BIOLOGICAL ASSESSMENT

BETA UNIT GEOPHYSICAL SURVEY
OFFSHORE HUNTINGTON BEACH, CALIFORNIA

Project No. 1602-1681

Prepared for:

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1.0 EXECUTIVE SUMMARY

The purpose of the Biological Assessment (BA) is to review the proposed Beta Unit Geophysical Survey (Survey) in sufficient detail to determine to what extent the proposed action may affect any Federally threatened, endangered or proposed species described in this document. This BA is prepared in accordance with legal requirements set forth under Section 7 of the Federal Endangered Species Act (FESA, 16 U.S.C. 1536(c)), and follows the standard established by the National Environmental Policy Act (NEPA) and ESA guidance.

The species considered in this document were based on information obtained from National Marine Fisheries Service (NMFS), and the U.S. Fish and Wildlife Service (USFWS) protected species list for the Project area. The listed and proposed species are detailed in Table 3.0-1. Critical habitat has been designated for five of the listed species. Minimization and avoidance measures will be initiated to ensure minimal impacts on marine species.

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2.0 PROJECT DESCRIPTION

Beta Operating Company (Beta) proposes to conduct a geophysical survey of the Beta Unit located within Federal outer continental shelf (OCS) waters approximately eight miles (12.9 kilometers [km]) offshore Huntington Beach, California (Figure 2.1-1). The proposed Project is intended to provide subsurface imaging of the oil productive formations which lie 3,000 to 5,000 feet (ft) (914 to 1,524 meters [m]) below the seafloor within the Beta Unit field. The enhanced imaging of the subsurface geology will enable more efficient recovery of the remaining natural resources within the field. The survey will be used to map the subsurface geology to locate remaining resources thereby reducing the number of wells required to recover the resource.

2.1 LOCATION

The geophysical survey area is located approximately eight miles (12.9 km) offshore Long Beach, California. The size of the survey area is approximately 18.885 square miles (48.91 sq.km.) in a North Northwest (NNW) to South Southeast (SSE) direction (Figure 2.1-2). Coordinates of the offshore survey area are provided in Table 2.1-1. Water depths in the survey area range from 148 to 1,083 ft (45 to 330 m).

Table 2.1-1. Coordinates of Offshore Survey Area

Corner of Survey Area	Coordinates	
	Latitude	Longitude
Southwest	33°32'13.74"N	118°6'43.91"W
Northeast	33°36’5.55"N	118°9’13.97"W
Northwest	33°36’4.76"N	118°7”11.44"W
Southeast	33°33’0.15"N	118°5’10.89"W

2.2 PROPOSED ACTION

The proposed scope of work offshore will require operating a node deployment/recovery vessel, geophysical survey vessel, support/monitoring vessels; as well as transit of the vessels between the survey area and nearby harbors (Port of Los Angeles [POLA] / Port of Long Beach [POLB]). The geophysical survey vessel will tow one source array consisting of three sub-arrays along the pre-determined transects shown in Figure 2.1-2 to acquire geophysical reflection data from the subsurface rock beds within the survey area.

2.2.1 Project Vessel Configuration and Mobilization

The proposed node deployment/recovery vessel is the Marine Vessel (M/V) Clean Ocean. The M/V Clean Ocean is based out of the POLA/POLB and is an offshore supply vessel that will be configured to support node storage, deployment, and retrieval. It is expected that the M/V Clean Ocean will be available to support the 2018 survey activities, however if the M/V Clean Ocean is unavailable; an equivalent vessel will be secured.

