta *et al*., 2006), and from the Pribilof Islands in the Bering Sea (NCCOS, 2007). During winter migration, female northern fur seals from the Pribilof Islands travel south and arrive off California beginning in February and remain until about August before returning to breeding grounds (NCCOS, 2007). The most recent population estimates for the San Miguel Island stock indicate that at least 5,395 individuals are known to occur (NMFS, 2011). No long-term population trends have been determined at this time (NMFS, 2011). None were observed during recent marine mammal monitoring projects in the general Project vicinity (Padre, 2010, 2011a).

4.3.3 Steller Sea Lion

The Steller or northern sea lion is a federally listed threatened species. The Steller sea lion ranges along the North Pacific rim, from northern Japan, the Aleutian Islands, Gulf of Alaska, and south to Año Nuevo Island, California (the southernmost rookery). Critical habitat identified for this species includes the major California rookeries at Año Nuevo and the Farallon Islands. At least 90 percent of the species' world population is centered in the Gulf of Alaska, the Bering Sea, and the Sea of Okhotsk. Historically, this species was one of the most abundant pinnipeds in the SCB. Adult males begin arriving on the rookeries first, in mid-May, and establish territories. Pregnant females arrive in late May and give birth to a single pup. Females and pups begin leaving the rookeries in September and pups typically remain with their mother through the first year. Steller sea lions are known to feed on a variety of nearshore, sublittoral prey in estuarine and marine waters. Jones (1981) reported that Steller sea lions feed mainly on bottom-dwelling fishes, and that all the prey items normally eaten by this species inhabit waters less than about 183 m (600 ft) deep.

Numbers have declined precipitously in the last several decades, but the causes of the decline are not well understood (Bartholomew 1967; Le Boeuf and Bonnell 1980). The most recent population estimate for the Steller sea lion indicate that at least 42,366 individuals occur in the Western U.S. Stock (NMFS, 2011). This population is decreasing (NMFS, 2011). There are three haul-out locations recorded near Lion Rock approximately 1.6 km (1 mi) north of the DCPP embayment. None were observed during recent marine mammal monitoring projects in the general Project vicinity (Padre, 2010, 2011a).

4.3.4 Guadalupe Fur Seal

The Guadalupe fur seal is a federally listed threatened species due to the near extinction by commercial sealing in the 19th century. The Guadalupe fur seal range is from Guadalupe Island north to the California Channel Islands, but individuals are occasionally sighted as far south as Tapachula near the Mexico-Guatemala border and as far north as Mendocino, California (Allen *et al*., 2011). As their numbers increase, Guadalupe fur seals are expanding their range and are regularly seen on San Miguel and San Nicolas islands, and, occasionally, on the South Farallon Islands. Presently, the species breeds only on Isla de Guadalupe off the coast of Baja California, Mexico, although individual animals are appearing more regularly in the Channel Islands and a single pup was born on San Miguel Island in 1997 (Allen *et al*., 2011). The most recent population estimates for the Guadalupe fur seal in Mexico is 3,028 individuals. Overall, the population is increasing at approximately 13 percent, considered to be relatively rapid (NMFS, 2011). None were observed during recent marine mammal monitoring projects in the general Project vicinity (Padre, 2010, 2011a).

4.3.5 Northern Elephant Seal

Northern elephant seals breed along the coast from Baja California north to Point Reyes. Northern elephant seals typically haul-out on land only to breed and molt and then disperse widely at sea. The breeding period is generally December through March and molting occurs April through August; females and juveniles molt in April to May; sub-adult males molt in May to June, and adult males molt in July to August; and yearlings molt in the fall. The Northern elephant seal is present year-round off central California; however, because they spend very little time at the surface and forage mostly offshore, at-sea sightings are rare (NCCOS, 2007). The most recent population estimates for the California breeding stock of northern elephant seals indicated that at least 74,913 individuals occur in California and the stock appears to increasing (NMFS, 2011). No haul-out or rookeries have been documented within the Project area (NMFS, 2011). However, there is a haul-out at Piedras Blacas within approximately 16 km (10 mi) of the Project area. No elephant seals were observed during recent marine mammal monitoring projects in the general Project vicinity (Padre, 2010, 2011a).

4.3.6 Pacific Harbor Seal

Pacific harbor seals range from Mexico to the Aleutian Islands (Allen *et al*., 2011). Pacific harbor seals are year-round residents of central California. Unlike most pinnipeds occurring off California, the Pacific harbor seal maintain haul-out sites on the mainland on which they pup and breed (Allen *et al*., 2011). Haul outs may be occupied at any time of year for resting. Pupping generally occurs between March and June and molting occurs between May and July (NCCOS, 2007). The most recent minimum population estimates of the California stock indicate there are at least 26,667 individuals (NMFS, 2011). After increases in the 1990s, this population is believed to be stable and possibly reaching its carrying capacity (NMFS, 2011). Harbor seals were observed regularly from late summer through winter of 2010 during marine mammal monitoring events within or near Project area waters (Padre, 2010, 2011a).

4.4 FISSIPEDS

One fissiped species is known to occur within the central California coast, the southern sea otter.

4.4.1 Southern Sea Otter

The southern sea otter is listed as “threatened” under the FESA, “depleted” under the Marine Mammal Protection Act (MMPA), and “fully protected” under California Fish and Game Code. Historically, the range of sea otters extended from the northern islands of the Japanese Archipelago northeast along Alaska and southward along North America to Baja California (Dailey *et al*., 1993). The sea otter was nearly extirpated by the fur trade during the 18th and 19th centuries. The current range extends from about Half Moon Bay in the north to Santa Barbara in the south. A small, satellite population of 20 to 40 animals also occurs at San Nicolas Island, the result of a translocation effort in the late 1980s (NCCOS, 2007). This species prefers rocky shoreline with water depth of less than 5 m (50 ft), which support kelp beds where they feed on benthic macro-invertebrates including clams, crabs, abalone, sea urchins, and sea stars. Recent minimum population estimates for southern sea otters in California indicate that at least 2,711 individuals are known to occur and no long-term trends in this population are available (USGS, 2010). Within the Project area, an increase in population could be seen during the period when most breeding occurs (June - November) (NCCOS, 2007). Southern sea otters were observed regularly from late summer through winter of 2010 during marine mammal monitoring events within or near Project area waters (Padre, 2010, 2011a).

Sea otters are most common in and around kelp beds and open water areas support substantially fewer adults. Kelp habitat provides territories and home range areas for male and females and sea otters will regularly be found in the same area over an extended period. Open water area can and do have large numbers of otters on a regular basis, but the distributions can shift. It is believed that some of the highest densities continue to be found in open water habitat, such as Estero Bay, Monterey, and offshore of Pismo Beach (M. Harris, pers. comm., 2011).

5.0 TYPE OF INCIDENTAL TAKE AUTHORIZATION REQUESTED

The type of incidental taking authorization that is being requested (i.e., takes by harassment only, takes by harassment, injury and/or death), and the method of incidental taking.

PG&E requests an Incidental Harassment Authorization (IHA) pursuant to Section 101(a)(5)(D) of the MMPA for the incidental take by harassment during its planned 3D marine seismic survey. The survey will occur in the Pacific Ocean off the Central Coast of California between Morro Bay and Avila Beach in San Luis Obispo County during the period between October 15 and December 31, 2012. Mobilization will initiate on October 15, 2012; however, air guns will be active from November 1 through December 31, 2012.

Sounds generated by the operations, as detailed in Sections 1.0, have the potential to result in the take of marine mammals, which under the legal definition of the MMPA includes harassment. Sound sources with the potential to “harass” marine mammals include air guns, the pinger system, echosounder, and sub-bottom profiler used during the surveys. Harassment of animals can potentially occur when marine mammals within the distance from a sound source that exposes them to pre-determined sound levels generated by the air guns. The effects will depend on species, the behavior of the animal at the time of reception of the stimulus, as well as the distance and received sound level (see Section 7.0). Disturbance reactions by some of the marine mammals in the general vicinity of the track lines of the source vessel may likely occur. No take by injury or death is anticipated due to the nature of the seismic surveys operations and the proposed mitigation measures (see Section 11.0).

6.0 NUMBERS OF MARINE MAMMALS THAT MAY BE TAKEN

By age, sex, and reproductive condition (if possible), the number of marine mammals (by species) that may be taken by each type of taking identified in Section V, and the number of times such takings by each type of taking are likely to occur.

6.1 INTRODUCTION

The proposed marine seismic survey activities outlined in Sections 1.0 and 2.0 have the potential to disturb or displace small numbers of marine mammals. These potential effects, as summarized in Section 7.0, will not exceed what is defined in the 1994 amendments to the MMPA as “Level B” harassment (behavioral disturbance). The mitigation measures to be implemented during this survey are based on Level B harassment criteria using the sound level of 160 dB re 1 µPa (rms), and will, as such, minimize any potential risk of injury, such as damage to the auditory organs. No take by injury or death is likely given the nature of the activities and proposed monitoring and mitigation measures. Section 7.0 provides a summary of potential sound-related impacts on marine mammals.

This section describes the methods used to estimate the numbers of marine mammals that might be “taken by harassment” during PG&E’s proposed marine seismic survey along the Central California Coast. Density estimates are based on the best available peer-reviewed scientific data, specifically, the NMFS on-line marine mammal database (Barlow *et al*., 2009). These data are supplemented with non-published survey data obtained from the Project area during an earlier low-energy 3D survey (Padre Associates, Inc., 2011b). The following subsections describe in more detail the data and methods used in deriving the estimated number of animals potentially “taken by harassment” during the proposed survey. It provides information on the expected marine mammal densities, estimated distances to received levels of 190, 180, 160, and 120 dB, and the calculation of anticipated areas ensonified by sound levels of ≥160 dB.

6.2 MARINE MAMMAL DENSITY ESTIMATES

The principal source of density information is the Strategic Environmental Research and Development Program (SERDP)- SDSS Marine Animal Model Mapper on the Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations (OBIS-SEAMAP) website (Barlow, *et al*., 2009), which was recommended by NMFS staff (M. DeAngelis, pers. comm., 2011). A second density dataset was prepared by Padre Associates, Inc. (2011b) based on marine mammal sightings recorded during a seismic survey conducted between October 2010 and February 2011. The Padre dataset was from the southern portion of the proposed 3D survey area, and contained densities for species for which data were sparse or absent from the National Oceanic and Atmospheric Administration (NOAA) database.

It should be noted that the Padre dataset was compiled from a series of daily marine mammal monitoring reports, and the data were not originally collected for the purpose of developing density estimates. Further, all survey data are subject to detectability and availability biases. Detectability bias is associated with diminishing sightability of marine mammals with increasing lateral distance from the survey trackline. Availability bias is due to the fact that not all marine mammals are at the surface at all times, and, as such, there is less than 100 percent probability of detecting a animals along the trackline. The Padre dataset was used particularly for species (i.e. gray whale) for which no data were reported in the NMFS database.

Within Tables 7 and 8, marine mammal densities were calculated based on available density or survey data. The preferred method of acquiring density data was the SERDP sponsored by Department of Defense (DOD) with mapping provided by OBIS-SEAMAP. Within the mapping program density data are available by strata or density models (indicated with a superscripted lower case “a” (^{a}). This method was recommended by Monica DeAngelis and Jay Barlow of NMFS.

For density models, the Geographic Information Systems (GIS) shapefile of the Project site (race track with Safety Zone buffer) was uploaded into the program and densities were calculated using available NMFS data within the uploaded Project site. Density data calculated using this method was indicated with a superscript 1 (^{1}). All densities calculated using this model was from summer data (defined as July-December). For density data indicated with a superscript 2 (^{2}), stratum density data was used within the same SERDP; however, a different layer of the mapping program were utilized. The stratum layer provides limited density data for the region the species occurs within. This density number within the stratum layer is static for the region.

For Padre densities indicated with a uppercase superscript B (^{B}), data were acquired between October 2010 and February 2011 during geophysical surveys. The data used to acquire the densities were collected from daily monitoring logs where species were observed and recorded when navigating survey track lines and transiting to and from the survey area. The density was calculated based on a 305 m (1,000 ft) visibility in each direction of the observer/vessel by the distance of track lines or transits conducted during the survey period. These density data were used as supplemental information based on the lack of density models of species within the SERDP.

For harbor porpoise density data indicated with superscripted c (^{C}), Dr. Karin Forney constructed fine-scale density estimates based on aerial surveys of the central coast conducted between 2002 and 2011. Dr. Forney provided latitude coordinates of density changes for the harbor porpoise, which was inserted into GIS to delineate the associated polygon within the project survey boxes. The corrected density data from Dr. Forney were extracted for the project site within the 160 dB ensonified areas of Boxes 2 and 4. The density data are variable based on the location within the project site, with the San Luis Bay having the highest density. Because of the variable densities used to extract the estimated number of individuals within the project site, the densities within Tables 7 and 8 are broad categorical densities for their corresponding survey box. Additionally, the offshore portion (> 92 m) of the harbor porpoise density is a stock-wide density used in Caretta et al. 2009 and also within the data provided by

Dr. Forney of NMFS. An additional figure illustrating the fine scale densities used to calculate the take numbers is available in Appendix B.

USGS southern sea otter density data was used to calculate the number of individuals that could occur within the project site. Southern sea otter (sea otter) census and distribution data and shapefiles were extracted from the USGS Western Ecological Research Center's (WERC) Spring 2010 (May-July 7). The WERC data contain a GIS shapefile with various density estimates delineated by polygons along the central California coast including the project area. These data are presented as a 3-year average of the number of sea otters per square kilometers (km^2) within each polygon; the data were averaged by 10 kilometer (km) coastline segments to account for spatial/temporal variation in sea otter activity and survey conditions. Data polygons are also provided from shore to the 30 meter (m) depth contour and between the 30 and 60 m depth contours. Similar to harbor porpoise density analysis, the density polygons that overlapped with the project footprint were extracted and analyzed. See Appendix C for density and sea otter range calculations and figures.

6.3 3D SEISMIC SURVEY AREA

The size of the proposed 2012 3D seismic survey area is approximately 740.52 km^2 (285.9 mi^2) and located adjacent to the coastline and extending from 11 to 21 km (6.8 to 13 mi) offshore, as depicted in Figure 2.

6.4 SAFETY RADIUS

This section describes the methods and underlying assumptions used to estimate the safety radius for received levels of the 160 dB re 1µPa (rms) for pulsed sounds emitted by the air gun array. Distance to received sound levels of 160 dB re 1µPa (rms) is used to estimate the potential number of marine mammals subject to Level B Harassment and forms the basis for the requested take authorization. Distances to received levels of 120, 154, 160, 170, 180, 187, and 190 dB re 1µPa (rms) are detailed in Table 5 below.

Table 5. Calculated Radii for Upslope, Downslope, and Alongshore Propagation Paths and Predicted RMS Radii for Single Bolt Air Gun

Sound Pressure Level (SPL) (dB re 1 uPa)	Upslope Distance (In shore)			Downslope Distance (Offshore)			Alongshore Distance		
	M[1]	SM[2]	NM[3]	M[1]	SM[2]	NM[3]	M[1]	SM[2]	NM[3]
190	250	0.16	0.13	280	0.17	0.15	320	0.20	0.17
187	390	0.24	0.21	370	0.23	0.20	410	0.25	0.22
180	1,010	0.63	0.55	700	0.43	0.38	750	0.47	0.40
170	2,990	1.86	1.61	1,760	1.09	0.95	1,760	1.09	0.95
160	6,210	3.86	3.35	4,450	2.77	2.40	4,100	2.55	2.21
154	8,570	5.33	4.63	7,820	4.86	4.22	6,780	4.21	3.66
120	24,650	15.32	13.31	251,320	156.16	135.70	94,870	58.95	51.23

Sound Pressure Level (SPL) (dB re 1 uPa)	Upslope Distance (In shore)			Downslope Distance (Offshore)			Alongshore Distance		
	M[1]	SM[2]	NM[3]	M[1]	SM[2]	NM[3]	M[1]	SM[2]	NM[3]

Predicted RMS Radii for Single Bolt Air Gun (40 in^3)[1]

Source and Volume	Water Depth	Predicted RMS Distances (m/mile)	
		180 dB	160 dB
Single Bolt air gun (40 in^3)	Shallow < 100 m	296 (0.18)	1,050 (0.65)
	Intermediate 100 – 1,000 m	60 (0.04)	578 (0.36)
	Deep > 1,000 m	40 (0.02)	385 (0.24)

[1] Diebold, J.B., M. Tolstoy, L. Doermann, S.L. Nooner, S.C. Webb, and T.J. Crone. 2010. R/V Marcus G. Langseth seismic source: Modeling and calibration. Geochem. Geophys. Geosyst

M[1] Meters
SM[2] Statute miles
NM[3] Nautical Miles

Impacts on marine mammals from the planned seismic survey focus on the sound levels from the seismic air gun. The strengths of the air gun pulses can be measured in a variety of ways, but NMFS commonly uses rms (in dB re 1µPa [rms]), which is the level of the received air gun pulses averaged over the duration of the pulse. The rms value for a given air gun pulse is typically 10 dB lower than the peak level, and 16 dB lower than the peak-to-peak level (McCauley *et al*., 1998, 2000a).

The 160 dB safety radius for the proposed 3D seismic survey was based on the results of mathematical modeling conducted by Greeneridge Sciences, Inc. (2011), and is summarized in Table 6 below. The modeling was based on the air gun description detailed previously in Section 1.3.4. A copy of the Greeneridge Sciences report is contained in Appendix A of this application.

6.5 3D SURVEY AREA WITH SAFETY RADIUS

The 3D survey area varies by survey box (Table 6). The anticipated area ensonified by the sound levels of ≥160 dB, based on the calculations provided by Greeneridge Scientific, is a 6.21 km (3.856 mi) radius extending from each point of the survey area perimeter (hereafter called the 160 dB safety radius). This results in a maximum total area as shown in Table 6 and depicted on Figures 11 and 12 below. This approach was taken because closely spaced survey lines and large cross-track distances of the ≥160 dB radii result in repeated exposure of the same area of water. Excessive amounts of repeated exposure probably results in an overestimate of the number of animals potentially exposed.

Table 6. Survey Areas and Survey Areas with 160 dB Safety Radius

Survey Box	Survey Area (km^2[mi^2])	Survey Area with Safety Radius (km^2[mi^2])
2	406.0 [156.8]	1,272.3 [491.2]

4	334.5 [129.1]	784.5 [302.9]

6.6 POTENTIAL NUMBER OF 'TAKES BY HARASSMENT"

The number of individuals of each species potentially exposed to received levels ≥160 dB re 1 µPa (rms) was estimated by multiplying each anticipated survey area (Boxes 2 and 4) to be ensonified by the expected species density (in number/km^2).

Some of the animals estimated to be exposed might show avoidance reactions before being exposed to ≥160 dB re 1 µPa (rms). Thus, these calculations actually estimate the number of individuals potentially exposed to ≥160 dB that would occur if there were no avoidance of the area ensonified to that level and, as such, may be overestimates.

In addition to density estimates, Tables 7 and 8 include the estimated number of marine mammals, by species, that would be potentially exposed to sounds ≥160 dB from seismic data acquisition in the 3D survey for each individual survey area. For the species that a density was not reported (Barlow *et al*., 2009), a minimum density (0.00001/km^2) was used for low probability for chance encounters.

Table 9 is a summary of requested take numbers by "harassment" for the two survey areas. Potential take numbers were derived from potential species to occur within the 160 dB safety radius in Tables 7 and 8. Within Table 9, an additional 25% has been added to the species expected to occur within the safety radius. This additional 25% will account for repeated exposure.

Figure 11. Box 2 Calculated Safety Zone Based on the 160 dB Distance

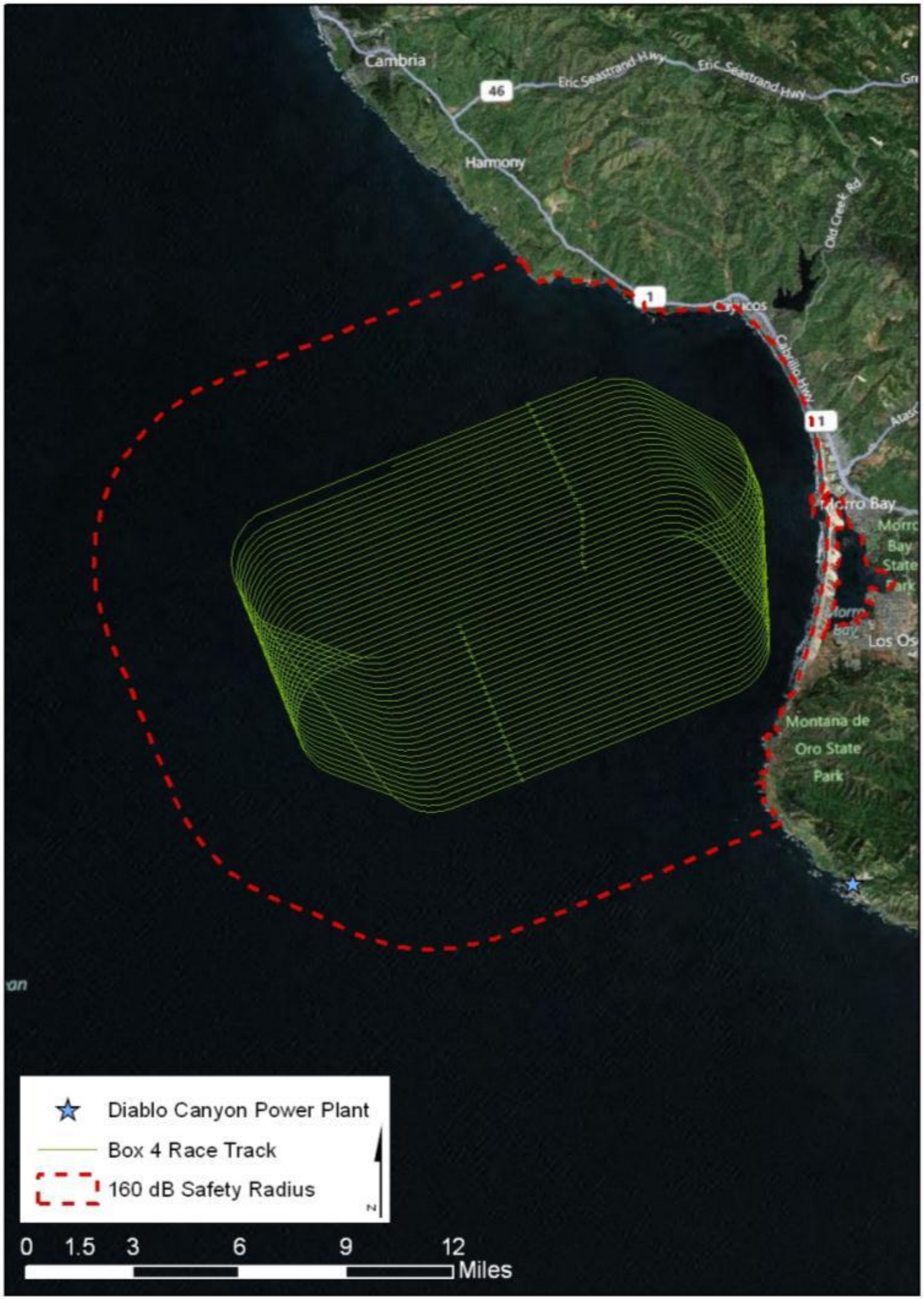

Figure 12. Box 4 Calculated Safety Zone Based on the 160 dB Distance

Table 7. Estimated Number of Marine Mammals by Species in Proposed Safety Radius in Box 2

Common Name ***Scientific Name***	**NOAA Density[a]** (No/km^2)			**Padre Density[b]** (No/km^2)		**Individuals in 160 dB Safety Radius[c]**
	Min	**Max**	**Mean**	**Transit**	**Transect**	
Mysticeti						
California gray whale *Eschrichtius robustus*	ND	ND	ND	0.0154	0.0211	27
Fin whale[1] *Balaenoptera physalus*	0.000142	0.01083	0.004385			6
Humpback whale[1] *Megaptera novaeangliae*	0.000088	0.005781	0.002349	0.0028	0.0065	3
Blue whale[1] *Balaenoptera musculus*	0.0001	0.006603	0.002652			3
Minke whale[2] *Balaenoptera acutorostrata*	0.000276	0.000276	0.000276	0.0007	0.0008	0
North Pacific right whale[2] *Eubalaena japonica*	0.000061	0.000061	0.000061			0
Sei whale[2] *Balaenoptera borealis*	0.000086	0.000086	0.000086			0
Odontoceti						
Short-beaked common dolphin[1] *Delphinus delphis*	0.01203	0.8019	0.3252	0.0252	0.0836	414
Long-beaked common dolphin[2] *Delphinus capensis*	0.018004	0.018004	0.018004			23
Small beaked whale[1e]	0.000042	0.003347	0.001363			2
Harbor porpoise[3] *Phocoena phocoena*						
Morro Bay Inshore Stock (<92 m)	0.43	4.17	1.83	0.0259	0.0016	895
Morro Bay Offshore Stock (>92 m)	0.062	0.062	0.062			
Dall's porpoise[1] *Phocoenoides dalli*	0.000441	0.03504	0.01433		0.0081	18
Pacific white-sided dolphin[1] *Lagenorhynchus obliquidens*	0.001027	0.08342	0.03364			43
Risso's dolphin[1] *Grampus griseus*	0.000672	0.04279	0.01721	0.0063	0.2881	22
Northern right whale dolphin[1] *Lissodelphis borealis*	0.00066	0.0503	0.02038			26
Striped dolphin[1] *Stenella coeruleoalba*	0.000039	0.0033	0.001379		0.0081	2
Baird's beaked whale[1] *Berardius bairdii*	0.000016	0.001148	0.000467			1
Bottlenose dolphin[2] *Tursiops truncatus*						
Coastal (year-round) (<1km)[4]	0.361173	0.361173	0.361173			14
Offshore (winter)	0.000616	0.000616	0.000616			1
Sperm whale[1] *Physeter macrocephalus*	0.000009	0.000723	0.000297			0
Kogia Species[2] *Kogia spp*	0.001083	0.001083	0.001083			1
Short-finned pilot whale[2]	0.000307	0.000307	0.000307			0

Common Name ***Scientific Name***	**NOAA Density[a]** (No/km2)			**Padre Density[b]** (No/km2)		**Individuals in 160 dB Safety Radius[c]**
	Min	**Max**	**Mean**	**Transit**	**Transect**	
Globicephala macrorhynchus						
Killer whale[2] *Orcinus orca*						2
Summer	0.000709	0.000709	0.000709			1
Winter	0.000246	0.000246	0.000246		0.0016	0
Pinnipedia						
California sea lion *Zalophus californianus*				0.0898	0.2321	295
Northern elephant seal *Mirounga angustirostris*			0.00001			0
Pacific harbor seal *Phoca vitulina richardsi*				0.0166	0.0089	21
Northern fur seal *Callorhinus ursinus*			0.00001			0
Guadalupe fur seal *Arctocephalus townsendi*			0.00001			0
Northern (Steller) sea lion *Eumetopias jubatus*			0.00001			0
Fissipedia						
Southern sea otter[5] *Enhydra lutris nereis*			1.07	0.3247	0.0235	78

[a] Barlow *et al*. (2009) Average density used in calculation.

[1] Density data based on density models of survey area in SERDP program

[2] Density data based on stratums within SERDP program

[3] Density data from Caretta *et al*., 2009

[4] Density data based on stratums within SERDP program with only area ensonified within 1km from shore calculated.

[5] Density is the overall average of the box, although fine-scale density numbers were used for the calculation. Take number reflects the 70% surface reduction factor, without reduction factor, take for Box 2 is 261(See appendix C).

[b] Padre Associates, Inc. (2011b) (Highest density between transit and track data used)

[c] Based on a 2,307 km^2 safety radius

[d] 0.00001 is an assumed minimum density for species with no reported densities.

SERPD Marine Mammal Mapper categorizes small-beaked whales as both Mesoplodon and Ziphiidae genera; whereas, the NMFS Stock Assessment has Ziphiidae genera whales as there own species assessment and combines only Mesoplodon species together.

160 dB Safety Zone = 878.8 km^2

Table 8. Estimated Number of Marine Mammals by Species in Proposed Safety Radius in Box 4

Common Name ***Scientific Name***	**NOAA Density[a]** (No/km^2)			**Padre Density[b]** (No/km^2)		**Individuals in 160 dB Safety Radius[c]**
	Min	**Max**	**Mean**	**Transit**	**Transect**	
Mysticeti						
California gray whale *Eschrichtius robustus*	ND	ND	ND	0.0154	0.0211	17
Fin whale[1] *Balaenoptera physalus*	0.00239	0.0113	0.006177			5
Humpback whale[1] *Megaptera novaeangliae*	0.00117	0.00635	0.003243	0.0028	0.0065	3
Blue whale[1] *Balaenoptera musculus*	0.001254	0.006777	0.003579			3
Minke whale[2] *Balaenoptera acutorostrata*	0.000276	0.000276	0.000276	0.0007	0.0008	0
Northern Pacific right whale[2] *Eubalaena japonica*	0.000061	0.000061	0.000061			0
Sei whale[2] *Balaenoptera borealis*	0.000086	0.000086	0.000086			0
Odontoceti						
Short-beaked common dolphin[1] *Delphinus delphis*	0.1612	0.8285	0.4443	0.0252	0.0836	349
Long-beaked common dolphin[2] *Delphinus capensis*	0.018004	0.018004	0.018004			14
Small beaked whale[1e]	0.000813	0.003422	0.001952			2
Harbor porpoise[3] *Phocoena phocoena*						
Morro Bay Inshore Stock (<92 m)	0.43	1,42	1.22	0.0259	0.0016	315
Morro Bay Offshore Stock (>92 m)	0.062	0.062	0.062			
Dall's porpoise[1] *Phocoenoides dalli*	0.008552	0.0396	0.0209		0.0081	16
Pacific white-sided dolphin[1] *Lagenorhynchus obliquidens*	0.01856	0.0896	0.04786			38
Risso's dolphin[1] *Grampus griseus*	0.007767	0.04545	0.02316	0.0063	0.2881	18
Northern right whale dolphin[1] *Lissodelphis borealis*	0.0112	0.05254	0.02867			22
Striped dolphin[1] *Stenella coeruleoalba*	0.000943	0.003448	0.002075		0.0081	2
Baird's beaked whale[1] *Berardius bairdii*	0.000244	0.001148	0.000638			1
Bottlenose dolphin[2] *Tursiops truncatus*						
Coastal (year-round) (<1km)[4]	0.361173	0.361173	0.361173			17
Offshore (winter)	0.000616	0.000616	0.000616			0
Sperm whale[1] *Physeter macrocephalus*	0.000187	0.000768	0.000436			0

Common Name *Scientific Name*	NOAA Density[a] (No/km^2)			Padre Density[b] (No/km^2)		Individuals in 160 dB Safety Radius[c]
	Min	**Max**	**Mean**	**Transit**	**Transect**	
Kogia Species[2] *Kogia spp*	0.001083	0.001083	0.001083			1
Short-finned pilot whale[2] *Globicephala macrorhynchus*	0.000307	0.000307	0.000307			0
Killer whale[2] *Orcinus orca*						1
Summer	0.000709	0.000709	0.000709			1
Winter	0.000246	0.000246	0.000246		0.0016	0
Pinnipedia						
California sea lion *Zalophus californianus*				0.0898	0.2321	182
Northern elephant seal *Mirounga angustirostris*			0.00001			0
Pacific harbor seal *Phoca vitulina richardsi*				0.0166	0.0089	13
Northern fur seal *Callorhinus ursinus*			0.00001			0
Guadalupe fur seal *Arctocephalus townsendi*			0.00001			0
Northern (Steller) sea lion *Eumetopias jubatus*			0.00001			0
Fissipedia						
Southern sea otter *Enhydra lutris nereis*			1.7	0.3247	0.0235	79

[a] Barlow *et al*. (2009) Average density used in calculation.

- [1] Density data based on density models of survey area in SERDP program
- [2] Density data based on stratums within SERDP program
- [3] Density data from Caretta *et al*., 2009
- [4] Density data based on stratums within SERDP program with only area ensonified within 1km from shore calculated.
- [5] Density is the overall average of the box, although fine-scale density numbers were used for the calculation. Take number reflects the 70% surface reduction factor, without reduction factor, take for Box 4 is 263 (See appendix C).

[b] Padre Associates, Inc. (2011b) (Highest density between transit and track data used)

[c] Based on a 2,307 km^2 safety radius

[d] 0.00001 is an assumed minimum density for species with no reported densities.

[e] SERPD Marine Mammal Mapper categorizes small-beaked whales as both Mesoplodon and Ziphiidae genera; whereas, the NMFS Stock Assessment has Ziphiidae genera whales as there own species assessment and combines only Mesoplodon species together.

160 dB Safety Zone = 878.8 km^2

Table 9. Requested "Take by Harassment" Numbers with Additional 25 Percent for Boxes 2 and 4

Common Name ***Scientific Name***	**Box 2 Requested Take Authorization**[1]	**Box 2 Take (with additional 25%)**[2]	**Box 4 Requested Take Authorization**[1]	**Box 4 Take (with additional 25%)**[2]
Mysticeti				
California gray whale *Eschrichtius robustus*	27	34	17	21
Fin whale *Balaenoptera physalus*	6	7	5	6
Humpback whale *Megaptera novaeangliae*	3	4	3	3
Blue whale *Balaenoptera musculus*	3	4	3	4
Minke whale *Balaenoptera acutorostrata*	0	0	0	0
Northern Pacific right whale *Eubalaena japonica*	0	0	0	0
Sei whale *Balaenoptera borealis*	0	0	0	0
Odontoceti				
Short-beaked common dolphin *Delphinus delphis*	414	517	349	436
Long-beaked common dolphin *Delphinus capensis*	23	29	14	18
Small beaked whale	2	2	2	2
Harbor porpoise[4] *Phocoena phocoena*	895	-	315	-
Dall's porpoise *Phocoenoides dalli*	18	23	16	20
Pacific white-sided dolphin *Lagenorhynchus obliquidens*	43	53	38	47
Risso's dolphin *Grampus griseus*	22	27	18	23
Northern right whale dolphin *Lissodelphis borealis*	26	32	22	28
Striped dolphin *Stenella coeruleoalba*	2	2	2	2
Baird's beaked whale *Berardius bairdii*	1	1	1	1
Bottlenose dolphin *Tursiops truncatus*				
Coastal (year-round)	14	18	17	21
Offshore (winter)	1	1	0	0
Sperm whale *Physeter macrocephalus*	0	0	0	0
Dwarf sperm whale *Kogia sima*	1	2	1	1
Short-finned pilot whale *Globicephala macrorhynchus*	0	0	0	0
Killer whale *Orcinus orca*	2	3	1	2
Summer	1	1	1	1

Common Name ***Scientific Name***	**Box 2 Requested Take Authorization**[1]	**Box 2 Take (with additional 25%)**[2]	**Box 4 Requested Take Authorization**[1]	**Box 4 Take (with additional 25%)**[2]
Winter	0	0	0	0
Pinnipedia				
California sea lion *Zalophus californianus*	295	369	182	228
Northern elephant seal *Mirounga angustirostris*	0	0	0	0
Pacific harbor seal *Phoca vitulina richardsi*	21	26	13	16
Northern fur seal *Callorhinus ursinus*	0	0	0	0
Guadalupe fur seal *Arctocephalus townsendi*	0	0	0	0
Northern (Steller) sea lion *Eumetopias jubatus*	0	0	0	0
Fissipedia				
Southern sea otter[3] *Enhydra lutris nereis*	78	98	79	99

[1] Requested take numbers are compiled from Tables 7 and 8

[2] Requested take numbers are compiled from column “Individuals in 160 dB Safety Radius” with an additional 25% added for repeated exposure.”

[3] The take with 25% includes the 70% surface reduction; however, the take without the surface reduction with the 25% additional repeated exposure is: Box 2 =261 (326 with 25%) and Box 4= 263 (329 with 25%).

[4] The combined take for Box 2 and 4 for this species is 959 Individuals. No additional take is being requested beyond the calculated value.

7.0 ANTICIPATED IMPACT ON SPECIES OR STOCKS

The anticipated impact of the activity upon the species or stock.

7.1 POTENTIAL EFFECTS OF AIR GUN SOUNDS

The following discussion provides a broad overview of the current understanding of the potential effects of air guns on marine mammals. A more comprehensive review of these issues can be found in the Programmatic Environmental Impact Statement/Overseas Environmental Impact Statement prepared for Marine Seismic Research that is funded by the National Science Foundation and conducted by the USGS (NSF/USGS, 2011).

7.1.1 Tolerance

Numerous studies have shown that marine mammals at distances more than a few kilometers from operating seismic vessels often show no apparent response (Richardson *et al.,* 1995; Southall *et al.,* 2007). 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 air gun 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.

7.1.2 Masking

Masking is the obscuring of sounds of interest by interfering sounds, generally at similar frequencies (Richardson *et al*., 1995). Introduced underwater sound will, through masking, reduce the effective communication distance of a marine mammal species if the frequency of the source is close to that used as a signal by the marine mammal, and if the anthropogenic sound is present for a significant fraction of the time (Richardson *et al*., 1995). If little or no overlap occurs between the introduced sound and the frequencies used by the species, communication is not expected to be disrupted. If the introduced sound is present only infrequently, communication is not expected to be disrupted. The duty cycle of air guns is low, and the air gun sounds are pulsed, with relatively quiet periods between pulses. In most situations, strong air gun sounds will only be received for a brief period (<1 sec), separated by at least several seconds of relative silence, and longer in the case of deep-penetration surveys or refraction surveys. A single air gun array might cause appreciable masking when propagation conditions are such that sound from each air gun pulse reverberates strongly and persists between air gun pulses (Simard *et al*., 2005; Clark and Gagnon, 2006).

Although masking effects of pulsed sounds on marine mammal calls and other natural sounds are expected to be limited, there are few specific studies on this. Some whales continue calling in the presence of seismic pulses and calls have been heard between the seismic pulses (e.g., Richardson *et al*., 1986; McDonald *et al*., 1995; Greene *et al*., 1999a,b; Nieukirk *et al*., 2004; Smultea *et al*., 2004; Holst *et al*., 2005a,b, 2006; Dunn and Hernandez, 2009). However, there is one recent summary report indicating that calling fin whales distributed in one part of the North Atlantic Ocean went silent for an extended period starting soon after the onset of a seismic survey in the area (Clark and Gagnon, 2006). It was not clear whether the whales ceased calling because of masking, or whether this was a behavioral response not directly involving masking. Also, bowhead whales in the Beaufort Sea may decrease their call rates in response to seismic operations, although movement out of the area might also have contributed to the lower call detection rate (Richardson *et al*., 1986). In contrast, DiIorio and Clark (2009) found evidence of increased calling by blue whales during operations by a lower-energy seismic source (i.e., a sparker).

Among the odontocetes, there has been one report that sperm whales ceased calling when exposed to pulses from a very distant seismic ship (Bowles *et al*., 1994). However, more recent studies of sperm whales found that they continued calling in the presence of seismic pulses (Madsen *et al*., 2002; Tyack *et al*., 2003; Smultea *et al*., 2004; Holst *et al*., 2006; Jochens *et al*., 2008). Madsen *et al*., (2006) noted that air gun sounds would not be expected to mask sperm whale calls given the intermittent nature of air gun pulses. Dolphins and porpoises are also commonly heard calling while air guns are operating (Gordon *et al*., 2004; Smultea *et al*., 2004; Holst *et al*., 2005a,b; Potter *et al*., 2007). Masking effects of seismic pulses are expected to be negligible in the case of the smaller odontocetes, given the intermittent nature of seismic pulses plus the fact that frequently used sounds are predominantly at much higher frequencies than are the dominant components of air gun sounds.

Pinnipeds and fissipeds have the most sensitive hearing and/or produce most of their sounds at frequencies higher than the dominant components of air gun sound, but there is some overlap in the frequencies of the air gun pulses and the calls. However, the intermittent nature of air gun pulses presumably reduces the potential for masking.

Marine mammals are thought to be able to compensate for masking by adjusting their acoustic behavior through shifting call frequencies, increasing call volume, and increasing vocalization rates. For example, blue whales are found to increase call rates when exposed to seismic survey noise in the St. Lawrence Estuary (Di Iorio and Clark, 2009). The North Atlantic right whales exposed to high shipping noise increased call frequency (Parks *et al.,* 2007), while some humpback whales respond to low-frequency active sonar playbacks by increasing song length (Miller *et al.,* 2000).

7.1.3 Disturbance Reactions

Marine mammals may behaviorally react to sound when exposed to anthropogenic noise. These behavioral reactions are often shown as: changing durations of surfacing and dives, number of blows per surfacing, or moving direction and/or speed; reduced/increased vocal activities; changing/cessation of certain behavioral activities (such as socializing or feeding); visible startle response or aggressive behavior (such as tail/fluke slapping or jaw clapping); avoidance of areas where noise sources are located; and/or flight responses (e.g., pinnipeds flushing into water from haul-outs or rookeries).

The biological significance of many of these behavioral disturbances is difficult to predict, especially if the detected disturbances appear minor. However, the consequences of behavioral modification could be expected to be biologically significant if the change affects growth, survival, and/or reproduction. Some of these significant behavioral modifications include:

- Drastic change in diving/surfacing patterns (such as those thought to be causing beaked whale stranding due to exposure to military mid-frequency tactical sonar);
- Habitat abandonment due to loss of desirable acoustic environment; and,
- Cessation of feeding or social interaction.

The onset of behavioral disturbance from anthropogenic noise depends on both external factors (characteristics of noise sources and their paths) and the receiving animals (hearing, motivation, experience, demography) and is also difficult to predict (Richardson *et al.,* 1995; Southall *et al.,* 2007).

Currently, NMFS uses 160 dB re 1 μPa at received level for impulse noises (such as air gun pulses) as the onset of behavioral harassment for marine mammals that are under its jurisdiction.

7.2 EFFECTS ON MYSTICETES

Baleen whales generally tend to avoid operating air guns, but avoidance radii are quite variable among species, locations, activities, and oceanographic conditions affecting sound propagation, etc. (Richardson *et al.,* 1995; Gordon *et al.,* 2004). Whales are often reported to show no overt reactions to pulses from large arrays of air guns at distances beyond a few kilometers, even though the air gun pulses remain well above ambient noise levels out to much longer distances. However, baleen whales exposed to strong sound pulses from air guns often react by deviating from their normal migration route and/or interrupting their feeding and moving away. Although baleen whales often show only slight overt responses to operating air gun arrays (Stone and Tasker, 2006; Weir, 2008), strong avoidance reactions by several species of mysticetes have been observed at ranges from 6 to 8 km (3.7 to 5 mi) and occasionally as far as 20 to 30 km (12.4 to 18.6 mi) from the source vessel when large arrays of air guns were used. Experiments with a single air gun showed that bowhead, humpback, and gray whales all showed localized avoidance to a single air gun of 20 to 100 in^3 (Malme *et al.,* 1984, 1985, 1986, 1988; Richardson *et al.,* 1986; McCauley *et al.,* 1998, 2000a, 2000b).

Studies of gray and humpback whales have shown that seismic pulses with received levels of 160 to 170 dB re 1 μPa (rms) seem to cause avoidance behavior in a substantial portion of the animals exposed (Richardson *et al.,* 1995). In many areas, seismic pulses from large arrays of air guns diminish to those levels at distances ranging from 4 to 15 km (2.5 to 9.3 mi) from the source. More recent studies have shown that some species of baleen whales (humpbacks in particular) at times show strong avoidance at received levels lower than 160 to 170 dB re 1 μPa (rms). In the cases of migrating gray whales, the observed changes in behavior appeared to be of little or no biological consequence to the animals. The migrating whales simply avoided the sound source by displacing their migration route to varying degrees, but within the natural boundaries of the migration corridors (Malme *et al.,* 1984; Malme and Miles, 1985; Richardson *et al.,* 1995). In cases where there is no conspicuous avoidance or change in activity upon exposure to sound pulses from distant seismic operations, there are sometimes subtle changes in behavior (e.g., surfacing, respiration, dive cycles) that are only evident through detailed statistical analysis (e.g., Richardson *et al.,* 1986; Gailey *et al.,* 2007).

Responses of humpback whales to seismic surveys have been studied during migration, on summer feeding grounds, on Angolan winter breeding grounds, and on the Brazilian wintering grounds. McCauley *et al*. (1998, 2000a) studied the responses of humpback whales off Western Australia to a full-scale seismic survey with a 16-air gun, 2,678-in^3 array, and to a single 20-in^3 air gun. McCauley *et al*. (1998) documented that avoidance reactions began at 5 to 8 km (3 to 5 mi) from the array, and that those reactions kept most pods approximately 3 to 5 km (1.8 to 2.5 mi) from the operating seismic boat. McCauley *et al*. (2000a) noted localized displacement during migration of 4 to 5 km (2.5 to 3.1 mi) by traveling pods and 7 to 12 km (4.3 to 7.5 mi) by more sensitive resting pods of cow-calf pairs. Avoidance distances with respect to the single air gun were smaller, but consistent with the results from the full array in terms of the received sound levels. The mean received level for initial avoidance of an approaching air gun was 140 dB re 1 µPa (rms) for humpback pods containing females, and at the mean closest point of approach (CPA) distance, the received level was 143 dB re 1 µPa (rms). The initial avoidance response generally occurred at distances of 5 to 8 km (3.1 to 5.0 mi) from the air gun array and 2 km (1.2 mi) from the single air gun. However, some individual humpback whales, especially males, approached within distances of 100 to 400 m (328 to 1,312 ft), where the maximum received level was 179 dB re 1 µPa (rms).

Data collected by observers during several seismic surveys in the Northwest Atlantic Ocean showed that sighting rates of humpback whales were significantly greater during non-seismic periods, compared against periods when a full array was operating (Moulton and Holst, 2010). In addition, humpback whales were more likely to swim away and less likely to swim towards a vessel during seismic vs. non-seismic periods (Moulton and Holst, 2010).

Humpback whales on their summer feeding grounds in southeast Alaska did not exhibit persistent avoidance when exposed to seismic pulses from a 1.64-L (100-in^3) air gun (Malme *et al*., 1985). Some humpbacks seemed “startled” at received levels of 150-169 dB re 1 µPa. Malme *et al*. (1985) concluded that there was no clear evidence of avoidance, despite the possibility of subtle effects, at received levels up to 172 re 1 µPa (rms). However, Moulton and Holst (2010) reported that humpback whales monitored during seismic surveys in the Northwest Atlantic Ocean had lower sighting rates and were most often seen swimming away from the vessel during seismic periods compared with periods when air guns were silent.

Engel *et al*. (2004) suggested that South Atlantic humpback whales wintering off Brazil may be displaced or even strand upon exposure to seismic surveys; however, the evidence for this was circumstantial and subject to alternative explanations (IAGC, 2004). It was also inconsistent with subsequent results from the same area of Brazil (Parente *et al*., 2006), or with direct studies of humpbacks exposed to seismic surveys in other areas and seasons. After allowance for data from subsequent years, there was “no observable direct correlation” between strandings and seismic surveys (IWC, 2007).

Reactions of migrating and feeding (but not wintering) gray whales to seismic surveys have been studied. Malme *et al*. (1986, 1988) studied the responses of feeding eastern Pacific gray whales to pulses from a single 100-in^3 air gun off St. Lawrence Island in the northern Bering Sea. They estimated, based on small sample sizes, that 50 percent of feeding gray whales stopped feeding at an average received pressure level of 173 dB re 1 µPa (rms), and that 10 percent 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 (Malme *et al*., 1984; Malme and Miles, 1985), and western Pacific gray whales feeding off Sakhalin Island, Russia (Würsig *et al*., 1999; Gailey *et al*., 2007; Johnson *et al*., 2007; Yazvenko *et al*., 2007a,b), along with data on gray whales off British Columbia, Canada (Bain and Williams, 2006).

Various species of *Balaenoptera* (blue, sei, fin, and minke whales) have occasionally been seen in areas ensonified by air gun pulses (Stone, 2003; MacLean and Haley, 2004; Stone and Tasker, 2006), and calls from blue and fin whales have been localized in areas with air gun operations (e.g., McDonald *et al*., 1995; Dunn and Hernandez, 2009; Castellote *et al*., 2010). Sightings by observers on seismic vessels off the United Kingdom 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 air guns were shooting vs. silent (Stone, 2003; Stone and Tasker, 2006). However, these whales tended to exhibit localized avoidance, remaining significantly further (on average) from the air gun array during seismic operations compared with non-seismic periods (Stone and Tasker, 2006). Castellote *et al*. (2010) reported that singing fin whales in the Mediterranean Sea moved away from an operating air gun array.

Ship-based monitoring studies of baleen whales (including blue, fin, sei, minke, and humpback whales) in the Northwest Atlantic Ocean found that, overall, this group had lower sighting rates during seismic vs. non-seismic periods (Moulton and Holst, 2010). Baleen whales as a group were also seen significantly farther from the vessel during seismic compared against non-seismic periods, and they were more often seen to be swimming away from the operating seismic vessel (Moulton and Holst, 2010). Blue and minke whales were initially sighted significantly farther from the vessel during seismic operations compared against non-seismic periods. A similar trend was observed for fin whales (Moulton and Holst, 2010). Minke whales were most often observed to be swimming away from the vessel when seismic operations were underway (Moulton and Holst, 2010).

Data on short-term reactions by cetaceans to impulsive noises are not necessarily indicative of long-term or biologically significant effects. It is not known whether impulsive sounds affect reproductive rates, distribution, and habitat use in subsequent days or years. However, gray whales have continued to migrate annually along the west coast of North America despite intermittent seismic exploration (and much ship traffic) in that area for decades (Appendix A in Malme *et al.,* 1984; Richardson *et al.,* 1995), and there has been a substantial increase in the population over recent decades (Allen and Angliss, 2010). The western Pacific gray whale population did not seem affected by a seismic survey in its feeding ground during a prior year (Johnson *et al.,* 2007). The history of coexistence between seismic surveys and baleen whales suggests that brief exposures to sound pulses from any single seismic survey are unlikely to result in prolonged effects.

7.3 EFFECTS ON ODONTOCETES

Little information is available about reactions of toothed whales to noise pulses. Seismic operators and marine mammal observers on seismic vessels regularly see dolphins and other small toothed whales near operating air gun arrays, but, in general, there is a tendency for most delphinids to show some avoidance of operating seismic vessels (L-DEO, 2011). Some dolphins seem to be attracted to the seismic vessel and floats, and some ride the bow wave of the seismic vessel even when large arrays of air guns are firing (e.g., Moulton and Miller, 2005). Nonetheless, small toothed whales more often tend to head away, or to maintain a somewhat greater distance from the vessel, when a large air gun array is operating (e.g., Stone and Tasker, 2006; Weir 2008; Barry *et al*., 2010; Moulton and Holst, 2010).

For delphinids, the available data suggest that a ≥170 dB re 1 µPa (rms) disturbance criterion (rather than ≥160 dB) would be appropriate. With a medium-to-large air gun array, received levels typically diminish to 170 dB within 1 to 4 km (0.62 to 2.5 mi), whereas levels typically remain above 160 dB out to 4 to 15 km (2.5 to 9.3 mi) (e.g., Tolstoy *et al.,* 2009). Reaction distances for delphinids are more consistent with the typical 170 dB re 1 µPa (rms) distances (L-DEO, 2011).

Results are species specific. The limited available data suggest that harbor porpoises show stronger avoidance of seismic operations than do Dall's porpoises (Stone, 2003; MacLean and Koski, 2005; Bain and Williams, 2006; Stone and Tasker, 2006). Dall's porpoises seem relatively tolerant of air gun operations (MacLean and Koski, 2005; Bain and Williams, 2006), although they, too, have been observed to avoid large arrays(Calambokidis and Osmek, 1998; Bain and Williams, 2006). This apparent difference in responsiveness of these two porpoise species is consistent with their relative responsiveness to boat traffic and some other acoustic sources (Richardson *et al.*, 1995; Southall *et al.*, 2007).

Most studies indicate that the sperm whale shows considerable tolerance of air gun pulses (e.g., Stone, 2003; Moulton *et al.*, 2005, 2006; Stone and Tasker, 2006; Weir, 2008). In most cases, the whales do not show strong avoidance, and they continue to call. However, controlled exposure experiments in the Gulf of Mexico indicate that foraging behavior was altered upon exposure to air gun sounds (Jochens *et al*., 2008; Miller *et al*., 2009; Tyack, 2009).