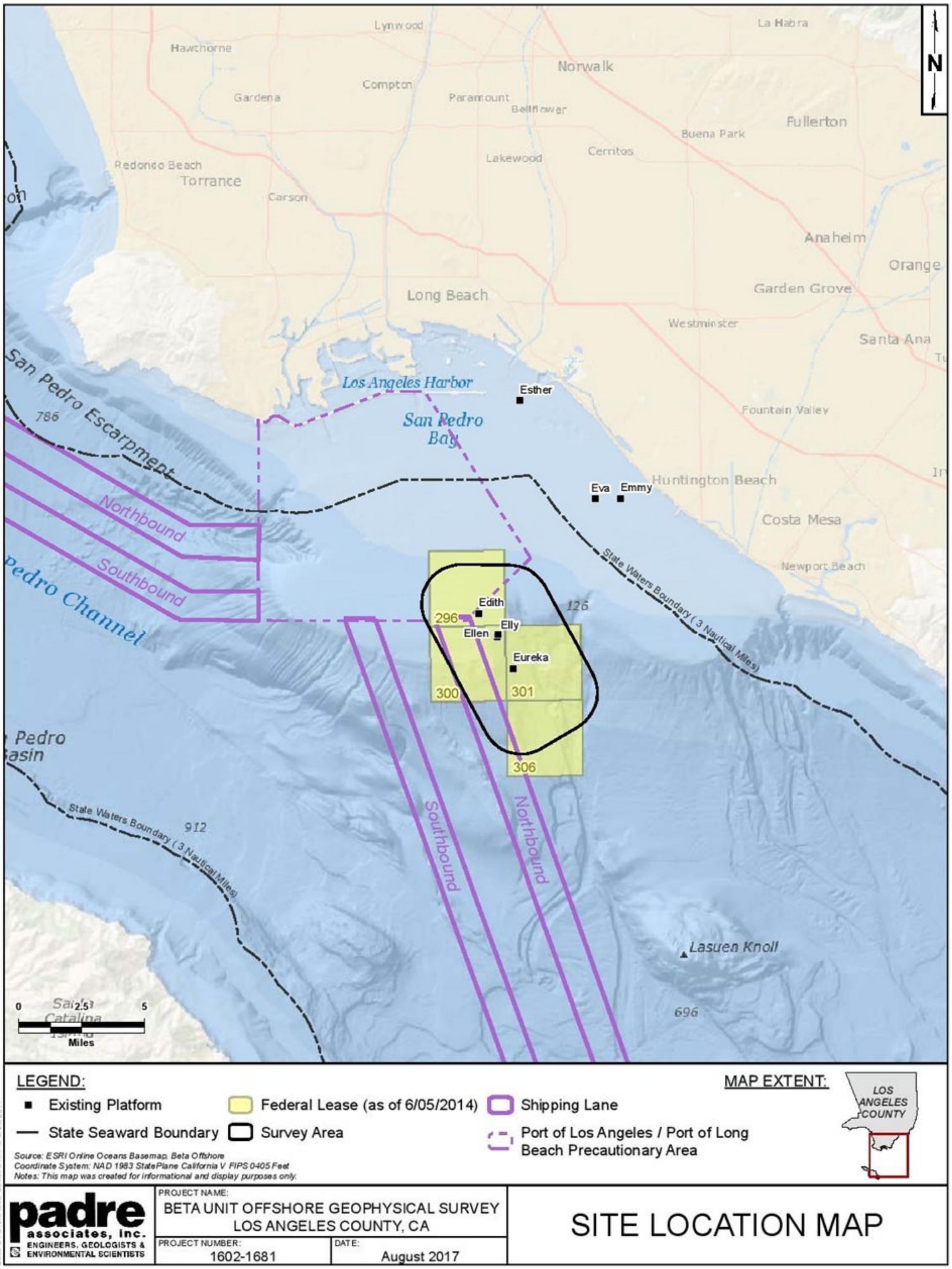

Figure 2.1-1. Project Site Location

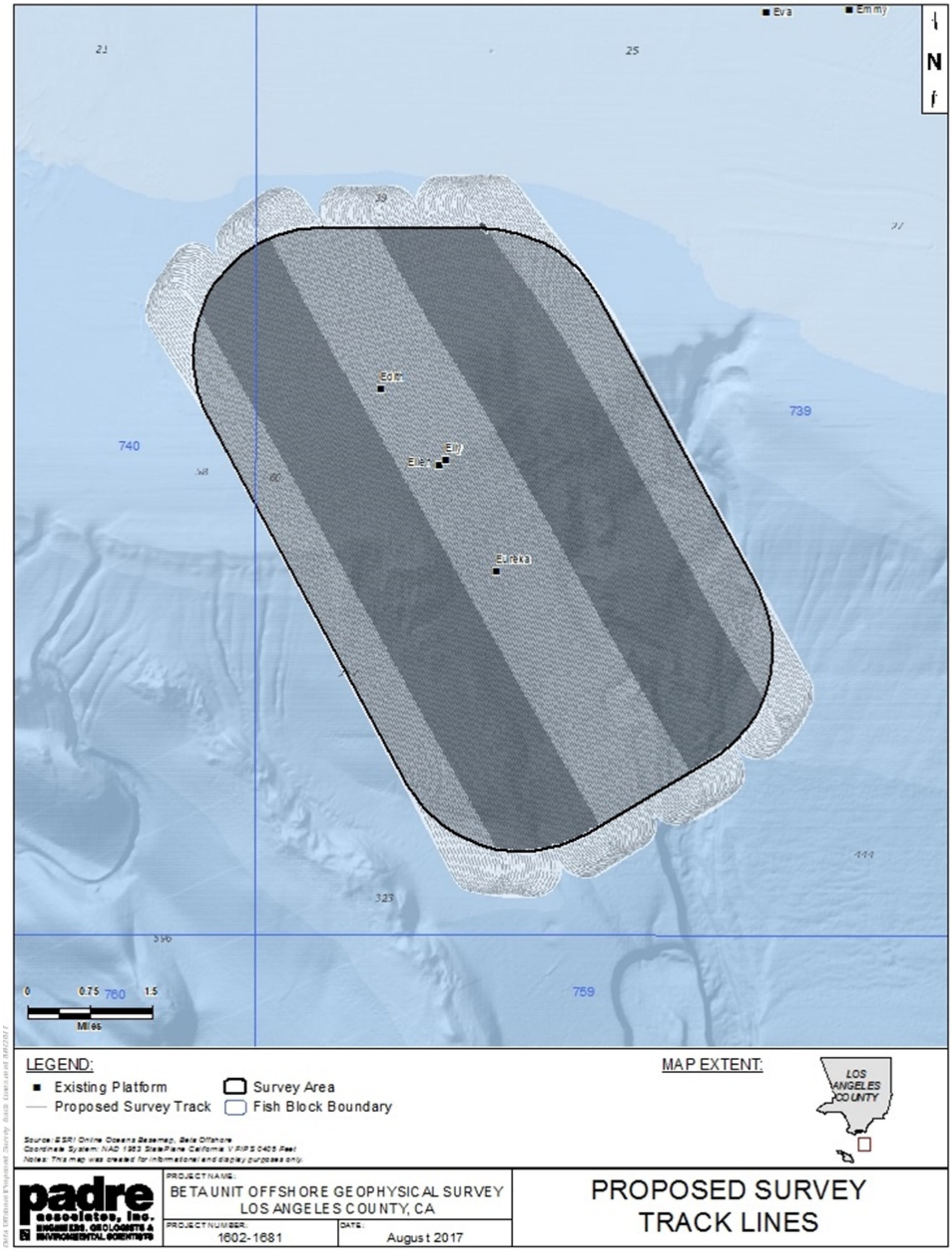

Figure 2.1-2. Source Vessel Track Map of Beta Unit Proposed Geophysical Survey Area

The proposed geophysical survey vessel has not been selected at this time; however, either a locally available work vessel utilizing containerized equipment (e.g. M/V Silver Arrow) or specialized geophysical survey vessel (e.g. R/V Marcus G. Langseth) will be used to conduct the survey. The M/V Silver Arrow would function as a containerized commercial vessel outfitted on behalf of the proposed survey activities. The R/V Marcus G. Langseth is a research vessel that is operated by Columbia University's Lamont-Doherty Earth Observatory's Office of Marine Operations (OMO) and can be utilized if available for commercial use. It is expected that one of these vessels would be available to support the 2018 survey activities, however if they are unavailable; an equivalent vessel will be secured. For the purposes of the enclosed analysis, the equipment aboard the M/V Silver Arrow is referenced as a likely case scenario, but an alternative vessel would have similar equipment and equivalent (or better) effects. The M/V Silver Arrow would be mobilized from Seattle, Washington to Southern California POLA/POLB and Beta Unit offshore Project area. Upon completion of the offshore survey operations, the vessel would return to the POLA/POLB to be outfitted for its next work location.

The M/V Jab or equivalent will also provide support during the proposed geophysical survey for operations coordination and vessel preclusion activities. The M/V Jab will also be based out of the POLA/POLB during the proposed Project activities.