Overall, odontocete reactions to large arrays of air guns are variable and, at least for delphinids and some porpoises, seem to be confined to a smaller radius than has been observed for some mysticetes. However, other data suggest that some odontocete species, including harbor porpoises, may be more responsive than might be expected given their poor low-frequency hearing. Reactions at longer distances may be particularly likely when sound propagation conditions are conducive to transmission of the higher frequency components of air gun sound to the animals' location (DeRuiter *et al.,* 2006; Goold and Coates, 2006; Tyack *et al,.* 2006; Potter *et al.,* 2007).

7.4 EFFECTS ON PINNIPEDS

Pinnipeds are not likely to show a strong avoidance reaction to an air gun array. Visual monitoring from seismic vessels has shown only slight (if any) avoidance of air guns by pinnipeds, and only slight (if any) changes in behavior (L-DEO, 2011). In the Beaufort Sea, some ringed seals avoided an area of 100 m (328 ft) to a few hundred meters (+660 ft) around seismic vessels, but many seals remained within 100 to 200 m (328 to 656 ft) of the trackline as the operating air gun array passed (Harris *et al*., 2001; Moulton and Lawson, 2002; Miller *et al*., 2005). In Puget Sound, sighting distances for harbor seals and California sea lions tended to be larger when air guns were operating (Calambokidis and Osmek, 1998).

During seismic exploration off Nova Scotia, gray seals exposed to noise from air guns and linear explosive charges did not react strongly (J. Parsons, in Greene *et al.* 1985). An air gun caused an initial startle reaction among South African fur seals, but was ineffective in scaring them away from fishing gear. Pinnipeds, in both water and air, sometimes tolerate strong noise pulses from non-explosive and explosive scaring devices, especially if attracted to the area for feeding or reproduction (Mate and Harvey, 1987; Reeves *et al.,* 1996). Thus, pinnipeds are expected to be rather tolerant of, or habituate to, repeated underwater sounds from distant seismic sources, at least when the animals are strongly attracted to the area.

7.5 EFFECTS ON FISSIPEDS

Riedman (1983, 1984) observed the behavior of sea otters along the California coast during single, 100 in^3 air gun pulses, and pulses from a 4,089 in^3 air gun array. No disturbance reactions were evident when the air gun array was as close as 0.9 km (0.5 mi), and the sea otters did not respond noticeably to the single air gun. The results suggest that sea otters are less responsive to marine seismic pulse than are baleen whales. Also, sea otters spend a great deal of time at the surface feeding and grooming, as such, the potential noise exposure would be much reduced by the pressure release effect at the surface.

7.6 HEARING IMPAIRMENT AND OTHER PHYSICAL EFFECTS

Exposure to very strong sounds could affect marine mammals in a number of ways. These include temporary threshold shift (TTS), which is a short-term hearing impairment, and permanent threshold shift (PTS), which is a permanent hearing loss. 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, as discussed below, there is no definitive evidence that any of these effects occur even for marine mammals in close proximity to large arrays of air guns. It is unlikely that any effects of these types would occur during the present Project given the brief duration of exposure of any given mammal and the planned monitoring and mitigation measures. The following subsections discuss in more detail the possibilities of TTS, PTS, and non-auditory physical effects.

7.6.1 Temporary Threshold Shift (TTS)

TTS is the mildest form of hearing impairment that can occur during exposure to a strong sound (Kryter, 1985). While experiencing TTS, the hearing threshold rises and a sound must be stronger in order to be heard. It is a temporary phenomenon, and (especially when mild) is not considered physical damage or "injury" (Southall *et al.,* 2007). Rather, the onset of TTS is an indicator that, if the animal is exposed to higher levels of that sound, physical damage is ultimately a possibility.

The magnitude of TTS depends on the level and duration of noise exposure, and to some degree, on frequency, among other considerations (Kryter, 1985; Richardson *et al*., 1995; Southall e*t al.*, 2007). For sound exposures at or somewhat above the TTS threshold, hearing sensitivity recovers rapidly after exposure to the noise ends. In terrestrial mammals, TTS can last from minutes or hours to days. Only limited data have been obtained on sound levels and durations necessary to elicit mild TTS in marine mammals (none in mysticetes), and none of the published data concern TTS elicited by exposure to multiple pulses of sound during operational seismic surveys (Southall *et al.*, 2007).

For toothed whales, experiments on a bottlenose dolphin and beluga whale showed that exposure to a single impulse at a received level of 207 kPa (or 30 psi) pk-pk,, which is equivalent to 228 dB re 1 µPa (p-p), resulted in a 7 and 6 dB TTS in the beluga whale at 0.4 and 30 kHz, respectively. Thresholds returned to within 2 dB of the pre-exposure level within 4 minutes of the exposure (Finneran *et al.,* 2002).

Finneran *et al.* (2005) examined the effects of tone duration on TTS in bottlenose dolphins. Bottlenose dolphins were exposed to 3 kHz tones (non-impulsive) for periods of 1, 2, 4, or 8 sec, with hearing tested at 4.5 kHz. For 1-sec exposures, TTS occurred with sound exposure levels (SELs) of 197 dB, and for exposures >1 sec, SEL >195 dB resulted in TTS (SEL is equivalent to energy flux, in dB re 1 µPa2-s). At an SEL of 195 dB, the mean TTS (4 min after exposure) was 2.8 dB. Finneran *et al.* (2005) suggested that an SEL of 195 dB is the likely threshold for the onset of TTS in dolphins and belugas exposed to tones of durations 1 to 8 sec (i.e., TTS onset occurs at a near-constant SEL, independent of exposure duration). That implies that, at least for non-impulsive tones, a doubling of exposure time results in a 3 dB lower TTS threshold.

However, the assumption that, in marine mammals, the occurrence and magnitude of TTS is a function of cumulative acoustic energy (i.e. SEL) is probably an oversimplification. Kastak *et al.* (2005) reported preliminary evidence from pinnipeds that, for prolonged non-impulse noise, higher SELs were required to elicit a given TTS if exposure duration was short than if it was longer, i.e., the results were not fully consistent with an equal-energy model to predict TTS onset. Mooney *et al.* (2009a) showed this in a bottlenose dolphin exposed to octave-band non-impulse noise ranging from 4 to 8 kHz at sound pressure levels (SPLs) of 130 to 178 dB re 1 µPa for periods of 1.88 to 30 minutes (min). Higher SELs were required to induce a given TTS if exposure duration was shorter than if it was longer. Exposure of bottlenose dolphins to a sequence of brief sonar signals showed that, with those brief (but non-impulse) sounds, the received energy (i.e. SEL) necessary to elicit TTS was higher than was the case with exposure to the more prolonged octave-band noise (Mooney *et al.* 2009b). The researchers concluded that, when using (non-impulse) acoustic signals of duration approximately 0.5 sec SEL must be at least 210 to 214 dB re 1 µPa2-s to induce TTS in the bottlenose dolphin. Most recent studies conducted by Finneran *et al.* also support the notion that exposure duration has a more significant influence compared to SPL as the duration increases, and that TTS growth data are better represented as functions of SPL and duration rather than SEL alone (Finneran *et al.,* 2010a,b). In addition, Finneran *et al*. (2010b) concluded that when animals are exposed to intermittent noises, there is recovery of hearing during the quiet intervals between exposures through the accumulation of TTS across multiple exposures. Such findings suggest that when exposed to multiple seismic pulses, partial hearing recovery also occurs during the seismic pulse intervals.

For baleen whales, there are no data on levels or properties of sound that are required to induce TTS. The frequencies to which baleen whales are most sensitive are lower than those to which odontocetes are most sensitive, and natural ambient noise levels at those low frequencies tend to be higher (Urick, 1983). As a result, auditory thresholds of baleen whales within their frequency band of best hearing are believed to be higher (less sensitive) than are those of odontocetes at their best frequencies (Clark and Ellison, 2004). From this, it is suspected that received levels causing TTS onset may also be higher in baleen whales. However, no cases of TTS are expected given the strong likelihood that baleen whales would avoid the approaching air guns (or vessel) before being exposed to levels high enough for there to be any possibility of TTS.

In pinnipeds, TTS thresholds associated with exposure to brief pulses (single or multiple) of underwater sound have not been measured. Initial evidence from prolonged exposures suggested that some pinnipeds may incur TTS at somewhat lower received levels than do small odontocetes exposed for similar durations (Kastak *et al.,* 1999, 2005). However, more recent indications are that TTS onset in the most sensitive pinniped species studied (harbor seal) may occur at a similar SEL as in odontocetes (Kastak *et al.,* 2005).

Most cetaceans show some degree of avoidance of seismic vessels operating an air gun array. It is unlikely that these cetaceans would be exposed to air gun pulses at a sufficiently high level for a sufficiently long period to cause more than mild TTS, given the relative movement of the vessel and the marine mammal (NMFS, 2010). TTS would be more likely in any odontocetes that bow- or wake-ride or otherwise linger near the air guns. However, while bow- or wake-riding, odontocetes would be at the surface and thus not exposed to strong sound pulses given the pressure release and Lloyd's mirror effects at the surface. But if bow- or wake-riding animals were to dive intermittently near air guns, they would be exposed to strong sound pulses, possibly repeatedly (NMFS, 2010).

If some cetaceans did incur mild or moderate TTS through exposure to air gun sounds in this manner, this would very likely be a temporary and reversible phenomenon. However, even a temporary reduction in hearing sensitivity could be deleterious in the event that, during that period of reduced sensitivity, a marine mammal needed its full hearing sensitivity to detect approaching predators (NMFS, 2010c).

Some pinnipeds show avoidance reactions to air guns, but their avoidance reactions are generally not as strong or consistent as those of cetaceans. Pinnipeds occasionally seem to be attracted to operating seismic vessels (NMFS, 2010c). There are no specific data on TTS thresholds of pinnipeds exposed to single or multiple low-frequency pulses. However, given the indirect indications of a lower TTS threshold for the harbor seal than for odontocetes exposed to impulse sound, it is possible that some pinnipeds within the 190 dB isopleths for a prolonged time of a large air gun array could incur TTS (NMFS, 2010c).

Current NMFS noise exposure standards require that cetaceans and pinnipeds should not be exposed to pulsed underwater noise at received levels exceeding, respectively, 180 and 190 dB re 1 µPa (rms) (NMFS, 2010c). These criteria were taken from recommendations by an expert panel of the HESS Team that did assessment on noise impacts by seismic air guns to marine mammals in 1997, although the HESS Team recommended a 180-dB limit for pinnipeds in California (HESS, 1999). The 180 and 190 dB re 1 µPa (rms) levels have not been considered to be the levels above which TTS might occur. Rather, they were the received levels above which, in the view of a panel of bioacoustics specialists convened by NMFS before TTS measurements for marine mammals started to become available, one could not be certain that there would be no injurious effects, auditory or otherwise, to marine mammals. As summarized above, data that are now available imply that TTS is unlikely to occur in various odontocetes (and probably mysticetes as well) unless they are exposed to a sequence of several air gun pulses stronger than 190 dB re 1 µPa (rms). On the other hand, for the harbor seal, harbor porpoise, and perhaps some other species, TTS may occur upon exposure to one or more air gun pulses whose received level equals the NMFS “do not exceed” value of 190 dB re 1 µPa (rms). That criterion corresponds to a single-pulse SEL of 175 to 180 dB re 1 µPa2-s in typical conditions, whereas TTS is suspected to be possible in harbor seals and harbor porpoises with a cumulative SEL of approximately 171 and approximately 164 dB re 1 µPa2-s, respectively.

It has been shown that most marine mammals show at least localized avoidance of ships and/or seismic operations. Even when avoidance is limited to the area within a few hundred meters of an air gun array, that should usually be sufficient to avoid TTS based on what is currently known about thresholds for TTS onset in cetaceans. In addition, ramping up air gun arrays, which is standard operational protocol for many seismic operators, should allow cetaceans near the air guns at the time of startup (if the sounds are aversive) to move away from the seismic source and to avoid being exposed to the full acoustic output of the air gun array. Thus, most baleen whales likely will not be exposed to high levels of air gun sounds provided the ramp-up procedure is applied. Likewise, many odontocetes close to the trackline are likely to move away before the sounds from an approaching seismic vessel become sufficiently strong for there to be any potential for TTS or other hearing impairment. Hence, there is little potential for baleen whales or odontocetes that show avoidance of ships or air guns to be close enough to an air gun array to experience TTS. Therefore, it is not likely that marine mammals in the vicinity of the proposed marine seismic surveys by PG&E would experience TTS as a result of these activities with implementation of the mitigation measures detailed in Section 11.0.

7.6.2 Permanent Threshold Shift (PTS)

When PTS occurs, there is physical damage to the sound receptors in the ear. In severe cases, there can be total or partial deafness. In other cases, the animal has an impaired ability to hear sounds in specific frequency ranges (Kryter, 1985).

There is no specific evidence that exposure to pulses from air guns can cause PTS in any marine mammal, even with large arrays of air guns. However, given the possibility that mammals close to an air gun array might incur at least mild TTS in the absence of appropriate mitigation measures, there has been further speculation about the possibility that some individuals occurring very close to air guns might incur PTS (e.g., Richardson *et al*., 1995; Gedamke *et al*., 2008). Single or occasional occurrences of mild TTS are not indicative of permanent auditory damage, but repeated or (in some cases) single exposures to a level well above that causing TTS onset might elicit PTS.

Relationships between TTS and PTS thresholds have not been studied in marine mammals, but are assumed to be similar to those in humans and other terrestrial mammals (Southall *et al.,* 2007). Based on data from terrestrial mammals, a precautionary assumption is that the PTS threshold for impulse sounds (such as air gun pulses as received close to the source) is at least 6 dB higher than the TTS threshold on a peak-pressure basis, and probably >6 dB higher (Southall *et al.,* 2007). The low-to-moderate levels of TTS that have been induced in captive odontocetes and pinnipeds during controlled studies of TTS have been confirmed to be temporary, with no measurable residual PTS (Kastak *et al.,* 1999; Schlundt *et al.,* 2000; Finneran *et al.,* 2002, 2005; Nachtigall *et al.,* 2003, 2004). However, very prolonged exposure to sound strong enough to elicit TTS, or shorter-term exposure to sound levels well above the TTS threshold, can cause PTS, at least in terrestrial mammals (Kryter, 1985). In terrestrial mammals, the received sound level from a single, non-impulsive sound exposure must be far above the TTS threshold for any risk of permanent hearing damage (Kryter, 1994; Richardson *et al.,* 1995; Southall *et al.,* 2007). However, there is special concern about strong sounds whose pulses have very rapid rise times. In terrestrial mammals, there are situations when pulses with rapid rise times (e.g., from explosions) can result in PTS even though their peak levels are only a few dB higher than the level causing slight TTS. The rise time of air gun pulses is fast, but not as fast as that of an explosion.

Some factors that contribute to onset of PTS, at least in terrestrial mammals, are as follows:

- exposure to single very intense sound;
- fast rise time from baseline to peak pressure;
- repetitive exposure to intense sounds that individually cause TTS but not PTS; and
- recurrent ear infections or (in captive animals) exposure to certain drugs.

Cavanagh (2000) reviewed the thresholds used to define TTS and PTS. Based on this review and Supreme Allied Commander, Atlantic (SACLANT) (1998), it is reasonable to assume that PTS might occur at a received sound level 20 dB or more above that inducing mild TTS. However, for PTS to occur at a received level only 20 dB above the TTS threshold, the animal probably would have to be exposed to a strong sound for an extended period, or to a strong sound with rather rapid rise time.

Southall *et al.,* (2007) estimated that received levels would need to exceed the TTS threshold by at least 15 dB, on an SEL basis, for there to be risk of PTS. Thus, for cetaceans exposed to a sequence of sound pulses, they estimate that the PTS threshold might be an M-weighted SEL (for the sequence of received pulses) of approximately 198 dB re 1 μPa2-s. Additional assumptions had to be made to derive a corresponding estimate for pinnipeds, as the only available data on TTS-thresholds in pinnipeds pertained to non-impulse sound. Southall *et al.,* (2007) estimated that the PTS threshold could be a cumulative SEL of approximately 186 dB re 1 μPa2-s in the case of a harbor seal exposed to impulse sound. The PTS threshold for the California sea lion and northern elephant seal would probably be higher given the higher TTS thresholds in those species. Southall *et al.,* (2007) also note that, regardless of the SEL, there is concern about the possibility of PTS if a cetacean or pinniped received one or more pulses with peak pressure exceeding 230 or 218 dB re 1 μPa, respectively. Thus, PTS might be expected upon exposure of cetaceans to either SEL ≥198 dB re 1 μPa2-s or peak pressure ≥230 dB re 1 μPa. Corresponding proposed dual criteria for pinnipeds (at least harbor seals) are ≥186 dB SEL and ≥ 218 dB peak pressure (Southall *et al.,* 2007). These estimates are all first approximations, given the limited underlying data, assumptions, species differences, and evidence that the "equal energy" model may not be entirely correct (L-DEO, 2011).

Sound impulse duration, peak amplitude, rise time, number of pulses, and inter-pulse interval are the main factors thought to determine the onset and extent of PTS. Ketten (1993) has noted that the criteria for differentiating the sound pressure levels that result in PTS (or TTS) are location and species specific. PTS effects may also be influenced strongly by the health of the receiver's ear.

As described above for TTS, in estimating the amount of sound energy required to elicit the onset of TTS (and PTS), it is assumed that the auditory effect of a given cumulative SEL from a series of pulses is the same as if that amount of sound energy were received as a single strong sound. There are no data from marine mammals concerning the occurrence or magnitude of a potential partial recovery effect between pulses. In deriving the estimates of PTS (and TTS) thresholds, Southall *et al.* (2007) made the precautionary assumption that no recovery would occur between pulses.

It is unlikely that an odontocete would remain close enough to a large air gun array for sufficiently long to incur PTS. Due to proposed monitoring and mitigation measures the source would quickly be powered down or shut down, thereby preventing marine mammals from prolonged exposure. There is some concern about bow-riding odontocetes, but for animals at or near the surface, auditory effects are reduced by Lloyd's mirror and surface release effects. The presence of the vessel between the air gun array and bow-riding odontocetes could also, in some, but probably not all cases, reduce the levels received by bow-riding animals (e.g., Gabriele and Kipple, 2009). The TTS (and PTS) thresholds of baleen whales are unknown but, as an interim measure, assumed to be no lower than those of odontocetes. Also, baleen whales generally avoid the immediate area around operating seismic vessels. So it is unlikely that a baleen whale could incur PTS from exposure to air gun pulses. The TTS (and PTS) thresholds of some pinnipeds (e.g., harbor seal), as well as the harbor porpoise, may be lower (Kastak *et al.,* 2005; Southall *et al.,* 2007; Lucke *et al.,* 2009). If so, TTS and potentially PTS may extend to a somewhat greater distance for those animals. Again, Lloyd's mirror and surface release effects will ameliorate the effects for animals at or near the surface.

Although it is unlikely that air gun operations during most seismic surveys would cause PTS in many marine mammals, caution is warranted given:

- the limited knowledge about noise-induced hearing damage in marine mammals, particularly baleen whales and pinnipeds;
- the seemingly greater susceptibility of certain species (e.g., harbor porpoise and harbor seal) to TTS and presumably also PTS; and
- the lack of knowledge about TTS and PTS thresholds in many species.

The avoidance reactions of many marine mammals, along with commonly applied monitoring and mitigation measures (See Section 11.0), would reduce the already low probability of exposure of marine mammals to sounds strong enough to induce PTS.

7.6.3 Non-Auditory Physiological Effects

Non-auditory physiological effects or injuries that theoretically might occur in marine mammals exposed to strong underwater sound include stress, neurological effects, bubble formation, resonance, and other types of organ or tissue damage (Southall *et al*., 2007). Studies examining such effects are limited. However, resonance effects (Gentry, 2002) and direct noise-induced bubble formation (Crum *et al*., 2005), are implausible in the case of exposure to an impulsive broadband source like an air gun array. If seismic surveys disrupt diving patterns of deep-diving species, this might perhaps result in bubble formation and a form of "the bends", as speculated to occur in beaked whales exposed to sonar. However, there is no specific evidence of this upon exposure to air gun pulses.

In general, very little is known about the potential for seismic survey sounds (or other types of strong underwater sounds) to cause non-auditory physical effects in marine mammals. Such effects, if they occur at all, would presumably be limited to short distances and to activities that extend over a prolonged period. The available data do not allow identification of a specific exposure level above which non-auditory effects can be expected (Southall *et al*., 2007), or any meaningful quantitative predictions of the numbers (if any) of marine mammals that might be affected in those ways. 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.

7.7 STRANDINGS AND MORTALITY

Marine mammals close to underwater detonations of high explosives can be killed or severely injured, and the auditory organs are especially susceptible to injury (Ketten *et al*., 1993; Ketten, 1995). However, explosives are no longer used for marine waters for commercial seismic surveys or (with rare exceptions) for seismic research. These methods have been replaced entirely by air guns or related non-explosive pulse generators. Air gun pulses are less energetic and have slower rise times, and there is no specific evidence that they can cause serious injury, death, or stranding, even in the case of large air gun arrays.

Specific sound-related processes that lead to strandings and mortality are not well documented, but may include (1) swimming in avoidance of a sound into shallow water; (2) a change in behavior (such as a change in diving behavior) that might contribute to tissue damage, gas bubble formation, hypoxia, cardiac arrhythmia, hypertensive hemorrhage, or other forms of trauma; (3) a physiological change such as a vestibular response leading to a behavioral change or stress-induced hemorrhagic diathesis, leading in turn to tissue damage; and, (4) tissue damage directly from sound exposure, such as through acoustically mediated bubble formation and growth or acoustic resonance of tissues. Some of these mechanisms are unlikely to apply in the case of impulse sounds. However, there are increasing indications that gas-bubble disease (analogous to “the bends”), induced in supersaturated tissue by a behavioral response to acoustic exposure, could be a pathologic mechanism for the strandings and mortality of some deep-diving cetaceans exposed to sonar. The evidence for this remains circumstantial and associated with exposure to naval mid-frequency sonar, not seismic surveys (Cox *et al*., 2006; Southall *et al*., 2007).

Seismic pulses and mid-frequency sonar signals are quite different, and some mechanisms by which sonar sounds have been hypothesized to affect beaked whales are unlikely to apply to air gun pulses. Sounds produced by air gun arrays are broadband impulses with most of the energy below 1 kHz. Typical military mid-frequency sonar emit non-impulse sounds at frequencies of 2 to 10 kHz, generally within a relatively narrow bandwidth at any one time. A further difference between seismic surveys and naval exercises is that naval exercises can involve sound sources on more than one vessel. Thus, it is not appropriate to assume that there is a direct connection between the effects of military sonar and seismic surveys on marine mammals. However, evidence that sonar signals can, in special circumstances, lead (at least indirectly) to physical damage and mortality (e.g., Balcomb and Claridge, 2001; NOAA and USN, 2001; Jepson *et al*., 2003; Fernández *et al*., 2004, 2005; Hildebrand, 2005; Cox *et al*., 2006) suggests that caution is warranted when dealing with exposure of marine mammals to any high-intensity “pulsed” sound.

L-DEO (2011) noted there is currently no conclusive evidence of cetacean stranding or deaths at sea as a result of exposure to seismic surveys, but a few cases of strandings in the general area where a seismic survey was ongoing have led to speculation of a possible link.

Engel *et al*., (2004, in L-DEO, 2011) suggested that humpback whales wintering off Brazil may be displaced or even stranded during seismic surveys. Others have suggested the evidence was circumstantial and subject to alternative explanations (IAGC, 2004), or inconsistent with subsequent results from the same area (IAGC, 2004; Parente *et al*. 2006, in L-DEO, 2011). Based on data from subsequent years, no observable direct correlation between strandings and seismic surveys was found (IWC, 2007, L-DEO, 2011).

In September 2002, two Cuvier's beaked whales stranded in the Gulf of California, Mexico at the same time when the L-DEO vessel R.V Maurice Ewing was operating a 20-air gun, 8,490 in^3 air gun array in the general area. The link was inconclusive and not based on any physical evidence (Hogarth, 2002; Yoder, 2002, in L-DEO, 2011). A need for caution is recommended when conducting seismic surveys in area occupied by beaked whales until more is known about the effect on those species (L-DEO, 2011).

7.8 POSSIBLE EFFECTS OF MULTIBEAM ECHOSOUNDER SIGNALS

The Kongsberg EM 122 MBES will be operated from the source vessel during the planned study. Sounds from the MBES are very short signals, occurring for 2 to 15 ms once every 5 to 20 sec, depending on water depth. Most of the energy in the signals emitted by this MBES is at frequencies near 12 kHz, and the maximum source level is 242 dB re 1 $\mu Pa_{rms}\cdot m$. The beam is narrow (1-2 degrees) in fore-aft extent and wide (150 degrees) in the cross-track extent. Each ping consists of 8 (in water >1,000 m deep [0.62 mi]) or 4 (<1,000 m deep [0.62 mi]) successive fan-shaped transmissions (segments) at different cross-track angles. Any given mammal at depth near the trackline would be in the main beam for only 1 or 2 of the 9 segments. Also, marine mammals that encounter the Kongsberg EM 122 are unlikely to be subjected to repeated pings because of the narrow fore-aft width of the beam and will receive only limited amounts of energy because of the short pings. Animals close to the ship (where the beam is narrowest) are especially unlikely to be ensonified for more than one 2 to 15 ms pings (or two pings if in the overlap area). Similarly, Kremser *et al*. (2005) noted that the probability of a cetacean swimming through the area of exposure when an MBES emits a ping is small. The animal would have to pass the transducer at close range and be swimming at speeds similar to the vessel in order to receive the multiple pings that might result in sufficient exposure to cause TTS.

Navy sonars that have been linked to avoidance reactions and stranding of cetaceans generally have longer signal durations than the Kongsberg EM 122, and are often directed close to horizontally vs. more downward for the MBES. The area of possible influence of the MBES is much smaller—a narrow band below the source vessel. The duration of exposure for a given marine mammal can be much longer for a naval sonar. During L-DEO's operations, the individual pings will be very short, and a given mammal would not receive many of the downward-directed pings as the vessel passes. Possible effects of an MBES on marine mammals are detailed below.

7.8.1 Masking

Marine mammal communications will not be masked appreciably by the MBES signals given the low duty cycle of the echosounder and the brief period when an individual mammal is likely to be within its beam. Furthermore, in the case of baleen whales, the MBES signals (12 kHz) do not overlap with the predominant frequencies in the calls, which would avoid any significant masking.

7.8.2 Behavioral Responses

Behavioral reactions of free-ranging marine mammals to sonars, echosounders, and other sound sources appear to vary by species and circumstance. Observed reactions have included silencing and dispersal by sperm whales (Watkins *et al*. 1985), increased vocalizations and no dispersal by pilot whales (Rendell and Gordon 1999), and the beaching by beaked whales. During exposure to a 21 to 25 kHz “whale-finding” sonar with a source level of 215 dB re 1 µPa m, gray whales reacted by orienting slightly away from the source and being deflected from their course by ~200 m (656 ft) (Frankel 2005). When a 38 kHz echosounder and a 150 kHz acoustic Doppler current profiler were transmitting during studies in the Eastern Tropical Pacific, baleen whales showed no significant responses, while spotted and spinner dolphins were detected slightly more often and beaked whales less often during visual surveys (Gerrodette and Pettis 2005).

Captive bottlenose dolphins and a white whale exhibited changes in behavior when exposed to 1 sec tonal signals at frequencies similar to those that will be emitted by the MBES used by L-DEO, and to shorter broadband pulsed signals. Behavioral changes typically involved what appeared to be deliberate attempts to avoid the sound exposure (Schlundt *et al*. 2000; Finneran *et al*. 2002; Finneran and Schlundt 2004). The relevance of those data to free-ranging odontocetes is uncertain, and in any case, the test sounds were quite different in duration as compared with those from an MBES.

Very few data are available on the reactions of pinnipeds to echosounder sounds at frequencies similar to those used during seismic operations. Hastie and Janik (2007) conducted a series of behavioral response tests on two captive gray seals to determine their reactions to underwater operation of a 375 kHz multibeam imaging echosounder that included significant signal components down to 6 kHz. Results indicated that the two seals reacted to the signal by significantly increasing their dive durations. Because of the likely brevity of exposure to the MBES sounds, pinniped reactions are expected to be limited to startle or otherwise brief responses of no lasting consequence to the animals.

7.8.3 Hearing Impairment and Other Physical Effects

Given recent stranding events that have been associated with the operation of naval sonar, there is concern that mid-frequency sonar sounds can cause serious impacts to marine mammals. However, the MBES proposed for use by L-DEO is quite different than sonars used for navy operations. Ping duration of the MBES is very short relative to the naval sonars. Also, at any given location, an individual marine mammal would be in the beam of the MBES for much less time given the generally downward orientation of the beam and its narrow fore-aft beam width; navy sonars often use near horizontally directed sound. Those factors would all reduce the sound energy received from the MBES rather drastically relative to that from the sonars used by the navy.

Given the maximum source level of 242 dB re 1 µPa·m_{rms}, the received level for an animal within the MBES beam 100 m (328 ft) below the ship would be ~202 dB re 1 µPa rms, assuming 40 dB of spreading loss over 100 m (328 ft) (circular spreading). Given the narrow beam, only one ping is likely to be received by a given animal as the ship passes overhead. The received energy level from a single ping of duration 15 ms would be ~184 dB re 1 µPa^2 s, i.e., 202 dB + 10 log (0.015 sec). That is below the TTS threshold for a cetacean receiving a single non-impulse sound (195 dB re 1 µPa^2 s) and even further below the anticipated PTS threshold (215 dB re 1 µPa^2 s) (Southall *et al*. 2007). In contrast, an animal that was only 10 m (32.8 ft) below the MBES when a ping is emitted would be expected to receive a level ~20 dB higher, i.e., 204 dB re 1 µPa^2 s in the case of the EM120. That animal might incur some TTS (which would be fully recoverable), but the exposure would still be below the anticipated PTS threshold for cetaceans. As noted by Burkhardt *et al*. (2008), cetaceans are very unlikely to incur PTS from operation of scientific sonars on a ship that is underway.

In harbor seals, the TTS threshold for non-impulse sounds is about 183 dB re 1 µPa^2 s, as compared with ~195 dB re 1 µPa^2 s in odontocetes (Kastak *et al*. 2005; Southall *et al*. 2007). TTS onset occurs at higher received energy levels in the California sea lion and northern elephant seal than in the harbor seal. A harbor seal as much as 100 m (328 ft) below the *R/V Langseth* could receive a single MBES ping with received energy level of ≥184 dB re 1 µPa^2 s and, thus, could incur slight TTS. Species of pinnipeds with higher TTS thresholds would not incur TTS unless they were closer to the transducers when a ping was emitted. However, the SEL criterion for PTS in pinnipeds (203 dB re 1 µPa^2 s) might be exceeded for a ping received within a few meters of the transducers, although the risk of PTS is higher for certain species (e.g., harbor seal). Given the intermittent nature of the signals, the narrow MBES beam, and proposed mitigation, only a small fraction of the pinnipeds below (and close to) the ship would receive a ping as the ship passed overhead.

7.9 POSSIBLE EFFECTS OF THE SUB-BOTTOM PROFILER SIGNALS

An SBP will also be operated from the source vessel during the planned study. Sounds from the SBP are very short pings, occurring for 1 to 4 ms once every second. Most of the energy in the pings emitted by the SBP is at 3.5 kHz, and the beam is directed downward. The SBP on the *R/V Langseth* has a maximum source level of 204 dB re 1 µPa·m. Kremser *et al*. (2005) noted that the probability of a cetacean swimming through the area of exposure when a bottom profiler emits a ping is small—even for an SBP more powerful than that on the *R/V Langseth*—if the animal was in the area, it would have to pass the transducer at close range and in order to be subjected to sound levels that could cause TTS.

7.9.1 Masking

Marine mammal communications will not be masked appreciably by the SBP signals given the directionality of the signal and the brief period when an individual mammal is likely to be within its beam. Furthermore, in the case of most baleen whales, the SBP signals do not overlap with the predominant frequencies in the calls, which would avoid significant masking.

7.9.2 Behavioral Responses

Marine mammal behavioral reactions to other sound sources are discussed above, and responses to the SBP are likely to be similar to those for other non-impulse sources if received at the same levels. However, the signals from the SBP are considerably weaker than those from the MBES. Therefore, behavioral responses are not expected unless marine mammals are very close to the source.

7.9.3 Hearing Impairment and Other Physical Effects

It is unlikely that the SBP produces sound levels strong enough to cause hearing impairment or other physical injuries even in an animal that is (briefly) in a position near the source. The SBP is usually operated simultaneously with other higher-power acoustic sources, including air guns. Many marine mammals will move away in response to the approaching higher-power sources or the vessel itself before the mammals would be close enough for there to be any possibility of effects from the less intense sounds from the SBP. In the case of mammals that do not avoid the approaching vessel and its various sound sources, mitigation measures from Section 11 would be applied to minimize effects of other sources would further reduce or eliminate any minor effects of the SBP.

7.10 ENTANGLEMENT

Entanglement can occur if wildlife becomes immobilized in survey lines, cables, nets, or other equipment that is moving through the water column. The proposed seismic survey would require towing approximately 6.4 km^2 (2.5 mi^2) of equipment and cables. This large of an array carries the risk of entanglement for marine mammals. Wildlife, especially slow moving individuals, such as large whales, have a low probability of becoming entangled due to the slow speed of the survey vessel and onboard monitoring efforts. The National Science Foundation has no recorded cases of entanglement during any of their 160,934 km (100,000 mi) of seismic surveys (2011). However, there have been cases of baleen whales, mostly gray whales (Heyning, 1990), becoming entangled in fishing lines. As stated in the Marine Wildlife Contingency Plan (MWCP), a Safety Zone radius of 6.2 km (3.85 mi) from the vessel will be enforced by Protected Species Observers (PSOs) and operations will be shut down before any marine mammal comes into close proximity with the survey equipment. The probability for entanglement of marine mammals is considered not significant because of the vessel speed and the efforts of marine mammal monitors onboard the survey vessel. If entanglement does occur the onboard PSO will contact the appropriate Wildlife Rescue Center immediately and all operations will be halted.

8.0. SUBSISTENCE USES

The anticipated impact of the activity upon the availability of the species or stocks of marine mammals for subsistence uses.

Not applicable to the Project.

9.0 ANTICIPATED IMPACT ON HABITAT

The anticipated impact of the activity upon the habitat of the marine mammal populations, and the likelihood of restoration of the affected habitat.

9.1 INTRODUCTION

The proposed seismic Project will not result in any permanent impact on habitats used by marine mammals, or to the food sources they utilize. The proposed activities will be of short duration in any particular area of the 1,237 km^2 (477.6 mi^2) Project area. As such, effects would be localized and short-term. The principal impact of the seismic survey will be temporarily elevated noise levels and their effects on marine mammals.

One of the reasons for the adoption of air guns as the standard energy source for marine seismic surveys was that, unlike explosives, they do not result in any appreciable fish kill. However, information on impacts to marine fish and invertebrates is limited.

9.2. SEISMIC SURVEY EFFECTS ON FISHES

Seismic surveys using air guns can disturb and displace fishes and interrupt feeding, but displacement may vary among species. Previous studies have shown that pelagic or nomadic fishes leave seismic survey areas (Engas *et al*., 1999; Lokkeborg and Soldal, 1993, in MMS, 2005). L-DEO (2011) noted that the potential effect of seismic surveys on fish includes: 1) pathological; 2) physiological; and 3) behavioral.

9.2.1 Pathological

The potential for pathological damage to hearing structures in fish depends on the energy level of the received sound and the physiology and hearing capabilities of the species in question (L-DEO, 2011).

McCauley *et al*., 2003 in MMS, 2005) noted the fishes exposed to an operating air gun may sustain extensive damage to their auditory hair cell, which would likely adversely affect hearing. Two months after exposure, the damage had not been repaired. Further, fishes with impaired hearing may have a temporary reduction in fitness resulting in increased vulnerability to predation, less success in locating prey and sensing their acoustic environmental, and, in the case of vocal fishes, reduction in ability to communicate. Some fishes displayed aberrant and disoriented swimming behavior, suggesting vestibular impacts. There was also evidence that seismic survey acoustic-energy sources could damage eggs and fry of some fishes, but the effect was limited to within 1 to 2 m (3.3 to 6.6 ft) of the array.

Popper *et al*. (2005, in MMS, 2005) investigated the effects of a 730 in^3 air gun array on the hearing of northern pike, broad whitefish, and lake chub in the Mackenzie River Delta. Threshold shifts were found for exposed fish at exposure of sound levels of 177 dB re 1µPa^2•s, as compared to controls in the northern pike and lake chub, with recovery within 24 hours. There was no threshold shift in the broad whitefish.

An experiment of the effects of a single, 700 in^3 air gun was conducted in Lake Mead, Nevada (USGS, 1999). The data were used in an environmental assessment of the effects of a marine reflection survey of the Lake Meade fault system by the National Park Service (Paulson *et al*., 1993, in USGS, 1999). The air gun was suspended 3.5 m (11.5 ft) above a school of threadfin shad in Lake Meade and was fired three successive times at a 30-sec interval. Neither surface inspection nor diver observations of the water column and bottom found any dead fish.

For a proposed seismic survey in Southern California, USGS (1999) conducted a review of the literature on the effects of air guns on fish and fisheries. They reported a 1991 study of the Bay Area Fault system from the continental shelf to the Sacramento River, using a 10-gun, 5,828 in^3 air gun array. Brezina and Associates were hired by USGS to monitor the effects of the surveys, and concluded that air gun operations were not responsible for the death of any of the fish carcasses observed, and the air gun profiling did not appear to alter the feeding behavior of sea lions, seals, or pelicans observed feeding during the surveys.

Some studies have reported, some equivocally, that mortality of fish, fish eggs, or larvae can occur close to seismic sources (Kostyuchenko, 1973; Dalen and Knutsen, 1986; Boorman *et al*., 1996, in L-DEO, 2011). Some of the reports claimed effects from treatments quite different from actual seismic survey sounds or even reasonable surrogates. However, Payne *et al*. (2009, in L-DEO, 2011) reported no statistical differences in mortality/morbidity between control and exposed groups of capelin eggs or monkfish larvae. Saetre and Ona (1996, in L-DEO, 2011) applied a “worst-case scenario” mathematical model to investigate the effects of seismic energy on fish eggs and larvae. They concluded that mortality rates caused by exposure to seismic surveys are so low, as compared against natural mortality rates, that the impact of seismic surveying on recruitment to a fish stock must be regarded as insignificant.

9.2.2 Physiological

Physiological effects refer to cellular and/or biochemical responses of fish to acoustic stress. Such stress potentially could affect fish populations by increasing mortality or reducing reproductive success. Primary and secondary stress responses of fish after exposure to seismic survey sound appear to be temporary in all studies done to date (Sverdrup *et al*., 1994; Santulli *et al*., 1999; McCauley *et al*., 2000a,b, in L-DEO, 2011). The periods necessary for the physiological changes to return to normal are variable and depend on numerous aspects of the biology of the species and the sound stimulus.

9.2.3 Behavioral Effects

Behavioral effects include changes in the distribution, migration, mating, and catchability of fish populations. Studies investigating the possible effects of sound (including seismic survey sound) on fish behavior have been conducted on both uncaged and caged individuals (Chapman and Hawkins, 1969; Pearson *et al*., 1992; Santulli *et al*., 1999; Wardle *et al*., 2001; Hassel *et al*., 2003, in L-DEO, 2011). Typically, fish exhibited a sharp “startle” response at the onset of a sound followed by habituation and a return to normal behavior after the sound ceased.

MMS (2005) assessed the effects of a proposed seismic survey in Cook Inlet. The seismic survey proposed using three vessels, each towing two, 4-air gun arrays ranging from 1,500 to 2,500 in^3. MMS noted that the impact to fish populations in the survey area and adjacent waters would likely be very low and temporary. MMS also concluded that seismic surveys may displace the pelagic fishes from the area temporarily when air guns are in use. However, fishes displaced and avoiding the air gun noise are likely to backfill the survey area in minutes to hours after cessation of seismic testing. Fishes not dispersing from the air gun noise (e.g., demersal species) may startle and move short distances to avoid air gun emissions.

In general, any adverse effects on fish behavior or fisheries attributable to seismic testing likely depends on the species and the nature of the fishery (season, duration, fishing method). They may also depend on the size and age of the fish, and numerous other factors that are difficult, if not impossible, to quantify at this point, given such limited data on effects of air guns on fish, particularly under realistic at-sea conditions.

9.3 SEISMIC EFFECTS ON INVERTEBRATES

9.3.1 Pathological Effects

Controlled seismic survey sound experiments have been conducted on adult crustaceans and adult cephalopods (Christian *et al*. 2003; DFO, 2004; McCauley *et al*., 2000a,b). No significant pathological impacts were reported. It has been suggested that exposure to commercial seismic survey activities had injured giant squid (Guerra *et al*., 2004), but there is no evidence to support such claims. However, Tenera Environmental (2011b) reported that Norris and Mohl (1983, summarized in Mariyasu *et al*., 2004) observed lethal effects in squid (*Loligo vulgaris*) at levels of 246 to 252 dB after 3 to 11 minutes.

9.3.2 Physiological Effects

Primary and secondary stress responses in crustaceans, as measured by changes in haemolymph levels of enzymes, proteins, etc., were noted several days and months after exposure to seismic sounds (Payne *et al*., 2007, in L-DEO, 2011). It was noted however, that no behavioral impacts were exhibited by crustaceans (Christian *et al*., 2003, 2004; DFO, 2004, in L-DEO, 2011).

9.3.3 Behavioral Effects

In its review of literature concerning the effects of seismic surveys on fishes and fisheries, Tenera Environmental (2011b) reported that McCauley *et al*. (2000b) observed an alarm response at 156 to 161 dB in caged squid subjected to a single air gun, and a strong startle response (ink ejection and rapid swimming) at 174 dB. No behavioral impacts were exhibited by crustaceans (Christian *et al*., 2003, 2004; DFO, 2004, in L-DEO, 2011). Adriguetto-Filho *et al*. (2005, in L-DEO, 2011) noted anecdotal reports of reduced catch rates of shrimp after exposure to seismic surveys; however, other studies have not reported significant changes in catch rates. Parry and Gason (2006, in L-DEO, 2011) did not find evidence of a reduced catch rate for lobsters exposed to seismic surveys.

10.0 ANTICIPATED LOSS OR MODIFICATION OF HABITAT ON MARINE MAMMALS

The anticipated impact of the loss or modification of the habitat on the marine mammal populations involved.

The proposed air gun operations will not result in any permanent impact on habitats used by marine mammals, or to the food sources they exploit. The main impact of the Project will be temporarily elevated noise levels and the effects on marine mammals discussed above.

During the seismic survey, only a small fraction of the available habitat would be ensonified at any given time. Disturbance to fish species would be short-term and fish are expected to return to their pre-disturbance behavior at the cessation of seismic activities.

11.0 MITIGATION MEASURES

The availability and feasibility (economic and technological) of equipment, methods, and manner of conducting such activity or other means of effecting the least practicable adverse impact upon the affected species or stocks, their habitat, and on their availability for subsistence use, paying particular attention to rookeries, mating grounds, and areas of similar significance.

During marine survey operations, potential impacts to marine mammals include exposure to high sound levels associated with the use of the air guns on a 24-hr basis, direct collisions with the survey vessels, and the effects from an accidental discharge of oil. PG&E is proposing to implement a MWCP that includes measures designed to reduce the potential impacts on marine wildlife, particularly marine mammals, from the proposed operations. This program will be implemented in compliance with measures developed in consultation with NMFS/FWS and will be based on anticipated Safety Zones that were determined from the results of mathematical modeling of the energy source levels. This program has been modeled after the mitigation measures (e.g., pre-project scheduling, visual monitoring (aerial and shipboard), passive acoustic monitoring, safety radii, shut down, ramp up, power down, etc.), currently used and recommended by the NSF and USGS in marine seismic research, as detailed in their recently completed Final Environmental Impact Statement (EIS)/Operational Environmental Impact Statement (OEIS) (Programmatic Environmental Impact Statement [PEIS]) (NSF/USGS, 2011). Specifically for this survey, additional measures have been proposed by PG&E and LDEO based on the requirements outlined within the HESS Study as well as measures identified by the California State Lands Commission’s (CSLC) Environmental Impact Report (EIR) (2012) and direct consultations with NMFS/FWS.

The Final EIS/OEIS notes that “preliminary results from completed NSF-funded L-DEO academic seismic surveys indicate that monitoring and mitigation measures have been effective in reducing the potential exposure of marine mammals and sea turtles to high-level seismic sounds and, presumably, of biologically significant effects (LGL, Ltd., unpublished data).”

11.1 MITIGATION MEASURES WITHIN THE SURVEY DESIGN

11.1.1 Vessel-based Marine Wildlife Contingency Plan (MWCP)

The vessel-based operations of the PG&E MWCP are designed to meet the anticipated federal and state regulatory requirements. The objectives of the program will be:

- to minimize any potential disturbance to marine mammals and other sensitive marine species and ensure all regulatory requirements are followed;
- to document observations of the proposed survey activities on marine wildlife; and,
- to collect baseline data on the occurrence and distribution of marine wildlife in the study area.

The MWCP will be implemented by a team of experienced PSOs. PSOs will be stationed aboard the survey vessels through the duration of the Project. Reporting of the results of the vessel-based monitoring program will include the estimation of the number of takes as stipulated in the Final IHA .

The vessel-based work will provide:

- the basis for real-time mitigation, if necessary, as required by the various permits and authorizations issued to PG&E;
- information needed to estimate the number of "takes" of marine mammals by harassment, which must be reported to NMFS and USFWS;
- data on the occurrence, distribution, and activities of marine wildlife in the areas where the survey program is conducted; and,
- information to compare the distances, distributions, behavior, and movements of marine mammals relative to the survey vessel at times with and without air gun activity.

11.1.2 Scheduling to Avoid Areas of High Marine Wildlife Activity

PG&E proposes to conduct offshore surveys from October 15 through December 31, with air gun operations taking place from November 1 through December 31 to coincide with the reduced number of cetaceans in the area, and outside the peak gray whale migration period. This time frame also is outside breeding and pupping periods for the harbor seal (March to June) and California sea lion (May to late July), both of which have rookeries inshore, but adjacent to the Project area. No other pinnipeds breed in the Project area. The southern sea otter breeds and pups in water, and do not have defined rookeries. Breeding is non-seasonal, but young are generally born within two peak periods in spring and fall. As such, breeding and pupping could occur during the Project period, but this is likely to occur closer to shore than the survey tracks. The 2012 survey timing has also been refined to address breeding activity of the resident Morro Bay harbor porpoise. As such, active use of air guns will be not be started until November 1st , which will minimize exposure of nursing harbor porpoise to seismic operations.

11.1.3 Aerial Surveys

PG&E proposes to conduct aerial surveys in conjunction with the proposed seismic survey operations as outlined in the HESS Guidelines and in accordance with the requirements established by the CSLC EIR mitigation measures (CSLC, 2012). In addition to the PG&E aerial surveys, NMFS/USFWS will be conducting low level aerial surveys designed to monitor southern sea otter and Morro Bay harbor porpoise movements in response to the seismic survey operations. These NMFS/USFWS aerial survey operations will be conducted in close coordination with the PG&E surveys but under existing authorizations. The information generated by these two survey operations will be used cooperatively as part of the project's Adaptive Management Plan. Discussions between PG&E and NMFS/USFWS are currently ongoing regarding the coordination of the aerial surveys and the potential for NMFS/USFWS undertake all aerial survey operations. Information regarding this NMFS/USFWS aerial survey operations is provided in Appendix D and E but are not part of this IHA request.

The purpose of the PG&E aerial surveys efforts are:

- obtain pre-survey information on the numbers and distribution of marine mammals or turtles in the seismic survey area;
- identify direction of travel and corridors utilized by marine mammals relative to the Project area;
- identify locations within the survey area that support aggregations of marine mammals;
- the relative abundance of marine mammals and turtles within the survey area; and
- document changes in the behavior and distribution of marine mammals and turtles in the area before, during, and after seismic operations.

With the proposed timing of the seismic survey operations, particular attention will be directed to the identification of the presence of large cetaceans including blue and humpback whales, as well as fin whales, due to the likelihood that those species will be present in the Project area (June to October). Aerial surveys operations will include the follow components:

- approximately 5-10 days prior to the start of seismic survey operations, an aerial survey will be flown to establish a baseline for numbers and distribution of marine mammals in the Project area;
- aerial surveys will be conducted weekly during seismic survey operations to assist in the identification of marine mammals within the Project Safety Zone. Aerial monitors will be in direct communications with ship-based monitors to assess the effectiveness of monitoring operations. Based on the results of these coordinated monitoring efforts, the need for additional aerial surveys will be evaluated; and,
- approximately 5-10 days following completion of the offshore seismic survey operations, a final aerial survey will be conducted to document the number and distribution of marine mammals in the Project area. These data will be used in comparison with original survey data completed prior to the seismic operations.

A copy of the draft Aerial Survey Plan is provided in Appendix F of this IHA request.

11.2 MITIGATION MEASURES DURING SURVEY ACTIVITIES

PG&E's planned site survey program and associated MWCP incorporates both survey design features and operational procedures for minimizing potential impacts on marine mammals. Survey design features include:

- timing and locating survey activities to avoid potential interference with the annual gray whale migration period;

- limiting the size of the seismic sound source to minimize energy introduced into the marine environment; and,
- establishing precautionary Safety and Exclusion Zone radii based on modeling results of the proposed sound sources.

The potential disturbance of marine mammals during survey operations will be minimized further through the implementation of several ship-based mitigation measures.

11.2.1 Safety and Exclusion Zones

Under current NMFS guidelines (e.g., NMFS, 2000), the "Exclusion Zone" is customarily defined as the distances within which received sound levels are ≥180 dB re 1 µPa (rms) and ≥190 dB re 1 µPa (rms) for cetaceans and pinnipeds, respectively. These safety criteria are based on an assumption that sound energy received at lower received levels will not injure these animals or impair their hearing abilities, but that higher received levels might have some effects. Disturbance or behavioral effects to marine mammals from underwater sound may occur after exposure to underwater sound at distances greater than the designated Exclusion Zone (Richardson *et al*., 1995). In addition, a 160 dB re 1 µPa (rms) safety zone has been designated to provide an adequate buffer to allow the initial reduction in sound levels prior to the potential entry of a protected species into the Exclusion Zone. Estimates of the 160 dB re 1µPa [rms]), safety zone sound levels produced by the planned air gun configurations have been estimated in Table 5 and depicted on Figures 11 and 12. For the purpose of this analysis the project is proposing to use the upslope distances for the determination of the exclusion and safety zones since this represents the greatest distance determined by the Greeneridge modeling (additional information on the noise modeling is provided in Appendix A). The Exclusion Zone for full air gun array will be extended to 1.8 km (1.1 mi) for mysticetes, sperm whales (*Physeter macrocephalus*) and large groups of marine mammals. For all other marine wildlife, the initial (prior to sound verification study results) Exclusion Zone radius for the full air gun array will be a 1.0 km (0.6 mi) around the sound source, and the Safety Zone will extend to 6.2 km (3.8 mi) from the sound source for all marine wildlife.

To augment PSO observations on the *R/V Langseth,* two scout vessels with a minimum of three qualified PSOs onboard each, shall be positioned adjacent to the R/V *Langseth*. These boats shall remain outside of the surface kelp area to avoid otter disturbance. The scout vessel PSOs will report to the *R/V Langseth* PSOs if any animals are observed.

At the initiation of the 3D seismic survey, an acoustics contractor will perform direct measurements of the received levels of underwater sound versus distance and direction from the air gun survey vessel using calibrated hydrophones. The acoustic data will be analyzed as quickly as reasonably practicable in the field and used to verify and adjust the safety and Exclusion Zone distances. The field report will be made available to NMFS and the PSOs within 120 hrs of completing the measurements. The mitigation measures to be implemented at the 180 dB sound levels will include power downs and shut downs as described below.