2.2.2 Offshore Survey Operations

The following sections outline the general equipment specifications and methodology proposed to complete the offshore geophysical survey. Figure 2.2-1 shows an illustration of the survey technique.

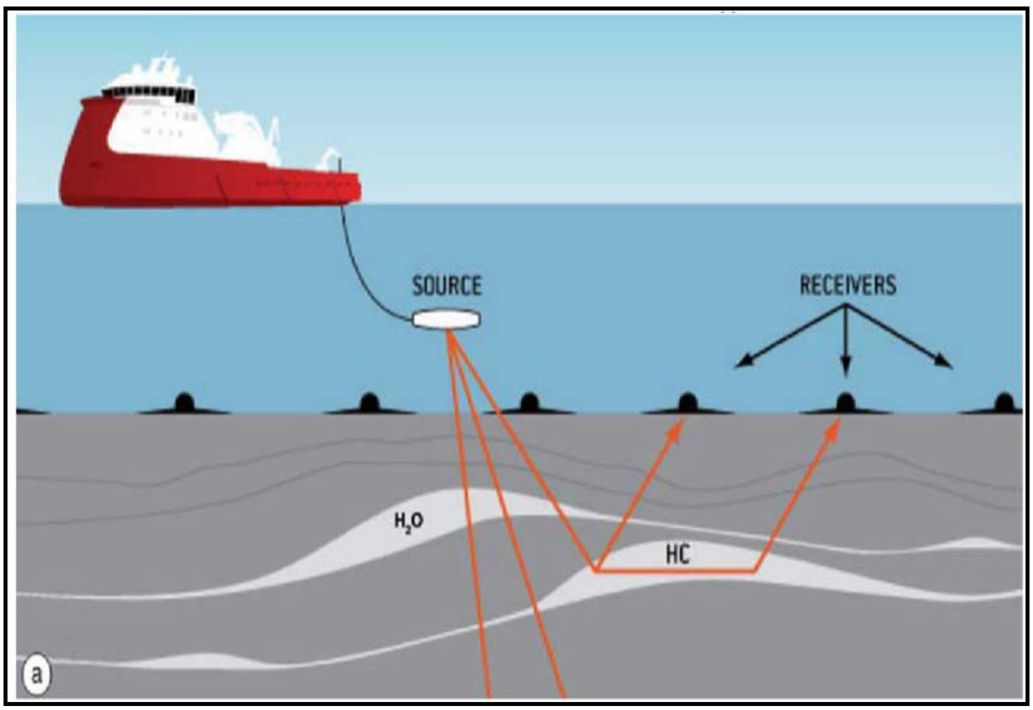

Figure 2.2-1. Illustration of the Nodal Marine Geophysical Subsurface Survey

2.2.2.1 Vessel Specifications

Node Deployment/Retrieval. The M/V Clean Ocean, or similar vessel, will be used to deploy and retrieve the ocean bottom nodes. The M/V Clean Ocean is a dynamically positioned vessel suitable for working near fixed structures and in deep water, where anchoring is not feasible. It has a length of 155 ft (47.24 m), a beam of 36 ft (10.97 m), and a maximum draft of 9.9 ft (3.0 m).

Source Vessel Operations. The M/V Silver Arrow, or similar vessel, will tow the source array along predetermined survey transects. The M/V Silver Arrow is a DP2 ship, has a length of 240 ft (73.2 m), a beam of 54 ft (16.5 m), and a maximum draft of 14.10 ft (4.52 m). The operation speed during geophysical data acquisition is typically 4.5 knots (8.3 kilometers per hour [km/h]). When not towing geophysical survey gear, the M/V Silver Arrow typically cruises at 10.0 knots (18.5 km/h). When the M/V Silver Arrow is towing the source array, the vessel would "fly" the appropriate United States Coast Guard (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 geophysical support vessel M/V Jab has a length of 43 ft (13.10 m), a beam of 15.5 ft (4.72 m) and a draft of 2.0 ft (0.6 m). It has a top speed of 34 knots (63.0 km/h). The M/V Jab will be utilized in support of the geophysical survey including enforcement of the proposed operational Exclusion Zone.