11.2.2 Speed and Course Alterations

If a marine mammal is detected outside the applicable Exclusion Zone and, based on its position and direction of travel, is likely to enter the Exclusion Zone, changes of the vessel's speed and course will be considered if this does not compromise operational safety. For marine seismic surveys using large streamer arrays, course alterations are not typically possible. After any such speed and/or course alteration is begun, the animals' activities and movements relative to the seismic vessel will be closely monitored to ensure that the animal does not approach within the Exclusion Zone. If the mammal appears likely to enter the Exclusion Zone, further mitigation actions will be taken, including a power down or shut down of the air gun(s).

11.2.3 Ramp Ups

Ramping up of an air gun array provides a gradual increase in sound levels, and involves a step-wise increase in the number and total volume of air guns firing until the full volume is achieved. The purpose of a ramp up (or soft start) is to "warn" cetaceans and pinnipeds in the vicinity of the air guns, and to provide the time for them to leave the area and thus avoid any potential injury or impairment of their hearing abilities.

During the proposed seismic survey program, the seismic operator will ramp up the air gun cluster slowly (6 dB/5 min). Full ramp ups (i.e., from a cold start after a shut down, when no air guns have been firing) will begin by firing a single air gun in the array. The minimum duration of a shut down period, (i.e., without air guns firing), which must be followed by a ramp up, is typically the amount of time it would take the source vessel to cover the 180-dB Exclusion Zone. Given the size of the planned air gun array, this period is estimated to be about 2 minutes based on the modeling results described above and a survey speed of 4.5 knots. Since from a practical and operational standpoint this time period is too brief, we propose to use 8 minutes, which is a time period used during previous 2D surveys.

The full ramp up, after a shut down, will not begin until there has been a minimum of 30 min of observation of the Exclusion Zone by PSOs to assure that no marine mammals are present. The entire Exclusion Zone must be visible during the 30-min lead-in to a full ramp up. If the entire Exclusion Zone is not visible, then ramp up from a cold start cannot begin. If a marine mammal(s) is sighted within the exclusionary zone during the 30-min watch prior to ramp up, ramp up will be delayed until the marine mammal(s) is sighted outside of the Exclusion Zone or the animal(s) is not sighted for 15 min for small odontocetes and pinnipeds, or 30 min for baleen whales and large odontocetes.

During turns or brief transits between seismic transects, one air gun will continue operating. The ramp up procedure will still be followed when increasing the source levels from one air gun to the full air gun array. However, keeping one air gun firing will avoid the prohibition of a cold start during darkness or other periods of poor visibility. Through use of this approach, seismic operations can resume without the 30-min watch period of the full Exclusion Zone required for a cold start, and without ramp-up if operating with mitigation gun for under 8 minutes, or with ramp-up if operating with mitigation gun for over 8 minutes. PSOs will be on duty whenever the air guns are firing during daylight, and at night during the 30-min periods prior to ramp ups as well as during ramp ups or when acoustical monitor detects the presence of marine mammals. The seismic operator and PSOs will maintain records of the times when ramp ups start and when the air gun arrays reach full power.

11.2.4 Power Downs

A power down for mitigation purposes is the immediate reduction in the number of operating air guns such that the radius of the Exclusion Zone is decreased to the extent that an observed marine mammal(s) is not in the applicable Exclusion Zone of the full array. Power downs are also used while the vessel turns from the end of one survey line to the start of the next. During a power down, one air gun continues firing. The continued operation of one air gun is intended to: (a) alert marine mammals to the presence of the seismic vessel in the area; and, (b) retain the option of initiating a ramp up to full operations under poor visibility conditions.

The full array will be immediately powered down whenever a marine mammal is sighted approaching close to or is first detected within the Exclusion Zone of the full array. If a marine mammal is sighted within or about to enter the applicable Exclusion Zone of the single mitigation air gun, it too will be shut down (see following section).

Following a power down, operation of the full air gun array will not resume until the marine mammal or turtle has cleared the Exclusion Zone. The animal will be considered to have cleared the Exclusion Zone if it:

- is visually observed to have left the Exclusion Zone of the full array; or,
- has not been seen within the Exclusion Zone for 15 min in the case of pinnipeds or small odontocetes; or,
- has not been seen within the Exclusion Zone for 30 min in the case of mysticetes or large odontocetes.

11.2.5 Shut Downs

The operating air gun(s) will be shut down completely if a marine mammal approaches or enters the Exclusion Zone and a power down is not practical or adequate to reduce exposure to less than 180 dB (rms). In most cases, this means the mitigation air gun will be shut down completely if a marine mammal approaches or enters the Exclusion Zone around the single mitigation air gun while it is operating during a power down. Air gun activity will not resume until the marine mammal has cleared the Exclusion Zone in accordance with the criteria above.

If a North Pacific right whale is observed at any distance from the vessel, the air guns will be shut down, and the PSOs on duty will immediately contact NMFS and consult on how to proceed with the survey. When four shut downs occur for mysticeti whales in the Exclusion Zone, a project review will be initiated immediately with CSLC and NMFS to assess the safety of project area conditions. The two agencies will be notified within twenty-four hours of the fourth consecutive shut down, however the survey activity may proceed while the agencies assess the situation, unless otherwise directed by the CSLC. Aerial survey data and observations noted by PSOs will be provided to the agencies for review and consideration of potential refinements to mitigation measures.

11.2.6 Monitors

See Vessel-based Monitoring below in Section 13.0.

11.2.7 Use of Mitigation Air Gun

Throughout the 24/7 geophysical survey, particularly during turning movements, and short-duration equipment maintenance activities, and unless animals are observed within the Exclusion Zone, the mitigation air gun will be continuously used to deter marine wildlife from being within the immediate area..

11.2.8 Passive Acoustic Monitoring

Visual monitoring typically is not as effective during periods of poor visibility or at night. Even with good visibility, visual monitoring is unable to detect marine mammals when they are below the surface or beyond visual range. Passive Acoustic Monitoring (PAM) will be conducted to complement the visual monitoring program. Acoustical monitoring can be used in addition to visual observations to improve detection, identification, and localization of cetaceans. The acoustic monitoring will serve to alert visual observers when vocalizing cetaceans are detected. It is only useful when marine mammals call, but it can be effective either by day or by night, and does not depend on good visibility. It will be monitored in real time so that the visual observers can be advised when cetaceans are detected.

The PAM system consists of hardware (i.e., hydrophones) and software. The “wet end” of the system consists of a towed hydrophone array that is connected to the vessel by a tow cable. The tow cable is 250 m (820 ft) long, and the hydrophones are fitted in the last 10 m (33 ft) of cable. A depth gauge is attached to the free end of the cable, and the cable is typically towed at depths <20 m (66 ft). The array will be deployed from a winch located on the aft deck. A deck cable will connect the tow cable to the electronics unit in the main computer lab where the acoustic station, signal conditioning, and processing system will be located. The acoustic signals received by the hydrophones are amplified, digitized, and then processed by the Pamguard software. The system can detect marine mammal vocalizations at frequencies up to 250 kHz.

One acoustic PSO (in addition to the visual PSOs) will be on board. The towed hydrophones will be monitored 24 hours per day during air gun operations. However, PAM may not be possible if damage occurs to the array or back-up systems during operations. One PSO will monitor the acoustic detection system at any one time by listening to the signals from two channels via headphones and/or speakers and watching the real-time spectrographic display for frequency ranges produced by cetaceans. The PSO monitoring the acoustical data will be on shift for 1 to 6 hours at a time. All PSOs are expected to rotate through the PAM position, although the acoustic PSO will be on PAM duty more frequently.

When a vocalization is detected while visual observations (during daylight) are in progress, the acoustic PSO will contact the visual PSO immediately, to alert him/her to the presence of cetaceans (if they have not already been seen), and to allow a power down or shut down to be initiated, if required. During non-daylight hours, when a cetacean is detected within the Exclusion Zone by acoustic monitoring, , the geophysical crew and the captain of the survey vessel will be notified immediately so that mitigation measures called for in the applicable authorization(s) may be implemented. The acoustic PSO will continue to monitor the hydrophones and inform the geophysical crew, and the captain when the mammal(s) appear to be outside the Exclusion Zone.

The information regarding each call will be entered into a database. The data to be entered include: an acoustic encounter identification number; whether it was linked with a visual sighting; date and, time when first and last heard and whenever any additional information was recorded; position and water depth when first detected; bearing, if determinable; species or species group (e.g., unidentified dolphin, sperm whale); types and nature of sounds heard (e.g., clicks, continuous, sporadic, whistles, creaks, burst pulses, strength of signal, etc.); and, any other notable information. The acoustic detection can also be recorded for further analysis.

11.2.9 Night Survey Areas

To the extent possible, nighttime operations will be restricted to areas in which marine wildlife abundance is low based on daytime observations and historical distribution patterns. Data collection along inshore tracklines and near Church Rock (35° 20.675’ N, 120° 59.049’ W) will be done during daylight hours to the extent possible.

If nighttime survey operations are located within the 40-m (131-ft) depth contour, PSOs will visually monitor the area forward the vessel with the aid of infrared goggles/binoculars and the forward-looking infrared system available on the *R*/V *Langseth*. Mitigation measures, such as avoidance, power down, and/or shut down, would be implemented, if a sea otter is observed within the vessels’ path.

11.3 ADAPTIVE MANAGEMENT PLAN

Data generated during pre-activities surveys and ongoing operational monitoring activities will actively be used during the proposed seismic survey to adjust or redirect operations should significant adverse impacts be observed to marine resources in the project area. The Adaptive Management Plan will be finalized in consultation with resource agencies involved in the permitting and monitoring activities associated with the proposed 2012 seismic survey operations. Information sources used as part of this plan will included but not be limited to the following:

- Pre-activity and weekly aerial surveys (See Appendix G);
- Sound source verification study;
- Onboard visual monitoring by PSOs;
- National Marine Fisheries Service Morro Bay harbor porpoise Monitoring Program (See Appendix D);

- Fish and Wildlife Service Southern Sea Otter Monitoring Program (See Appendix E); and
- Marine Mammal Stranding Response Plan (Appendix F).

Data developed during the 2012 seismic survey operations will also be used to revise proposed survey operations within Survey Box 1 currently scheduled for 2013.

12.0 ARCTIC SUBSISTENCE HUNTING AREAS

Where the proposed activity would take place in or near a traditional Arctic subsistence hunting area and/or may affect the availability of a species or stock of marine mammal for Arctic subsistence uses, the applicant must submit either a "plan of cooperation" or information that identifies what measures have been taken and/or will be taken to minimize any adverse effects on the availability of marine mammals for subsistence uses.

Not applicable to Project.

13.0 MONITORING AND REPORTING PLAN

The suggested means of accomplishing the necessary monitoring and reporting that will result in increased knowledge of the species, the level of taking or impacts on populations of marine mammals that are expected to be present while conducting activities and suggested means of minimizing burdens by coordinating such reporting requirement with other schemes already applicable to persons conducting such activity. Monitoring plans should include a description of the survey techniques that would be used to determine the movement and activity of marine mammals near the activity site(s) including migration and other habitat uses, such as feeding. Guidelines for developing a site-specific monitoring plan may be obtained by writing to the Director, Office of Protected Resources.

13.1 VESSEL-BASED MONITORING

Vessel-based monitoring for marine wildlife will be done by trained PSOs throughout the period of survey activities to comply with expected provisions in the IHA that L-DEO and PG&E receives. The visual PSOs will monitor the occurrence and behavior of marine mammals near the survey vessel during daylight survey operations. Acoustic monitoring will occur 24 hours per day, please refer to Section 11.2.8 – Passive Acoustic Monitoring. PSO duties will include watching for and identifying marine mammals; recording their numbers, distances, and reactions to the survey operations; and, documenting potential “take by harassment” as defined by NMFS.

- A sufficient number of PSOs will be required onboard the survey and support vessels to meet the following criteria:
    - 100 percent monitoring during all periods of survey operations (daylight visual and acoustic monitoring, and non-daylight acoustic monitoring); and
    - maximum of four consecutive hours on watch per PSO;

PSO teams will consist of at least one NMFS-approved PSOs and experienced field biologists. An experienced field crew leader will supervise the PSO team onboard the survey vessels. Crew leaders and most other biologists serving as PSOs will be individuals with experience as PSOs during high energy survey projects, and/or shallow hazards surveys in California.

PSOs will have previous marine mammal observation experience, and field crew leaders will be highly experienced with previous vessel-based marine mammal monitoring and mitigation projects. Resumes for those individuals will be provided to NMFS and USFWS for review and acceptance of their qualifications. PSOs will be experienced in the region, familiar with the marine mammals of the area, and complete an in-house observer training course designed to familiarize individuals with monitoring and data collection procedures.

The PSOs will watch for marine mammals from the best available vantage point on the survey vessels, typically the PSO tower on the *R/V Langseth*, or from dedicated monitoring vessel. The PSOs will scan systematically with the unaided eye and with binoculars. Personnel on the bridge of the survey and monitoring vessels will assist the PSOs in watching for marine mammals.

Information to be recorded by PSOs will include the same types of information that were recorded during recent monitoring programs associated with surveys completed offshore California. When a mammal sighting is made, the following information about the sighting will be recorded:

- species, group size, age/size/gender (if determinable), behavior when first sighted and after initial sighting, heading (if determinable), bearing and distance from observer, apparent reaction to activities (e.g., none, avoidance, approach, paralleling, etc.), closest point of approach, and pace;
- time, location (GPS coordinates), speed, activity of the vessel, sea state, visibility, and sun glare will be recorded; and,
- the positions of other vessel(s) in the vicinity of the observer location.

The ship's position, speed of the vessel, water depth, sea state, visibility, and sun glare will also be recorded at the start and end of each observation watch, every 30 min during a watch, and whenever there is a substantial change in any of those variables.

When a marine mammal is seen within the Exclusion Zone, the geophysical crew will be notified immediately so that mitigation measures called for in the applicable authorization(s) can be implemented. It is expected that the air gun arrays will be shut down within several seconds—often before the next shot would be fired, and almost always before more than one additional shot is fired. The PSO will then maintain a watch to determine when the mammal(s) appear to be outside the Exclusion Zone such that air gun operations can resume.

13.2 AERIAL SURVEYS

See Section 11.0 (Mitigation Measures) above for discussion of aerial surveys.

13.3 REPORTING

13.3.1 Field Data Recording, Verification, Handling, and Security

The PSOs will record their observations onto datasheets. During periods between watches and periods when operations are suspended, those data will be entered into a laptop computer running a custom computer database. The accuracy of the data entry will be verified in the field by computerized validity checks as the data are entered, and by subsequent manual checking of the database printouts. These procedures will allow initial summaries of data to be prepared during and shortly after the survey, and will facilitate transfer of the data to statistical, graphical, or other programs for further processing. Quality control of the data will be facilitated by: (1) the start-of survey training session; (2) subsequent supervision by the onboard PSO crew leader; and, (3) ongoing data checks during the survey.

The data will be backed up regularly onto CDs and/or USB drives, and stored at separate locations on the vessel. If possible, data sheets will be photocopied daily during the survey. Data will be secured further by having data sheets and backup data CDs carried back to the shore during crew rotations.

13.3.2 Field Reports

Throughout the survey program, PSOs will prepare a report each day or at such other intervals as required by NMFS, USFWS, U.S. Army Corps of Engineers (ACOE), California State Lands Commission, California Coastal Commission, or PG&E, summarizing the recent results of the monitoring program. The reports will summarize the species and numbers of marine mammals sighted. These reports will be provided to NMFS and to PG&E, LDEO, and NSF.

13.3.3 Marine Mammal Carcasses

If an injured or dead marine mammal is sighted within an area where air guns had been operating within the past 24 hours, the array will be shut down immediately. Activities can resume after the lead PSO has (to the best of his/her ability) determined that the injury resulted from something other than air gun operations. After documenting those observations, including supporting documents (e.g., photographs or other evidence), the operations will resume. Within 24 hours of the observation, the vessel operator will notify NMFS and provide them with a copy of the written documentation.

If the cause of injury or death cannot be immediately determined by the lead PSO, the incident will be reported immediately to either the NMFS Office of Protected Resources and the NMFS Southwest Regional Office. The seismic air gun array shall not be restarted until NMFS is able to review the circumstances, make a determination as to whether modifications to the activities are appropriate and necessary, and has notified the operator that activities may be resumed.

In addition to PG&E proposed monitoring and notification protocols, NMFS will develop and implement a Stranding Response Plan. PG&E will work in close coordination with NMFS to follow the procedures and notification requirements outline in this plan.

13.3.3 Final Reporting

The results of the vessel-based monitoring, including estimates of potential “take by harassment,” will be in a report and submitted to NMFS within 90-days of survey conclusion; the report will also be posted on the NSF website at: http://www.nsf.gov/geo/oce/envcomp/index.jsp. Reporting will address any requirements established by NMFS and USFWS.

Along with any other state or federal requirements, the 90-day report minimally will include:

- summaries of monitoring effort: total hours, total distances, and distribution of marine mammals through the study period accounting for sea state and other factors affecting visibility and detectability of marine mammals;
- analyses of the effects of various factors influencing detectability of marine mammals including sea state, number of observers, and fog/glare;
- species composition, occurrence, and distribution of marine mammal sightings including date, water depth, numbers, age/size/gender, and group sizes; and analyses of the effects of survey operations:
- sighting rates of marine mammals during periods with and without air gun activities (and other variables that could affect detectability);
- initial sighting distances versus air gun activity state;
- closest point of approach versus air gun activity state;
- observed behaviors and types of movements versus air gun activity state;
- numbers of sightings/individuals seen versus air gun activity state;
- distribution around the survey vessel versus air gun activity state; and
- estimates of potential “take by harassment”.

14.0 COORDINATING RESEARCH TO REDUCE AND EVALUATE INCIDENTAL TAKE

Suggested means of learning of, encouraging, and coordinating research opportunities, plans, and activities relating to reducing such incidental taking and evaluating its effects.

PG&E will cooperate with external entitles (agencies, universities, NGO's) to manage, understand, and communicate information about environmental impacts related to the seismic activities provided an acceptable methodology and business relationship can be agreed upon. PG&E is currently working with a number of agencies and groups to implement monitoring programs to address potential short term and long term effects on marine resources within the project area. These study programs include:

- Monitoring activities associated with the California Department of Fish and Game Scientific Collection Permit for Point Buchon Marine Protected Area;
    - Vessel based visual monitoring
    - Nature Conservancy ROV Monitoring Program
    - California Collaborative Fisheries Research Program
- National Marine Fisheries Service Morro Bay Harbor Porpoise Monitoring Program (See Appendix D).
- Fish and Wildlife Service Southern Sea Otter Monitoring Program (See Appendix E); and

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APPENDIX A
GREENERIDGE SCIENCES, INC. 2011

GREENERIDGE SCIENCES, INC.

6160-C WALLACE BECKNELL ROAD • SANTA BARBARA, CALIFORNIA 93117 • TEL/FAX 805 967-7720

MEMORANDUM

To: Ray de Wit, Padre Associates, Inc.
From: Katherine H. Kim, Charles R. Greene, Jr.
Date: 22 September 2011
Re: Central California acoustic propagation modeling report
[GSI Technical Memorandum 470-2RevB]

This is a report of acoustic propagation modeling conducted by Greeneridge Sciences, Inc., sponsored by Padre Associates, Inc., to estimate received sound pressure level radii for airgun pulses operating off central California in the vicinity of the Diablo Canyon Nuclear Power Plant.

Introduction

The objective of the work reported here is to predict the distances to received sound pressure levels (SPLs) of 190, 187, 180, 170, 160, 154, and 120 dB re 1 μPa_{rms} from a specified airgun array using a range-dependent acoustic propagation model and local environmental parameters. These predicted distances are needed for establishing exclusion radii, or safety radii, for pinnipeds and cetaceans that might occur in the survey area. Array airgun details and preliminary exclusion radii based upon a measurement-based propagation model were reported in GSI Technical Memorandum 470-1.

Due to model input uncertainties, the predicted distances should be confirmed by measurements at the beginning of survey operations. Adjustments to the exclusion radii should be made using the measurement results.

Methods

To accurately model sound transmission in the ocean, one requires a wave-theory model and precise waveguide parameters that describe sound reflections and refractions at the ocean surface, seafloor, and water column. The current study uses RAM, Range-dependent Acoustic Model developed by Michael Collins at the Naval Research Laboratory, to compute acoustic transmission loss for the survey site offshore of central California. Specifically, a variant of RAM known as RAMGEO, based on RAM version 1.5 and also developed by Collins, which implements a stratified seabed model in which multiple bottom layers run parallel to the bathymetry, was utilized in the current study. RAM is based on the parabolic equation (PE) solution to the acoustic wave equation and is widely used by the ocean acoustics community due to its proven accuracy and computational efficiency. The theory behind RAM is discussed in detail in Collins 1993.

The accuracy of the sound field predicted by an acoustic propagation model is limited by the quality and resolution of the available environmental data. The environmental parameters that describe the ocean waveguide, affect sound propagation in the ocean, and serve as input into an acoustic propagation model are: (a) bathymetry data, i.e., water depth, (b) water column sound speed profiles, and (c) geoacoustic profiles of the ocean subbottom.

Figure 1 shows the bathymetry data for the survey site, where water depth is in meters. The triangle denotes the location of the Diablo Canyon Power Plant, lines and squares represent propagation paths and their respective waypoints, and circles indicate locations of water column sound speed measurements. Three different acoustic propagation paths were examined in this study:

(1) upslope, from waypoints A to C, 5.0 km long, 138.8 m to 55.8 m in depth,

(2) downslope, from waypoints A to B, 40.0 km long, 138.8 m to 610.0 m in depth,

(3) alongshore, from waypoints A to D, 55.7 km long, 138.8 m to 340.1 m in depth

Waypoint A lay roughly in the middle of the airgun survey site in 138.8 m deep water and served as the source location.

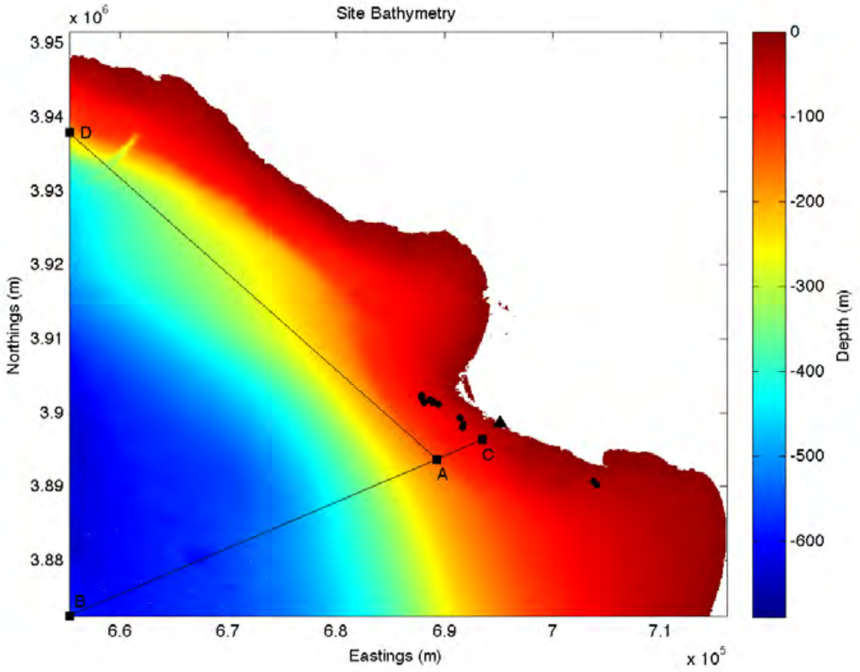

Figure 1. Bathymetry at the survey site, water depth in meters. Triangle denotes the location of the Diablo Canyon Power Plant, lines and squares represent propagation paths and their respective waypoints, and circles indicate locations of water column sound speed measurements.

Water column sound speed profiles (SSPs) were measured daily from 20 January through 2 February 2011 and are displayed in Figure 2. The locations of these SSP measurements were depcited as circles in Figure 1. Apart from spurious data points at the bottom of two of the SSPs not uncommon in such measurements, the water column sound speed at these shallow waters is effectively isovelocity. For the model input, the sound speed was thus considered to be simply 1495 m/s at all depths.

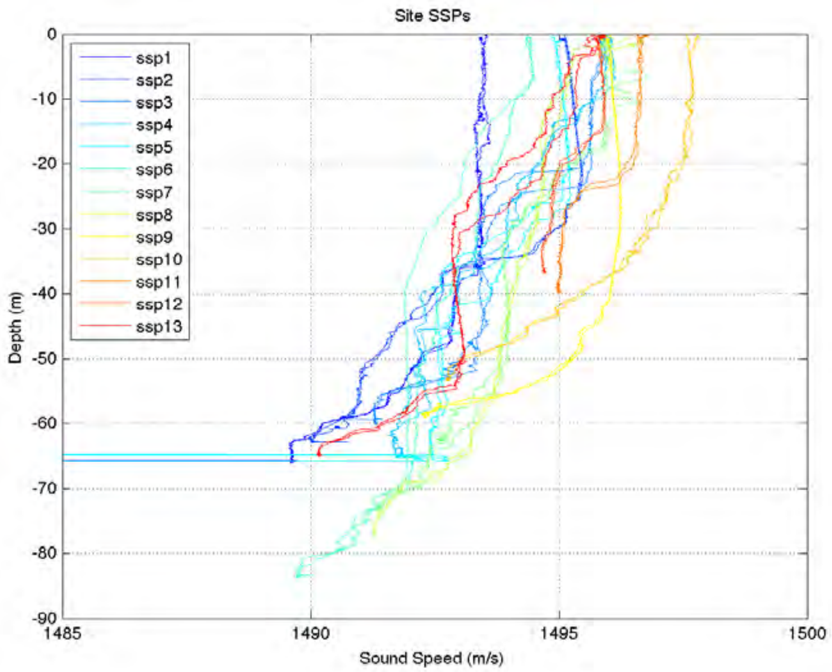

Figure 2. Water column sound speed profiles (SSPs). Measurement locations are shown in Figure 1.