2.2.2.2 Source Description

The proposed geophysical source array is comprised of 3 sub-arrays with a combined volume of 3,480 cubic inches (in^3) (57 liters [l]). An example sub-array is shown in Figure 2.2-2. The sub-arrays would be configured as three identical, linear arrays or "strings" (Figure 2.2-3). Each string will have eleven active sound sources (and one spare) in six clusters. Each of the clusters is approximately 9.18 ft (2.8 m) apart. Each of the three sub-arrays would be towed approximately 328 to 492 ft (100 to 150 m) behind the vessel and separated from each other by approximately 23 ft (seven meters). Depth ropes from source floats would be used to keep the sound source at a depth of 23 ft (seven m). The vessel speed during data collection would range from 4 to 5 knots (7.4 to 9.3 km/h). Depths are monitored by depth sensors mounted on the arrays and horizontal positions are monitored using surface GPS relative to the vessel. The expected timing of the shots is once approximately every seven seconds, and/or approximately every 82.02 ft (25 m) based on an assumed boat speed of 4.5 knots (8.3 km/h).

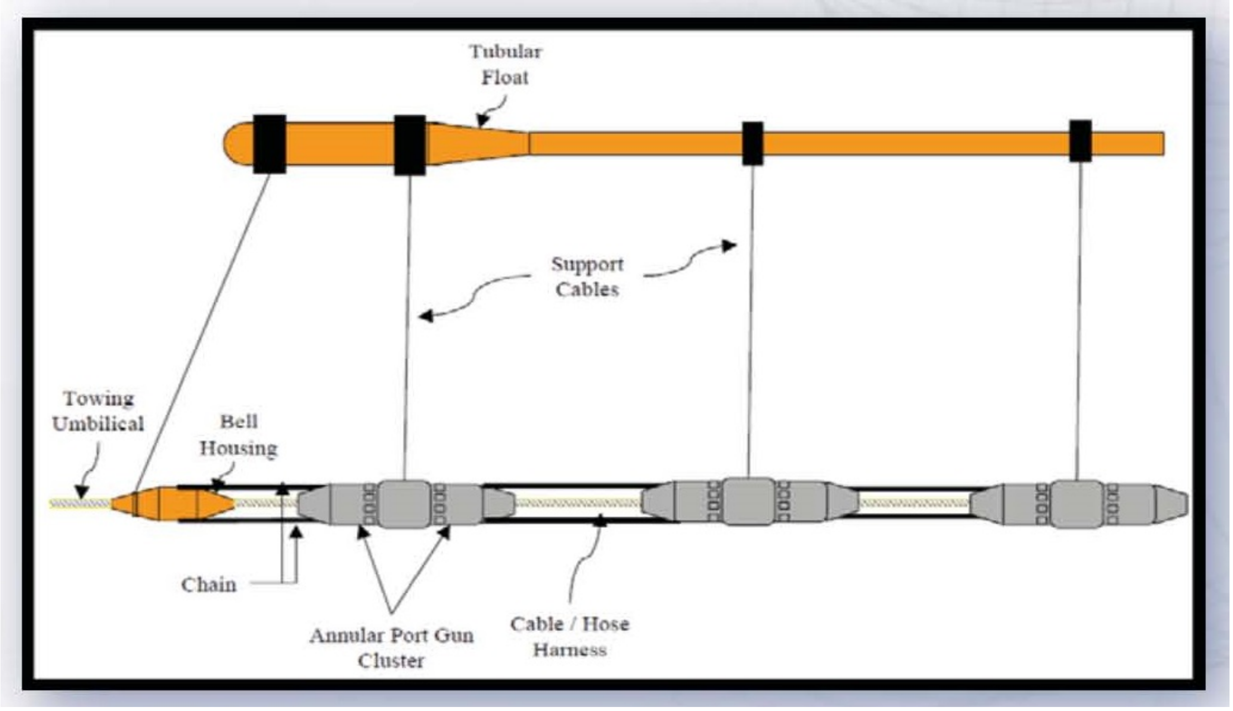

Figure 2.2-2. APG Sub-Array Sound Source (Example)

The discharge pressure of the array is approximately 2,000 pounds per square inch (psi). To reduce potential noise, the sound source will be operated in “distributed or popcorn mode”. During discharge, a brief (~0.1 seconds) pulse of sound is emitted. The sound source would be silent during the intervening periods. Because the actual source is a distributed sound source rather than a single point source, the highest sound levels measurable at any location in the water will be significantly less than the nominal single point source level emitted (as would be the case during other non-related “typical” geophysical surveys). Specifically, rather than activating all sound sources at the same time to generate a sharp source peak, the sound source is initiated independently over a short period of time to generate a firing sequence with reduced peak amplitudes. As only one sound source would be firing at any given time, the effective (perceived) source level for sound propagating would be substantially lower than the nominal source level because of the distributed nature of the sound from the source array. The source array is designed to focus maximum energy downwards rather than in the horizontal directions.