General offshore rock properties were provided by Pacific Gas & Electric and Padre Associates, Inc. (Stu Nishenko, Pacific Gas & Electric, personal communications, August–September 2011; Ray de Wit, Padre Associates, personal communications, August–September 2011). These data indicated that the region inshore of Waypoint A was composed of primarily unconsolidated soft sediments mixed with sand. Offshore of Waypoint A, silts and clays were the dominant surficial sediments. This sediment layer overlaid sedimentary bedrock, composed largely of sandstone .

In terms of geoacoustic parameters, these bottom layers were modeled as a 10-m thick, sand seafloor (1650 m/s compressional sound speed) for the upslope propagation path and a 10-m thick, silt seafloor (1575 m/s compressional sound speed) for the downslope and alongshore propagation paths. In all cases, the sediment layer overlaid an 800-m, effectively halfspace, sandstone layer (3000 m/s compressional sound speed). Consequently, density and compressional attenuation values for the bottom layers were estimated to be 1.9 g/cc and 0.8 dB/λ for the upslope sediment layer, 1.7 g/cc and 1.0 dB/λ for the downslope and alongshore sediment layers, downslope and alongshore), and 2.4 g/cc and 0.1 dB/λ (Jensen et al., 1994).

The frequency content of the broadband airgun signal was expressed in terms of eighteen 1/3-octave band frequencies, spanning 10 to 500 Hz, this frequency range containing the vast majority of acoustic energy radiated by an airgun array. The powers in these bands were summed to yield the total sound pressure level of the broadband signal. The frequency dependence of the source level was taken into account using the source spectrum for this array configuration which was characterized by a 0.11 dB/Hz rolloff from peak amplitude.

Predicted sound contours for the airgun array were modeled by L-DEO/Columbia University and cast in terms of sound exposure levels (SEL) (Helene Carton, personal communications, September 2011). SEL is a measure of the received energy in the pulse, calculated as the time-integral of the square pressure over the pulse duration, defined as the time from 5% to 95% of the total pulse energy. (These limits exclude long periods of low-level reverberation. If included, the pulse energy would be unrealistically diminished.) Sound pressure level (SPL) is the root-mean-square (rms) pressure averaged over the pulse duration and is utilized in U.S. National Marine Fisheries Service guidelines regarding marine mammals and seismic noise. For a pulse duration of 1 s, SEL and SPL are equivalent. However, seismic pulses are less than 1 s in duration in most situations, and, therefore, the SEL value for a given pulse is usually lower than the SPL calculated over the actual pulse duration. Based upon measured airgun pulses, the difference between SEL and SPL values for the same pulse measured at the same location average ~10–15 dB, depending on the propagation characteristics of the location (Greene 1997). Consequently, in this report, the rms pressure levels of received seismic pulses are assumed to be 13 dB higher than the SEL values predicted by L-DEO's source model. Specifically, the source modeled as operating at a tow depth of 6 m was assumed to have an effective source level at 1 m of 223.8 dB re 1 $\mu Pa^2 \cdot s$ SEL or, equivalently, 236.8 dB re 1 μPa_{rms} SPL.

Results

Two-dimensional (depth vs. range) transmission loss results are shown in Figures 3 through 5 for each of the propagation path cases: upslope, downslope, and alongshore, respectively. In each figure, the top plot represents a 10 Hz source and the bottom plot a 500 Hz source, the outer limits of the frequencies under consideration. In all cases, low frequency sounds were readily absorbed into the bottom compared to high frequency sounds, as expected in bottom-interacting ocean environments. Due to the isovelocity sound speed profile and relatively reflective seafloor, higher frequency energy was largely retained in the water column.

Received levels as a function of range for a receiver depth of 6 m (the same depth as the source/airgun array) is shown in Figure 6 for each of the propagation path cases. Received levels (SPLs) were calculated from the aforementioned transmission loss results via:

$$RL = SL - TL,$$

where RL denotes received level, SL source level (236.8 dB re 1 µPa at 1 m, as described above), and TL transmission loss. In Figure 6, the thin black line is the received level curve output by the acoustic propagation model, the thick black line is a regression equation for the aforementioned curve, and the colored lines are SPL limits for exclusion radii. Regression equations derived from propagation model received levels (predicted SPLs) for each of the propagation paths are:

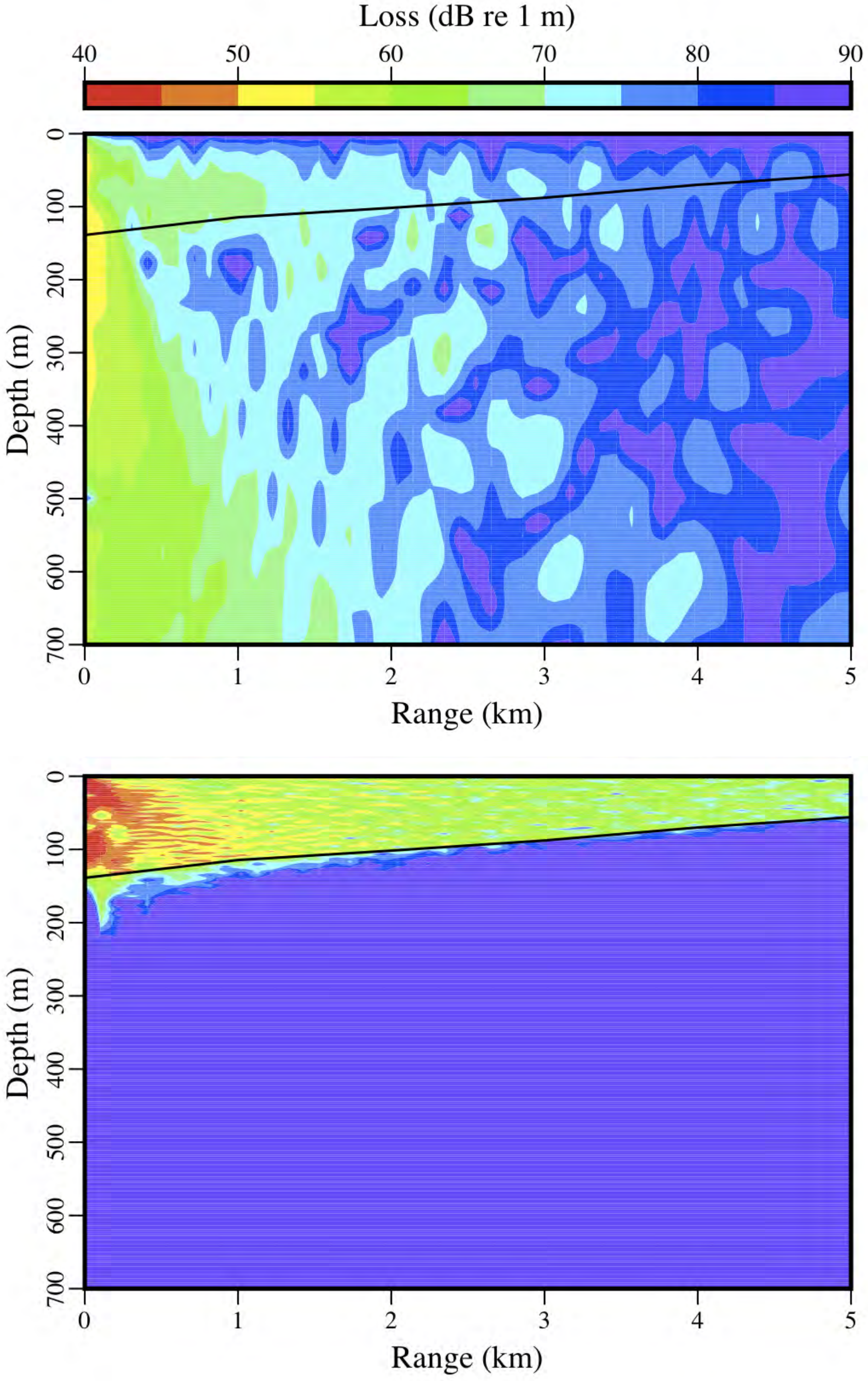

Figure 3. Transmission loss as a function of range (10 Hz source, upper plot; 500 Hz source, lower plot) for an upslope propagation path.

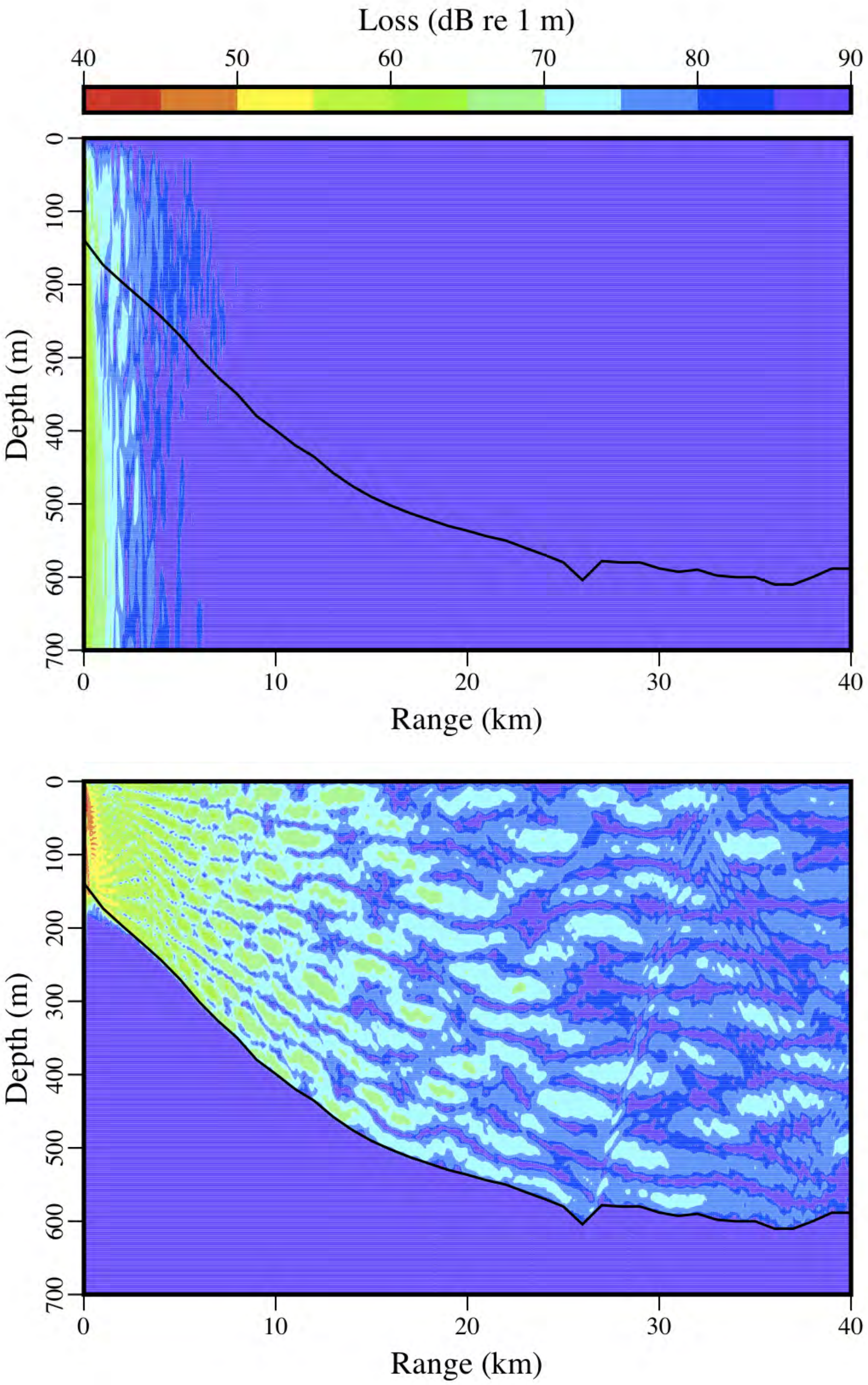

Figure 4. Transmission loss as a function of range (10 Hz source, upper plot; 500 Hz source, lower plot) for a downslope propagation path.

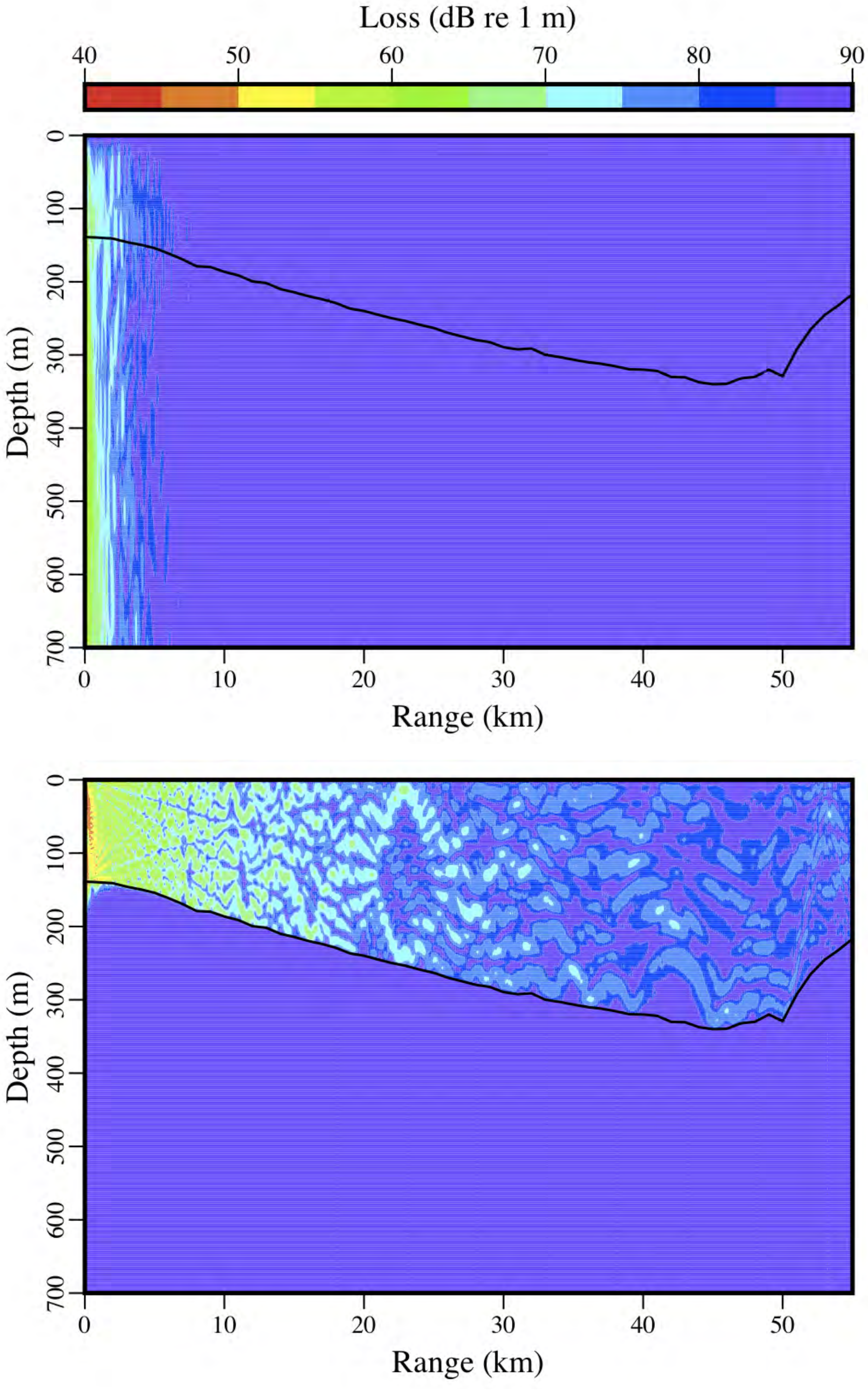

Figure 5. Transmission loss as a function of range (10 Hz source, upper plot; 500 Hz source, lower plot) for an alongshore propagation path.

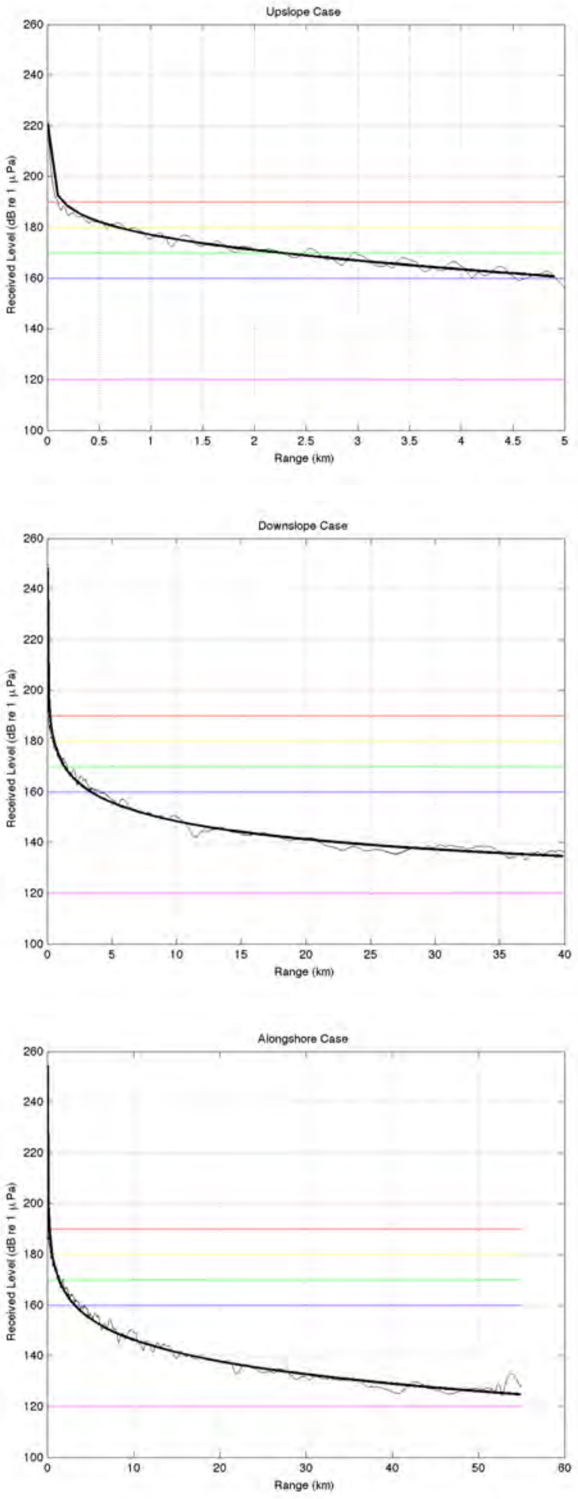

Figure 6. Received levels as a function of range for upslope, downslope, and alongshore propagation paths (top to bottom plots). The thin black line is the received level curve output by the acoustic propagation model, the thick black line is a regression equation for the aforementioned curve, and the colored lines are SPL limits for exclusion radii.

$$SPL_{\text{predicted, upslope}} = 224.1 - 14.1\log(R) - 0.0017R,$$

$$SPL_{\text{predicted, downslope}} = 251.3 - 25.1\log(R) - 0.0000R, \text{ and}$$

$$SPL_{\text{predicted, alongshore}} = 257.5 - 27.0\log(R) - 0.0000R.$$

in units of dB re 1 μPa for a given range R in meters. The second term in the above equations indicate spreading loss for the survey site is indicative of spherical combined with cylindrical spreading, a result of reflection, absorption, and refraction of sound energy in this waveguide.

Table 1 summarizes the exclusion radii given the predicted regression equations.

SPL (dB re 1 μPa)	Upslope: Distance (m | statute mi | nautical mi)			Downslope: Distance (m | statute mi | nautical mi)			Alongshore: Distance (m | statute mi | nautical mi)		
190	250	0.16	0.13	280	0.17	0.15	320	0.20	0.17
187	390	0.24	0.21	370	0.23	0.20	410	0.25	0.22
180	1,010	0.63	0.55	700	0.43	0.38	750	0.47	0.40
170	2,990	1.86	1.61	1,760	1.09	0.95	1,760	1.09	0.95
160	6,210	3.86	3.35	4,450	2.77	2.40	4,100	2.55	2.21
154	8,570	5.33	4.63	7,820	4.86	4.22	6,780	4.21	3.66
120	24,650	15.32	13.31	251,320	156.16	135.70	94,870	58.95	51.23

Table 1. Predicted exclusion radii for upslope, downslope, and alongshore propagation paths.

Discussion

The exclusion radii predicted via propagation modeling (Table 1 above) compared favorably with previous radii predicted via measurements made in the Chukchi Sea and applied to this California site (refer to GSI Technical Memorandum 470-1). Discrepancies between the two can be attributed to the two sites' different waveguide characteristics (shallow versus relatively deeper and depth-varying water columns, varying seafloor properties, etc.) as well as different airgun array source levels (measured versus modeled levels, SEL to SPL conversion).

The order of magnitude difference in the 120-dB exclusion radii for the downslope propagation path compared with the upslope and alongshore cases is likely a result of a phenomenon in shallow water underwater acoustics known as "downslope conversion". Acoustic energy originating from a source over the continental shelf becomes increasingly distributed close to the horizontal (i.e., low angle in the vertical plane) as the energy travels seaward into deeper water, due to its interaction with the sloping seafloor. The result is less interaction with the seafloor in the deeper water (fewer bottom bounces) and, thus, less transmission loss (higher received levels as a function of range and, thus, larger exclusion radii).

As with all theoretically-based acoustic propagation models, their output, in this case transmission loss and, consequently, received levels, are only as good as their input, specifically, waveguide environmental parameters and especially geoacoustic parameters which are typically poorly known in terms of spatial and temporal variability. In addition, the propagation model utilized in this report does not account for airgun array directionality. Therefore, the exclusion radii summarized in Table 1should be considered estimates until confirmed by in situ measurements.

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Appendix B:
Harbor Porpoise Density Figures and Calculations

Survey Design and Harbor Porpoise Distribution

As indicated in Section 4.1.3, according to the recent density data provided by Dr. Karin Forney (see Table 1 and Figure 1 below); the highest density area of the Morro Bay stock is south of Oceano averaging over two individuals per km^2, with a total area of 504 km^2. Dr. Forney provided data from aerial flight referenced by Caretta et al. 2009 with additional data from 2009-2011. This data contained delineating aerial transect lines (start/end latitude) that separate the project site by density. The latitude provided by D. Forney was imputed into GIS and each density was grouped into a specific polygon based on the density provided. The project site was overlayed and polygons were clipped by the corresponding 160 dB for each survey box. The densities within the associated GIS database were compiled and the used to gather the estimated number of individuals within each boxes 160 dB safety zone.

Using data from GIS and Figure 1 below some basic calculations and explanations were made. Approximately 48 percent of this high density area will not be ensonified by survey activities (total ensonified area is 261 km^2). No matter what order the Boxes are surveyed, 48 percent of the highest density area in the Morro Bay stock will remain open without ensonification. Typically, food, shelter, and lack of competition and or predators are the reason for populations sustaining higher densities in one area and not the other. Under the assumption that the biology and population dynamics of the harbor porpoise operate in the same manner, by temporarily limiting the species to this high density, successful area would not be detrimental to the population.

Surveying the project site in a manner to allow harbor porpoises to seek refuge in high density areas while the survey is being conducted is plausible. If Box 4 of the survey plan was to be conducted first, it would allow all of the high density area south of Oceano and San Luis Bay (second highest density area) to remain open for harbor porpoises to seek refuge. If Box 2 was conducted in the same survey year, but after Box 4, harbor porpoise individuals located in Box 2 (159 km^2 of high density area ensonified) would be able to move west along the coastline, where ensonification does not reach. Much of San Luis Bay and areas to the south would also remain open, totaling 68 percent of the 504 km^2 high density habitat remaining un-ensonified. In addition, individuals that were present near the northern portion of Box 2 would be able to remain along shoreline of the Morro Bay area where they would not be ensonified.

Table 1. PRELIMINARY ANALYSES, conducted by Karin Forney, NOAA/SWFSC, 8/2/2012, in support of NMFS Permit Office evaluation of potential impacts. Table below uses the line-transect parameter estimates [f(0) and g(0)] from Carretta et al. 2009, and includes 2002-2011 data for the same survey conditions (cloud cover < 25%, Beaufort sea states 0-2 only) to estimate finer-scale densities within the inshore stratum for this stock (<50fm or <92m)

Start Lat	**End Lat**	**TRANSECT / Stratum**	**Area (km^{-2}) represented**	**# Harbor porpoise sightings**	**# Harbor porpoise individuals**	**Km surveyed**	**Porpoise seen per km**	**Density (D)* (ani km^{-2})**	**Approximate stratum abundance**	**Average porpoise density**	**Notes**
34.448	34.568	**1**	165	2	3	182	0.016	0.146	24	0.736	Southern edge of stock range
34.568	34.755	**2**	276	10	21	171	0.123	1.089	300		
34.755	35.007	**3**	347	43	78	338	0.231	2.040	708	**2.178**	**Core Area of Stock Range**
35.007	35.098	**4**	157	39	79	168	0.471	4.167	652		
35.098	35.207	**5**	182	37	52	300	0.173	1.533	280		
35.207	35.425	**6**	193	9	29	180	0.161	1.423	275		
35.425	35.577	**8**	524	7	13	269	0.048	0.427	224	0.427	Northern edge of stock range
35.577	35.692	**9**		3	6	139	0.043	0.381			
35.692	35.757	**10**		0	0	62	0.000	0.000			
35.757	35.91	**11**		8	13	216	0.060	0.533			
35.91	36.192	**12**		5	7	332	0.021	0.186			
36.192	36.238	**13**		0	0	153	0.000	0.000			
		All Inshore	1844	163	301	2510	0.120	1.061	2463		

These "All Inshore" values are equivalent to the Carretta et al. 2009 Morro Bay stock (Inshore) density=0.959 and Abundance = 1776. Differences could be caused by random sampling variation, the per-transect stratification, and/or increasing population trend in recent years. Further analyses will be required to examine differences and finalize these preliminary estimates, as appropriate.