The autonomous nodes are described in Table 2.2-1. There are 20 receiver lines proposed containing approximately 730 nodes total as shown in Figure 2.2-5. The survey was designed to satisfy a maximum offset consistent with the design, which is approximately 410 ft (125 m) so node separation would be no more than 820 ft (250 m). The system is autonomous and would not require electrical cable connection for operation, though nodes are physically tethered together by cable/rope. The nodes are circular and approximately 65 pounds (lbs) (29.5 kilograms [kg]) in air, and are 17.0-inches (in) in diameter by six-inches high (43.2 centimeters [cm] by 15.2 cm) (Figure 2.2-4). Typical node specifications (Example: FairfieldNodal, 2016) are provided in Table 2.2-2.

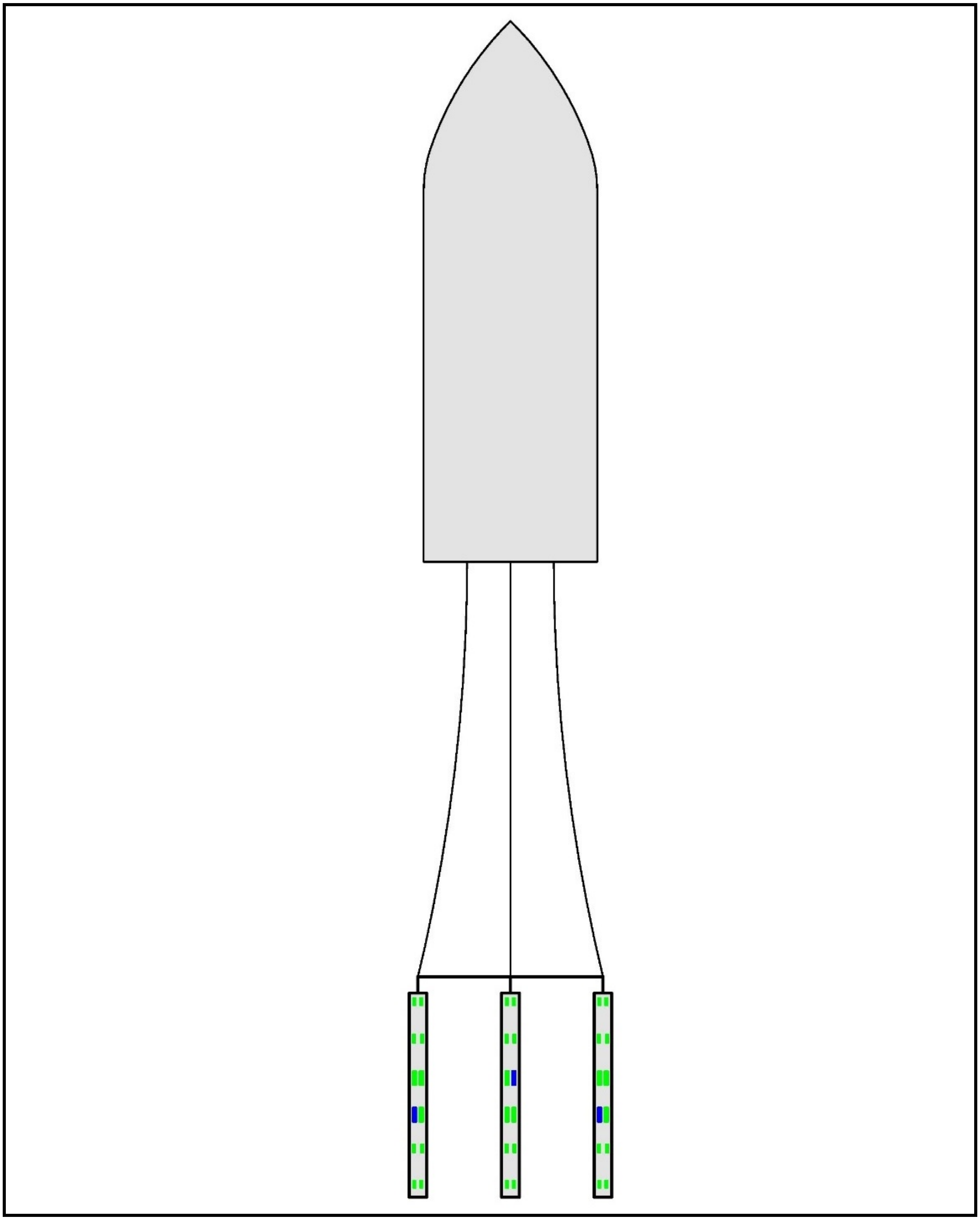

Figure 2.2-3. Source Array Configuration

Table 2.2-1. Node Specifications

Node spacing distance	820 ft (250m)
Receiver line separation	820 ft (250m)
Number of receiver lines	20
Number of nodes total	730
Shot distance	82 ft (25m) inline
Shot line separation	82 ft (25m)
Bin dimension	41 x 41 ft (12.5m x 12.5m)
Azimuth of RL	328.84 deg
Azimuth of SL	53.84 deg
Shots per Sq.km.	1,600
Active nodes per shot	506

Figure 2.2-4. Shallow Water Node (FairfieldNodal, 2016)

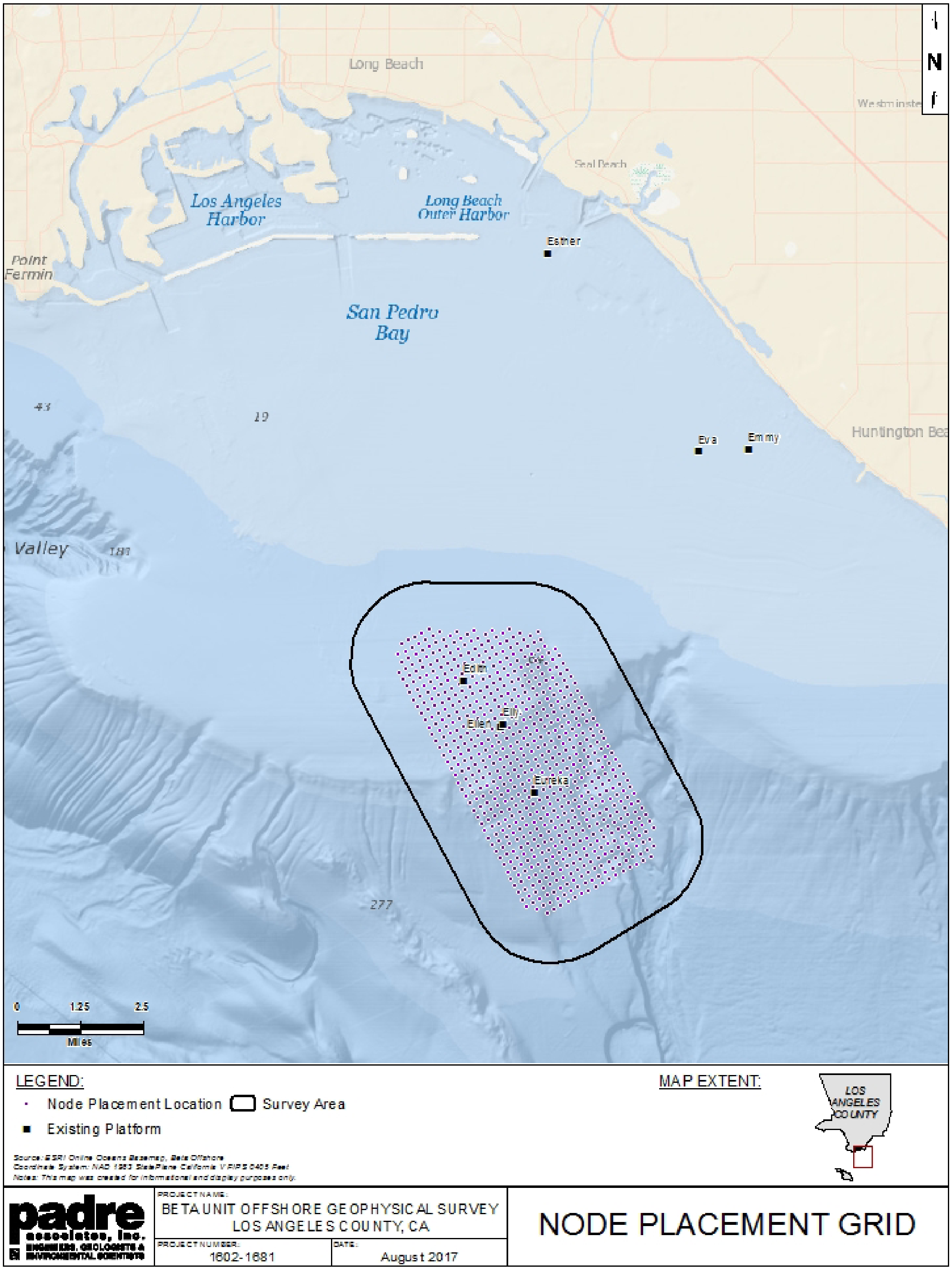

Figure 2.2-5. Anticipated Node Placement Grid

Table 2.2-2. Typical Node Specifications (FairfieldNodal, 2016)

Typical Node Specifications

Seismic Data Channels: 4

ADC Resolution: 24 bits

Sample Interval: 2, 4 milliseconds

Preamplifier Gain

0 dB to 36 dB in 6 dB steps

Anti-Alias Filter

206.5 Hz (82.6% of Nyquist) @ 2 ms, Linear Phase

DC Blocking Filter

1 Hz to 60 Hz, 6 dB/Octave, or OUT

Operating Temperature Range

-10˚C to +60˚C

Operating Life (100% Charge)

Up to 60 days continuous recording

Battery

Charging Temperature Range
+3˚C to +40˚C

Recharge Time: < 8 hours

Acquisition Channel

(2 ms sample interval, 25°C, 31.25 Hz, internal test, unless otherwise indicated)

Total Harmonic Distortion
0.0003% @ 12 dB gain, -3dB Full Scale

Equivalent Input Noise
1.0 μVrms @ 0 dB
0.4 μVrms @ 12 dB
0.3 μVrms @ 24 dB
0.3 μVrms @ 36 dB

Full Scale Input Signal
2500 mV peak @ 0 dB
625 mV peak @ 12 dB
156 mV peak @ 24 dB
39 mV peak @ 36 dB

Gain Accuracy: 0.50%*

Dynamic Range
120 dB @ 0 dB Preamplifier Gain

Crossfeed
<-100 dB Geophone Channels
<-80 dB Hydrophone Channel**

Common Mode Rejection Ratio
>+90 dB Geophone Channels