L-T parameter estimates from Carretta et al. 2009:

f(0)= 5.166
g(0)= 0.292

*D = (porp/km * f(0))/(2*g(0))

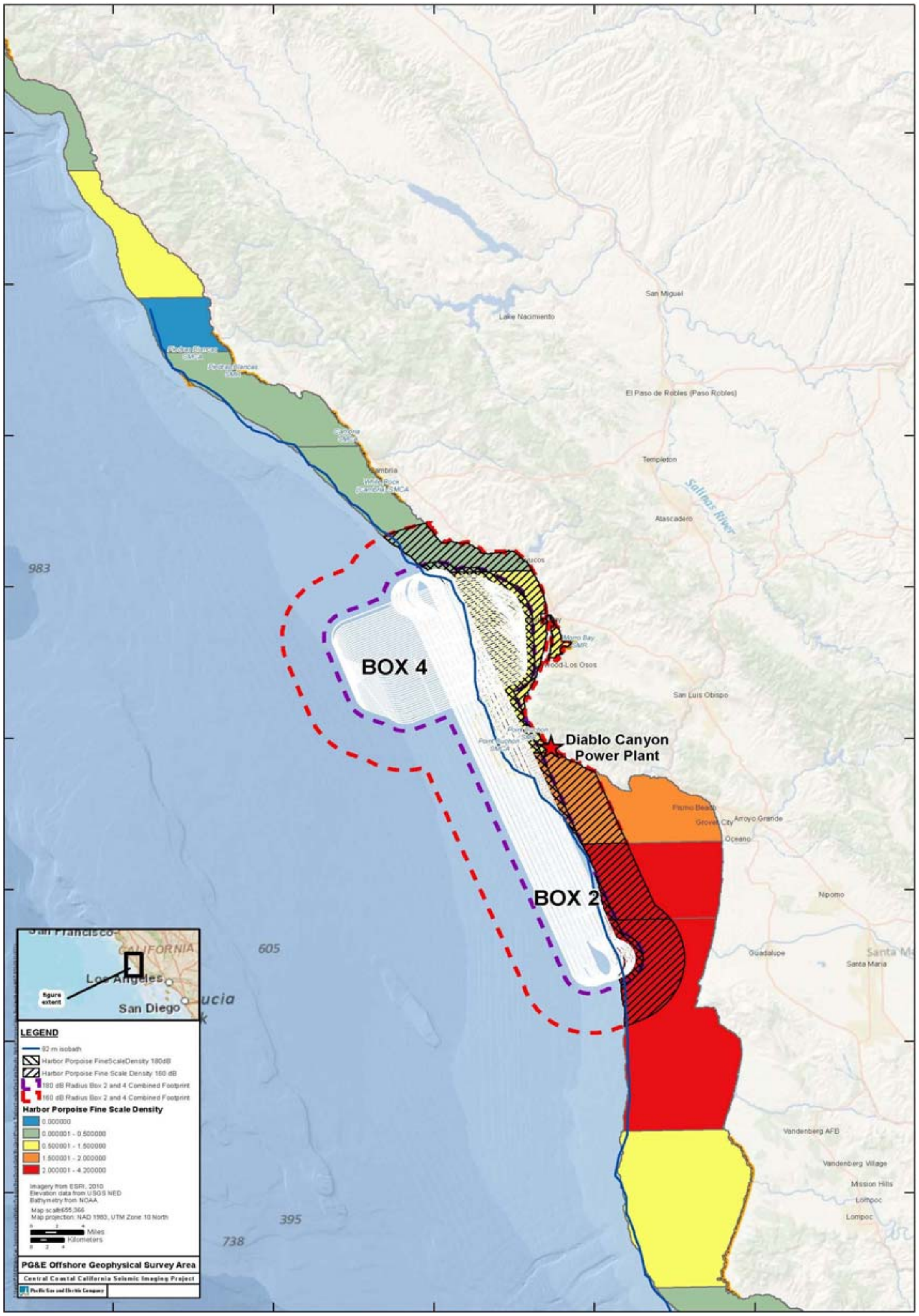

Figure 1. Harbor Porpoise Fine-Scale Density

Appendix C:
Southern Sea Otter Density Figures and Calculations

Survey Design and Sea Otter Distribution

Southern sea otter (sea otter) census and distribution data and shapefiles were extracted from the USGS Western Ecological Research Center's (WERC) Spring 2010 (May-July 7) survey results (http://www.werc.usgs.gov/ProjectSubWebPage.aspx?SubWebPageID=4&ProjectID=91. The WERC data contains a GIS shapefile with various density estimates delineated by polygons along the central California coast and includes the project area. These data are presented as a 3-year average of the number of sea otters per square kilometers (km^2) within each polygon; the data were averaged by 10 kilometer (km) coastline segments to account for spatial/temporal variation in sea otter activity and survey conditions. Data polygons are also provided from shore to the 30 meter (m) depth contour and between the 30 and 60 m depth contours (See Figure 1).

Level B "Take by Harassment" Calculation

In order to estimate the number of sea otters within each polygon ensonified by the 160 dB, ArcGIS was used to delineate a 6,210 m radius zone of ensonification. The USGS 2010 Sea Otter Census data polygons within each of these ensonification areas were extracted and the area calculated (Figures 1 and 2). The census data associated with the extracted areas were exported to an Excel spreadsheet for data analysis and to calculate the estimated number of sea otters within each area.

Once the data were exported to Excel, the number of sea otters within the 160 dB ensonification area zone were totaled (See Table 1).

Table 1 Otter Density and number of Individuals per Survey Box

	Area of 160 dB buffer	# of Otters in Buffer	Otter/Km	70% surface reduction
Box 2	245	261	1.07	78.3
Box 4	155	263	1.70	78.9
Total	**400**	**524**		**157.2**

The estimated number of sea otters was then reduced by the 70 percent to account for the time when sea otters are at the surface and not subjected to underwater ensonification (see discussion below regarding Surface Time).

70% Surface Time Reduction:

The basis for reducing the estimated number of sea otters that will be exposed to "take" noise levels within each of the estimated ensonification zones by 70% are studies that have documented the amount of time that sea otters actually spend underwater where the animal is exposed to the sound generated by the air guns. Below are summaries of several studies on the percentage of time that sea otters spend in specific activities. For this analysis, it is assumed that "feeding" and "foraging" are activities that require the animal to be underwater.

Yeates, et al. (2007) reported the following mean percent activity categories for six adult male California sea otters: feeding (36.3); resting (40.2); swimming (8.5); grooming (9.1); and, other (7.3). Estes, et al. (1986) reported 11,939 observations of sea otter activity in four areas of the central California coast involving 245 sea otters in spring of 1982 and 219 in fall of 1982. The mean time foraging was 24.5 percent, the mean time resting was 59 percent, and other behaviors accounted for 17 percent.

Bodkin, et al. (2004), cited in Watwood and Buonantony (2012) studied activity patterns of 14 sea otters in southern Alaska and found that those animals spent an average of 37 percent of their time foraging, 11 percent diving/non-foraging, and 52 percent resting. Walker, et al. (2008) reported on 7,116 observations of sea otter activity in Washington State between 2003 and 2004. The percent of activity times were: feeding (7.6); grooming (19.7), resting (62.3), play (1.8), travel (7.6), nursing (0.6), and other (0.4).

Based on these data, a 30 percent "underwater time" was selected as a conservative value for the purpose of this analysis. The actual submerged time when the sea otters could be exposed to subsurface noise generated by the seismic equipment would be expected to be a fraction of the 30 percent, as it is assumed that more time is spent consuming food than the actual capture of the prey.

Ensonification and Boat Transect time and Linear Length within Otter Habitat

Using the USGS otter density and the otter delineating habitat depth of the 40 meter isobath contour, GIS was used to isolate tracklines that ensonify otter habitat and also tracklines that are traversed shoreward of the 40 m isobath. See Table 2 and Figure 3 and 4 for illustrations and calculations

Table 2. Portion of Otter Range Impacted by tracklines and 160 dB Ensonification.

	Otter Habitat within 160 dB Buffer[1,2]	**% of Otter Range within 160 dB Buffer**	**Otter Habitat (<40 m) within Boat Transect Boxes[1,2]**	**% of Otter Range within Transect Boxes**
Box 2	111.5	8.28%	1.67	0.12%
Box 4	100	7.43%	44.74	3.32%
Total	**211.5**	**15.71%**	**46.41**	**3.45%**

[1] Area calculated in km^2
[2] Area calculated contains overlap of boxes
Total Area of southern sea otter Habitat within range is 1,346 km^2

Using the linear length and an average boat speed of 8.5 km^2 per hour the amount of time spent ensonifying otter habitat was calculated. In addition, the amount of time spent traversing shoreward of the 40 m contour was also calculated, see Table 3.

Table 3: Southern Sea Otter Habitat Exposure Time and Linear Length

	Total Length Transects within Box (km)	Total Length of Tracks within 6,210 m of 40 m Contour (160 dB)	Total # of Hours of 160 dB Exposure	Km^2 Traveled Landward of 40 m Contour (otter habitat)	Total # of Hours of Survey Boat within Otter Habitat
Box 2	2148.2	981.2	115.4	1.67	0.2
Box 4	1417.6	583.9	68.7	44.74	5.3
Total	**3565.8**	**1565.1**	**184.1**	**46.4**	**5.5**

Based on the travel speed of 8.5 km/hour

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FIGURES

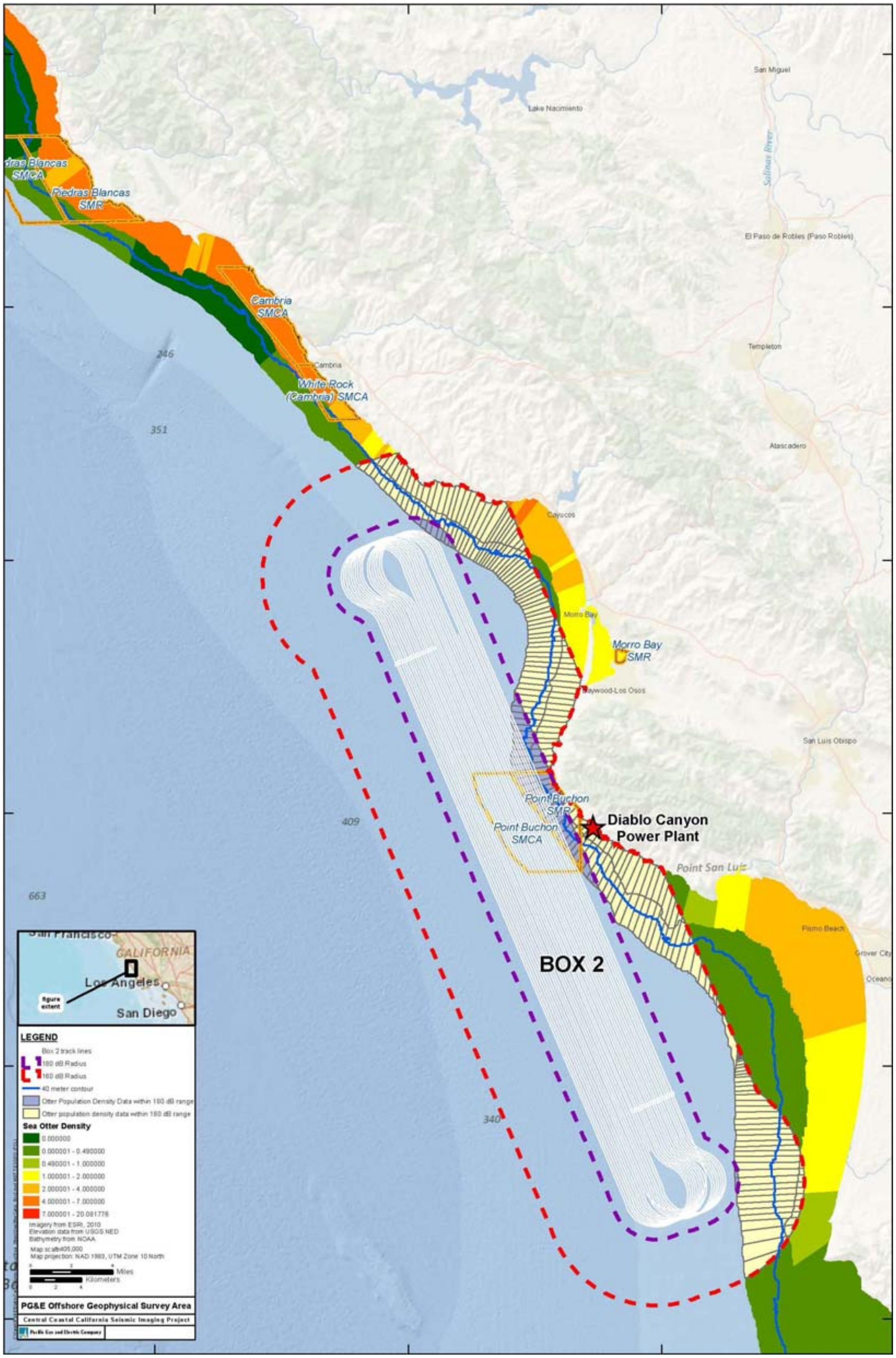

Figure 1. Sea otter 160 dB and 180 dB Buffer for Box 2

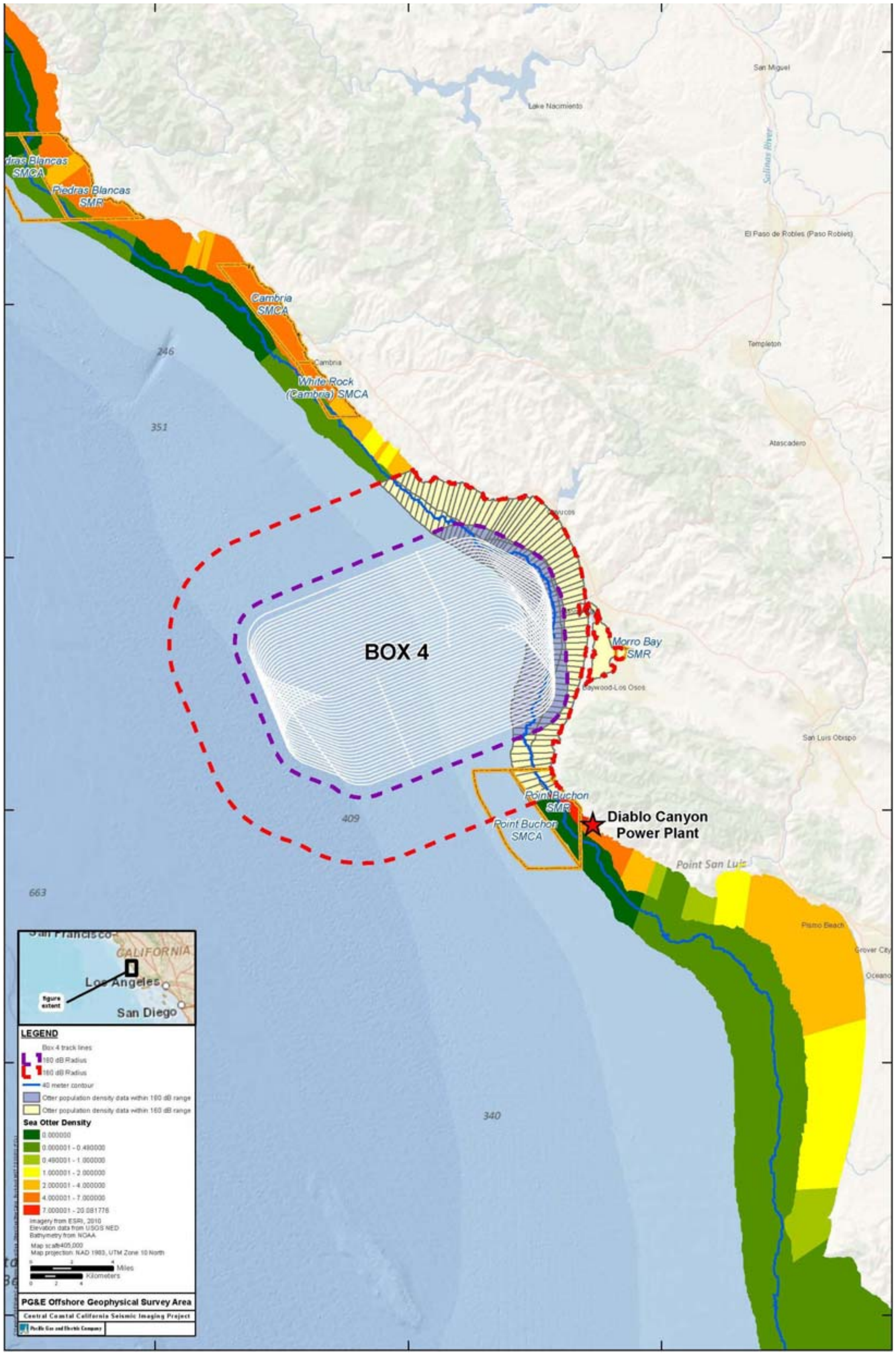

Figure 2. Sea otter 160 dB and 180 dB Buffer for Box 4

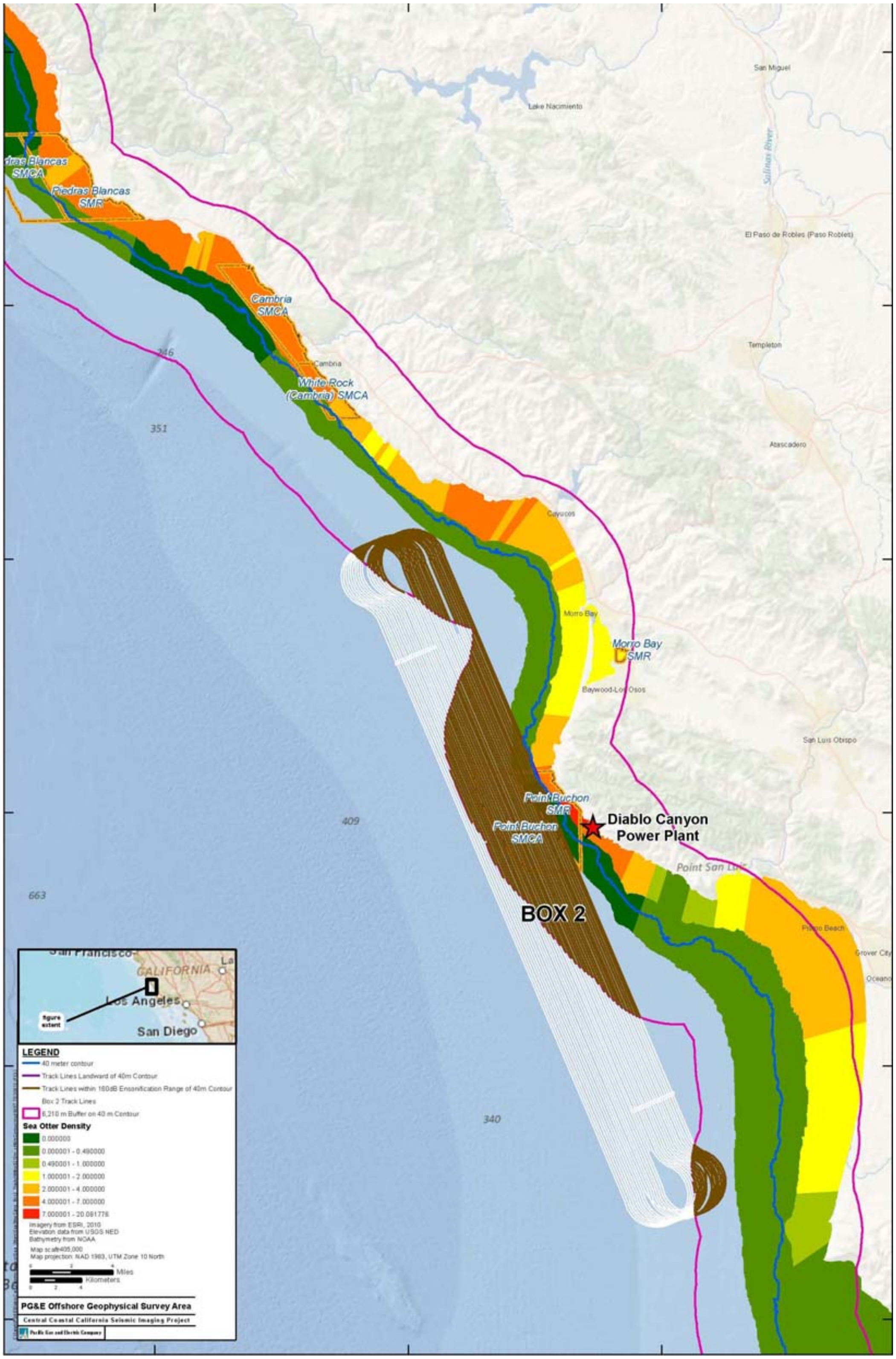

Figure 3. Box 2 Tracklines Ensonifying Sea Otter Habitat and Boat Tracklines shoreward of the 40 meter Contour

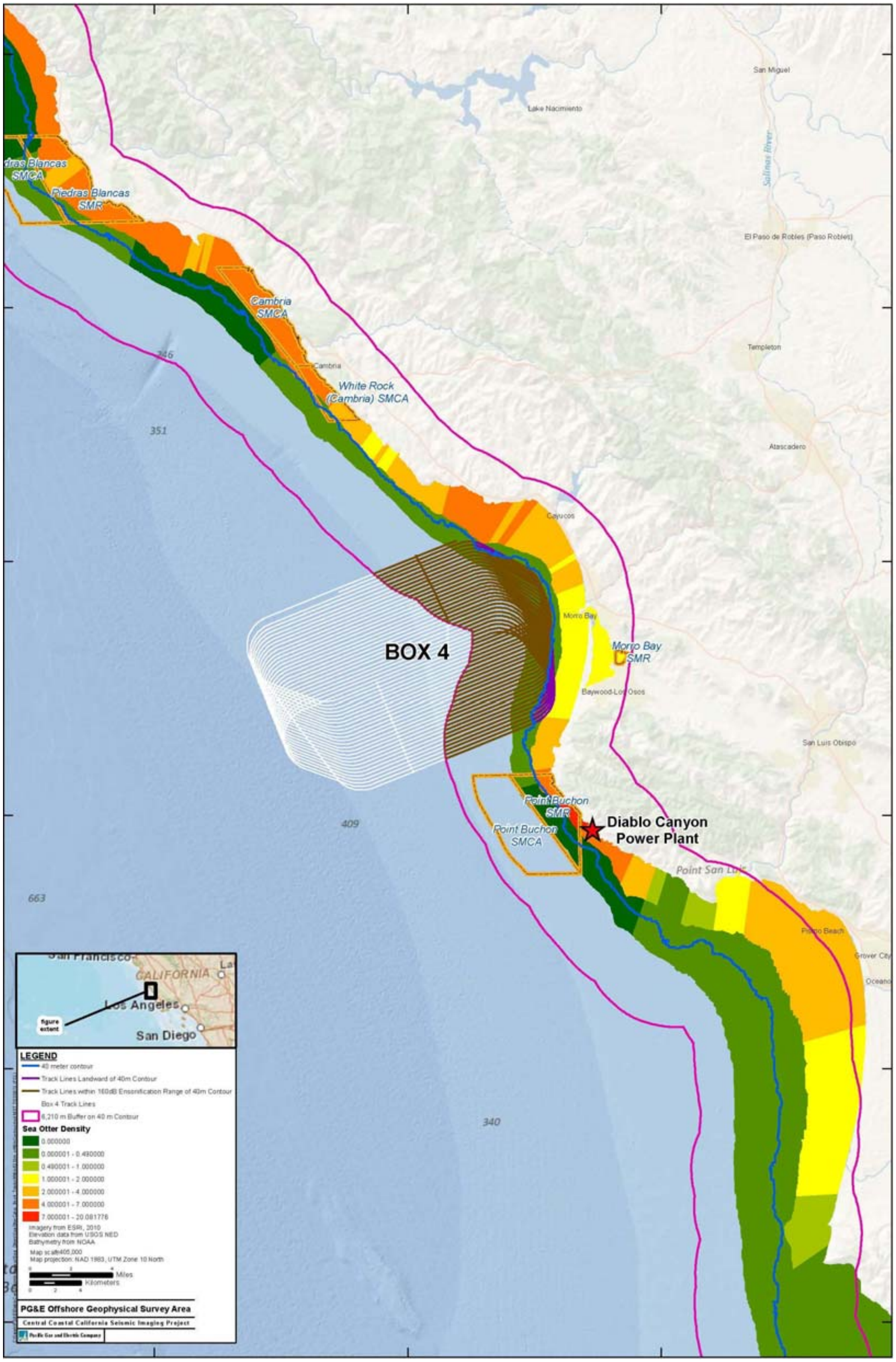

Figure 4. Box 4 Tracklines Ensonifying Sea Otter Habitat and Boat Tracklines shoreward of the 40 meter Contour

Appendix D:
NMFS Harbor Porpoise Monitoring Study

Seismic Survey Harbor Porpoise Monitoring Project – Conceptual Outline

Prepared by Karin Forney, NOAA/SWFSC, August 8, 2012

The bullets below provide a conceptual framework for monitoring of potential impacts to the Morro Bay Stock of harbor porpoise with respect to planned seismic surveys off the Diablo Canyon Nuclear Power Plant. The monitoring project would involve a direct collaboration between NOAA/SWFSC, USGS (to reduce costs and share instrumentation/airtime when possible), Brandon Southall (SEA, Inc.), and possibly others. Details will need to be worked out when all collaborators can meet, sometime after I return to the office on August 24. A very rough cost estimate is attached; actual costs will depend on design and could be higher or lower.

Monitoring would involve a 3-pronged approach to collect data before, during and after the seismic surveys.

1. <u>Replicated Aerial Surveys</u>: [NOAA] Conduct fine-scale aerial surveys within the entire range of the Morro Bay harbor porpoise stock. Transect design is still to be determined, but would likely include ~2 naut. mi. spacing for lines within the core area/ seismic survey impact area and lower intensity outside of this area.

o Field requirements: ~ 10 hrs. airtime per survey in a suitable twin-engine, high-wing aircraft (preferably Partenavia P-68 or Twin Otter), 4 marine mammal observers, misc. survey equipment including laptops, GPS, clinometers etc. (NMFS/SWFSC has the equipment).

o Operational constraints: Surveys can only be conducted effectively when skies are clear and seas are calm (Beaufort sea state <3), and should be flown at ~500-700 ft altitude. Late September and early October are, fortunately, the best months for good weather. Surveys should start with sufficient time to conduct at least 3 replicated surveys before any seismic activities commence, to provide baseline information on fine-scale porpoise distribution and variation therein.

2. <u>Moored passive acoustic instrumentation</u>: Two types of moored acoustic instruments will be required.

a) [NOAA] A network of instruments to monitor harbor porpoise presence using echolocation click detectors (CPODs). A network of CPODs (perhaps 10-12) should be placed throughout the core and peripheral habitat of harbor porpoises. Design to be determined.

b) [SEA, Inc.] Passive acoustic instrument to monitor received sound levels at varying locations within the habitat. Some of the instruments planned for sea otter monitoring will be useful for harbor porpoises as well, but we will need additional instruments farther from shore to collect data within harbor porpoise habitat. Design to be determined; Brandon Southall would be the contact for instrumentation details, cost and availability.

Stranding Response: [NOAA] Personnel, equipment, transportation, and pathology resources need to be lined up and funded to allow the detection, rapid collection, and examination of any porpoise carcasses or injured animals. Whenever possible, dad animals should be CAT scanned to provide data on any internal injuries.

Appendix E
USFWS Southern Sea Otter Monitoring Study

CENTRAL COASTAL CALIFORNIA SEISMIC IMAGING PROJECT
Supplementary Monitoring/Study

USGS-Western Ecological Research Center, Santa Cruz Field Station
Department of Ecology & Evolutionary Biology, University of California, Santa Cruz
Principal Investigator: Dr. M. Tim Tinker

Background

The coastal regions to the north and south of Diablo Canyon Power Plant (DCPP) provide vital habitat for a relatively large proportion (~23%) of the federally threatened southern sea otter (*Enhydra lutris nereis*) population. The proposed High Energy Seismic Survey in the vicinity of DCPP, designed to image of major geologic structures and fault zones in the vicinity of the DCPP, represents a potentially significant disturbance to certain marine wildlife species in the area. However, to date there is a paucity of information as to the sensitivity of sea otters to acoustic disturbances of this nature and thus little basis for estimating the magnitude of the impacts on individual sea otter behavior and/or population level vital rates.

We propose to address this information need by using the proposed seismic surveys as a natural experiment, measuring behavioral and demographic responses (if any) to the acoustic disturbance event. The proposed work would provide a real-time monitoring infrastructure with which to detect and measure levels of harassment caused by the surveys, as required by the U.S. Fish and Wildlife Service, while at the same time providing useful information on behavioral response thresholds as a function of sound exposure for sea otters. While these might seem to be ambitious goals, the aims are reasonable in light of the extensive baseline data we have amassed over the past two decades on sea otter behavior, habitat use, movements, and rates of survival and reproduction, using telemetry-based field studies. This information includes data collected from sea otters in the area of DCPP. We will take advantage of this baseline data set, and using well-established methodological protocols we will conduct a case/control comparison study, based around radio-tagged sea otters equipped with bio-logging time-depth recorders (TDRs) that have been shown to provide highly-resolved information on dive behavior and activity.

Objectives

Research objectives include: 1) assessment and description of pre-survey (baseline) values of standard health and behavioral metrics of sea otters in the “treatment” area (the region that will be impacted by the seismic surveys) and a nearby control area (San Simeon, immediately to the north of the treatment area). Metrics include body condition, blood panel diagnostics, gene expression biomarkers, habitat/spatial use patterns, activity budgets (% time feeding and forage bout durations) and details of diving behavior such as mean dive depth; 2) real-time and post-hoc (bio-logged) measurement of behavioral responses to seismic surveys, defined as statistically detectable changes in one or more behavioral metrics concurrent with the timing of seismic surveys that are observed in treatment but not control populations; 3) in the event of detection of significant responses, establishment of behavioral response thresholds as a function of sound exposure levels at the sea otter’s location (accounting for propagation of sound within kelp forest habitat); and 4) in the event of detection of significant responses to the survey, determination of any effects on sea otter survival or reproductive success (as measured by differing hazard rates for sea otters within the treatment area as compared to control area, within the context of baseline values from previous studies).

Methods

Working closely with our collaborators from California Department of Fish and Game Marine Wildlife Veterinary Care and Research Center (MWVCRC), the Monterey Bay Aquarium Sea Otter Research and Conservation department (SORAC), and the University of California at Santa Cruz and Davis (UCSC and UCD), we will capture and implant radio-transmitters into 60 free-ranging sea otters in the region of DCPP, including 40 otters within the treatment area (between Port San Luis in the south and Cayucos in the north) and 20 in the control area (north of Cambria and south of San Simeon Point). We will target resident females and territorial males in kelp-dominated habitat, as opposed to the more transient male population in Estero Bay, as previous research has shown that the latter group are more likely to disperse and thus not be present during the seismic surveys, and disturbance impacts to the former group would have a greater population-level impact.

Captures will occur during September 2012 using scuba-based techniques from small boats, identical to the procedure used by our group on dozens of previous projects (*e.g.,* Tinker *et al*. 2006). Captured sea otters will be transported to a mobile veterinary lab stationed at the Morro Bay Coast Guard office or other suitable facility (depending on the location of the targeted sea otter group). At the mobile lab they will be anesthetized by a qualified veterinarian for the placement of flipper tags, VHF transmitter, and TDRs. Health parameters, including weight, body condition, tooth wear, will be assessed at the same time, and a pre-molar tooth will be collected for cementum-based age estimation. Blood and tissue samples will be taken from each sea otter to evaluate overall health and nutritional state, immune function, pathogen exposure and presence, and exposure to petrochemicals and other contaminants. In addition to venous blood samples, we will collect skin punches (obtained during flipper tag application), vibrissae (for characterizing diets via stable isotope analysis; Newsome *et al.* 2009), nasal swabs, and fat and liver biopsies. We will use gene expression analysis for assessing recent or chronic exposure to a suite of stressors and xenobiotics, including hydrocarbons (Bowen *et al.* 2012), which will be important for assessing any later emerging health symptoms unrelated to the seismic surveys. All the above activities are covered by an existing federal permit and institutional animal care and use (IACUC) permit issued to the principal investigator.

Intensive tracking and observation of the study animals will commence immediately after captures and will occur throughout the study area, defined as the coastal waters between Pismo Beach in the south and Point Piedras Blancas to the north, from the low tide line out to the 40m isobath. Field personnel will conduct shore-based daily surveys using standard telemetric protocols (triangulation on radio signal and visual identification, *e.g.,* Tinker *et al.* 2008) to locate all study animals within the study area and record precise GPS position, survival, reproductive status and instantaneous behavior. Aerial flights will be conducted at approximately 2-week intervals to supplement these data and to locate missing study animals, including those that have moved outside of the intensive study area. Aerial flights will include coastal areas between Pt. Conception and Monterey. A schedule of intensive focal-animal observations (12-hour activity sessions) will be established to collect detailed behavioral data from all animals before, during and after the seismic survey experiment. During these sessions, data are recorded at 10 minute intervals (and continuously during feeding bouts) on activity state, diet, dive behavior, distance-to-shore and fine-scale movements (habitat use). Dive behavior recorded during these observational sessions can later be cross-matched to bio-logged data from TDRs in order to detect even subtle responses to disturbances (*e.g.,* sudden changes in dive depth or cessation of feeding behavior concurrent with received noise disturbance).

To measure the actual received noise levels at sea otter resting and feeding sites adjacent to or within kelp beds (which will be very different from noise levels in open water), we will work closely with Dr. Brandon Southall from SEA Inc. (www.sea-inc.net) and Dr. Colleen Reichmuth from the Cognition and Sensory Systems Laboratory at UC Santa Cruz to deploy a series of bottom-mounted, passive acoustic recording arrays in key sea otter habitat areas, to be determined based on previous time series of USGS survey data and on preliminary telemetry tracking data from tagged study animals. Data from these receivers will be cross-reference with data from the vessel in order to develop a basic model of noise propagation and received levels within sea otter habitat.

Beginning approximately 1 year after initial captures, attempts will be made to re-capture all study animals. Methods for recaptures are essentially identical to those of the initial captures. Sea otters will be anesthetized and archival TDR instruments retrieved for data collection. Health parameters will be re-assessed, tissue samples taken, and any missing flipper tags will be replaced. Any study animals (as well as non-tagged animals within the study area) that die during the course of the study will be immediately retrieved by field personnel. Data on primary and contributing causes of morality in wild sea otters, as well as information on environmental risk factors, can be obtained from thorough necropsies of dead animals (*e.g.,* Miller *et al.* 2010). Any animals that disappear from the study areas will be located by airplane and, if a mortality signal is detected, personnel will be dispatched (by car, boat, or on foot) to retrieve the carcass. Carcasses will be subjected to detailed necropsies by a veterinary pathologist at MWVCRC following established protocols. In addition to determining the primary and contributing cause(s) of death, the pathologist will supervise collection of tissue samples for a variety of otter and ecosystem health studies.

Daily reports will be provided by field staff during the seismic surveys on any observed responses (either perceived or empirically measured) of sea otters to the seismic surveys. A progress report will be provided after the completion of the surveys to describe preliminary results, and annual reports will be provided after year 1 and year 2 of the project. A final project report will be submitted upon completion of the project (Sept. 2015) with comprehensive analyses of the behavior, habitat use, health parameters, reproduction and survival of study animals in treatment and control groups, including detailed descriptions of any detected responses to acoustic disturbance and a model of behavioral response thresholds as a function of sound exposure levels in sea otter habitat.

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Appendix F
Marine Mammal Stranding Response Plan

Appendix G:
Aerial Survey Plan

CENTRAL COASTAL CALIFORNIA SEISMIC IMAGING PROJECT REDUCED SURVEY AREA

AERIAL SURVEY PLAN

Submitted to:

National Marine Fisheries Service
Southwest Region Protected Resources Division
501 W. Ocean Blvd., Suite 4200
Long Beach, CA 90802

U.S. Fish and Wildlife Service
Ventura Fish and Wildlife Office
2493 Portola Road, Suite B
Ventura, CA 93003

Submitted by:

Pacific Gas and Electric Company
Diablo Canyon Power Plant
Avila Beach, California 93424

August 2012

AERIAL SURVEY PLAN

1.0 INTRODUCTION

Consistent with actions described in the Project Environmental Impact Report (EIR), Marine Wildlife Contingency Plan and Incidental Harassment Assessment, aerial surveys for marine mammals will be conducted prior to the initiation of, during, and after the proposed Central Coastal California Seismic Imaging Project (Project). Particular attention will be directed to recording the presence of larger cetaceans including blue, humpback, and fin whales, and sea otters due to their protected status and higher likelihood of their presence in the Project area during the October to November survey period. Should survey operations occur later in the year, observations will focus on gray whales which migrate through the Project area from mid-December through mid-May.

The methods described below are based on those that have been used in census-type aerial surveys along the west coast of the United States (U.S.) by National Marine Fisheries Service (NMFS), and other resource agencies. Those methods have been modified to be conducive to the collection of the type of data required for this Project and in consideration of prevailing weather, pilot and observer safety, and purpose and objectives of the surveys.

2.0 PURPOSE AND OBJECTIVE

The purpose of the aerial observations is to:

1) collect data on the abundance and distribution of marine mammals in the Project region prior to, during, and after the seismic survey;
2) identify migration/travel direction of and corridors utilized by marine mammals relative to the Project area;
3) identify locations within the survey area that support aggregations of marine mammals; and
4) document observed changes in the behavior and distribution of marine mammals in the area during seismic operations.

The objective of the observations is to provide data that can be used to assist in the planning of the geophysical survey operations to avoid concentrations of marine mammals whenever possible. The data will also be used to evaluate whether any detectable changes in numbers and distribution may have occurred as a result of the seismic operations

3.0 METHODOLOGY

The following details the specific components of the proposed aerial surveys.

3.1 SURVEY AREAS

The survey areas are shown in Figures 3-1 and 3-2. The areas encompass unrestricted airspaces within the offshore area from just south of Cambria to Pt. Sal (approximately 67 kilometers [km] [42 statute miles {mi}]), and will, in accordance with the project EIR, extend up to 13.8 km (8.6 mi) offshore (west) of the westernmost survey lines. The total proposed survey area is approximately 393 square kilometers (km^2) (152 square statute miles [mi^2]), some of which will be surveyed during both periods.

3.2 TIMING AND NUMBER OF FLIGHTS

As specified in the project EIR, one aerial survey will be completed 7 days prior to the initiation of seismic survey operations within whichever “box” where geophysical data will be collected first. Additional aerial surveys within that box area will be completed weekly during project activities. Similarly, and following the designated period between geophysical data collection within the first and second boxes, weekly aerial surveys will be completed within the second box area. Within 10 days of the completion of the geophysical data collection, an aerial survey of both box areas will be completed.

3.3 AIRCRAFT TYPE AND SPECIFICATIONS

3.3.1 Aircraft Type

Due to the size of the survey area, the need for clear observations, and the amount of overwater flight required, the proposed aircraft is expected to be the Partenavia P68-OBS “Observer”, a high-wing, twin-engine plane (Figure 3-3) or equivalent. The aircraft has two “bubble” observation windows, a glass nose for clear observation, and will be equipped with communication and safety equipment sufficient to support the proposed operations.

3.3.2 Number of Observers

The crew for each flight will include a pilot and at three or four NMFS-approved observers who will have experience in the identification of marine mammals.

3.3.3 Flight Constraint Parameters

Flights will not be started or will be terminated when flight safety (e.g., distance to landing, unsafe weather conditions) and/or observation conditions (e.g., sea state in excess of Beaufort Scale 3, low cloud cover) are sub-optimal.

Transects will be flown in accordance with weather conditions and existing air space restrictions, but will be between 328 to 366 m (1,000 to 1,200 ft) elevation and flight speed is expected to be between 167 to 185 kilometers/hour (km/hr) (90 to100 knots). The surveys will take precautions to avoid local pinniped haul-out areas .

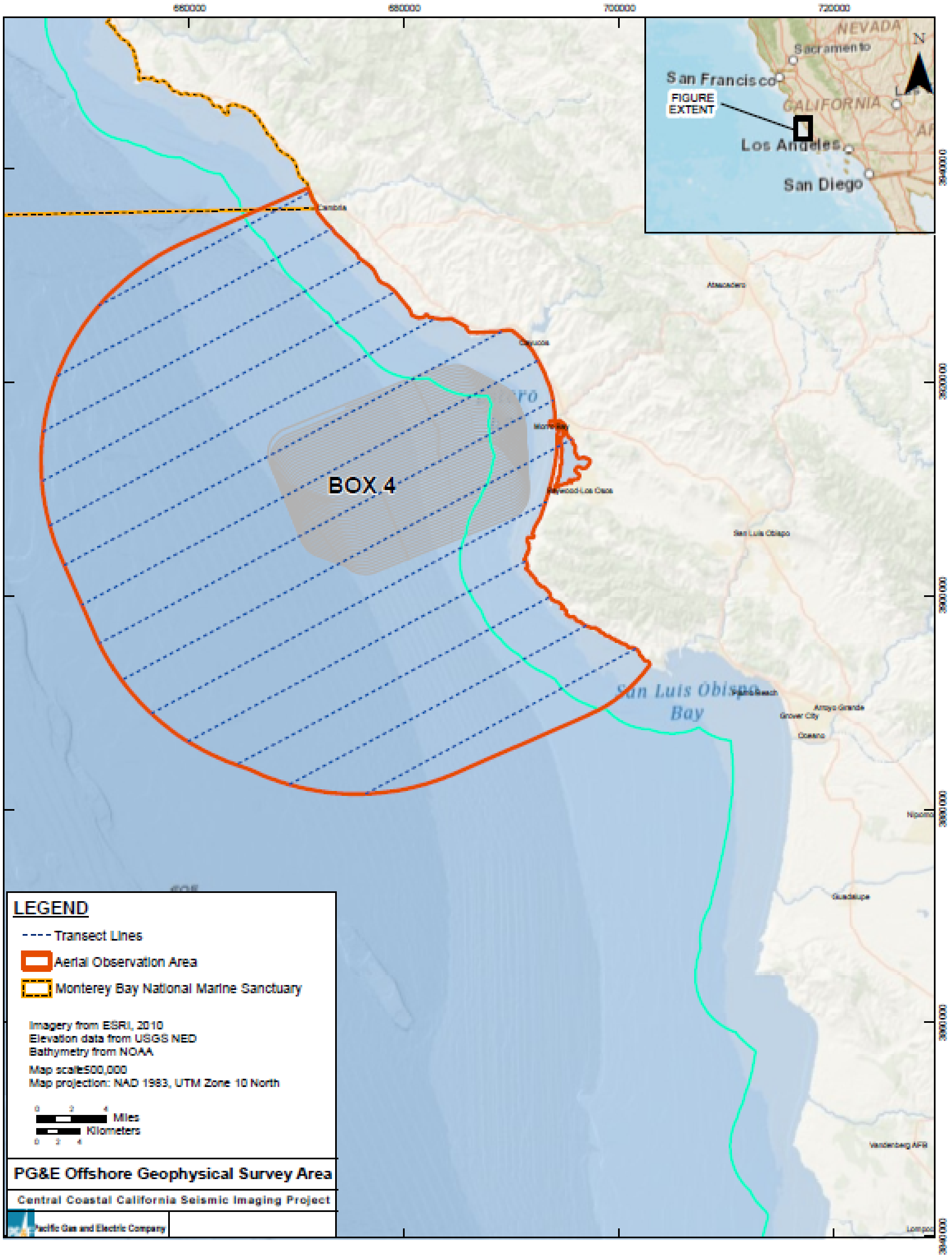

Figure 3-1 Proposed Aerial Survey Area and Transect Lines (Overlaid on the Proposed HESS Survey Area for Box 4)

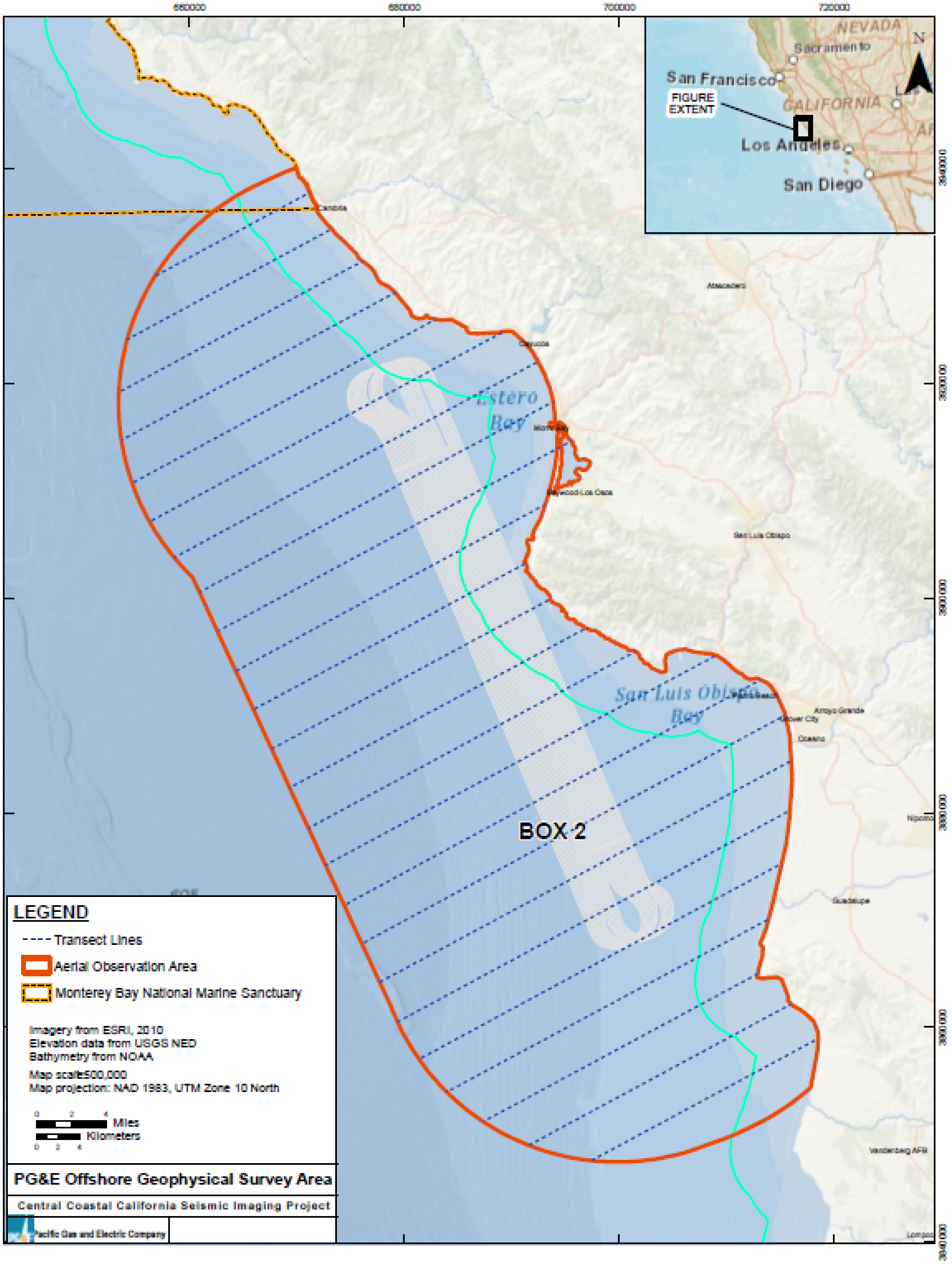

Figure 3-2 Proposed Aerial Survey Area and Transect Lines (Overlaid on the Proposed HESS Survey Area for Box 2)

Figure 3-3 Partenavia P68-OBS "Observer"

3.4 TRANSECTS AND OBSERVATIONS

3.4.1 Transect Length and Spacing

Transects will be flown in the mid-morning to early afternoon timeframe and will be in a southwest-to-northeast direction to minimize glare (Figures 3-1 and 3-2). Each transect will vary in length, ranging from approximately 15.0 km (9.3 mi) to 45.0 km (27.9 mi) long; parallel transects will be spaced approximately every 4.0 km (2.5 mi) to assure full coverage of the sampling area. Transect spacing is based on the observer "footprint" of approximately 4.0 km (2.5 mi) wide (2.0 km [1.2 mi] on each side of the plane). The actual width of transect will be based on weather conditions and safety considerations, however at the proposed 328 m (1,000 ft) altitude will be sufficient to detect aggregations of marine mammals. If approved by the appropriate agencies, aerial surveys could be at a lower altitude.

Transects will be flown in a "closing mode." For example, once a marine mammal or aggregation is observed along a transect, the location will be recorded, and the pilot will leave the transect to circle the animal(s) to obtain a positive identification and to collect other relevant data. Once the data have been recorded, the pilot will return to the transect alignment and continue until the next sighting or transect turn.

3.4.2 Flight Data

For each flight, the start and finish times, and total transect distance will be recorded. Environmental conditions (e.g., temperature, sea state, cloud cover, water color, etc.) will be recorded at the start and finish of each flight, and when substantial changes in a condition are observed during the flight.

3.4.2.1 Transect Data

Observations that will be recorded along each transect using onboard electronic equipment and pre-printed data sheets and will include: the start and end times, total distance, geographic coordinates of a transect start and end points, and environmental data. The location of observed water-related activities or features such as surface plankton swarms (water color change), seabird aggregations, fish schools, other marine wildlife, oceanographic fronts, fishing vessels, marine debris, oil spills, and shipping will also be recorded.

3.4.2.2 Marine Mammal Sighting Data

Upon sighting a marine mammal or aggregation, the time and date, environmental conditions, location of sighting, species (if possible), number of individuals (by species), direction of travel, behaviors (e.g., feeding, surfacing, traveling, etc.), presence of prey (krill, fish, birds, etc.), oceanographic fronts, and any other relevant environmental data will be recorded.

For aerial surveys conducted during seismic operations, observations will be communicated via radio to the Protected Species Observers (PSO) onboard the geophysical survey vessel.

4.0 FLIGHT DATA ANALYSIS AND REPORTING

4.1 Pre-Geophysical Survey Aerial Data Analysis

Data specific to mysticete will be assessed prior to initiating seismic survey activities. Animal density data collected during the aerial survey will be compared to that provided in the EIR (Table 4-1).

Table 4-1. Mysticete Density Thresholds

ESA-Listed Mysticete Species	Density Threshold Predicted to Result in High Magnitude Intensity Rating (per km^2)[a]	Number of Animals within Estimated Aerial Survey Area [b]	
		Box 2 Area (4,038 km^2)	Box 4 Area (1,970 km^2)
Fin whale *Balaenoptera physalus*	0.0073	30	14
Blue whale *Balaenoptera musculus*	0.0063	25	12
Humpback whale *Megaptera novaeangliae*	0.0053	21	10

Source: Modified from California State Lands Commission (2012)

[a] Densities correspond to 2.5 percent threshold for probabilistic Level B noise disturbance over duration of Project.

[b] Survey area based on 14-kilometer (8.6 mile) buffer of the 160 dB ensonified area.

If the density of these taxa observed during the aerial survey is greater than the values noted in Table 4-1, then a consultation will be initiated with CSLC and NMFS to discuss potential strategies to avoid conducting seismic surveys in areas with higher concentrations of those species.

Pre-survey findings will be reported to the CSLC at least two days prior to beginning seismic survey operations.

4.2 Weekly Aerial Survey Data Analysis

Upon completion of each flight, the location of individual marine mammals and/or aggregations will be plotted using a GIS database. The results of the during-geophysical survey aerial observations will be provided to the survey crew via radio during and immediately following each survey and will be used to develop an approach for the upcoming segments of the seismic survey to reduce potential impacts to marine mammals.

A more detailed post-flight technical memorandum that lists the location, water depth, distance from shore, and observed direction of travel of animals will be prepared. That memo will also include information on the estimated number of marine mammals and document the estimated time for those animals to approach the Safety Zone. Those estimates will be compared with the IHA predicted Level B take numbers.

4.3 Post-Geophysical Survey Aerial Data Analysis

Within 10 days of the completion of the offshore seismic survey operations, an aerial survey will be conducted to document the number and distribution of marine mammals in the Project area. These data will be compared with pre- and during survey data, and the postsurvey results and data analysis will be included in the Marine Mammal Summary Report which will be provided to NMFS, CSLC, USFWS, and PG&E.

5.0 REFERENCES

California State Lands Commission, 2012. Draft Environmental Impact Report, Central Coastal California Seismic Imaging Project. SCH No. 2011061085. CSLC EIR No. 758. March 2012.