>+40 dB Hydrophone Channel**

DC Offset
<10% of Input Noise with DC Blocking Filter IN

Timing Accuracy
CSAC clock

Self Test Features

Internal Noise (preamp input terminated)
Internal THD
Internal Gain Accuracy
Internal CMRR
Internal Crossfeed
Internal Impulse
Sensor Impedance

Sensors

Geophone
3 orthogonal, omni directional, 15 Hz @ -3 dB, 70% damped 0.57 V/in/s (22.4 V/m/s)

Hydrophone
3.4 Hz @ -3 dB, 8.9 V/Bar

Orientation
±1.5° tilt indication
±5° azimuth (at Latitudes within ± 50° of the Equator)

Physical

Weight: 65 lb (29.5 kg) in air, 40 lb (18.1 kg) in water

Dimensions: 17 in (43.2 cm) diameter by 6 in (15.2 cm) high

Operating Depth: 700 meters

* Does not include high-impedance low-cut filter for directly coupled hydrophone interface.
** Channel includes high-impedance low-cut filter for directly coupled hydrophone interface.

All specifications relate to Node Part Number 221.6862.0003 only.
FairfieldNodal reserves the right to change specifications without notice to provide the best possible product.

Drawing Number 601.0002.0003 Rev. –
Z700 Node (Version 3) Specifications Sheet

August 2016

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The nodes will be loaded onto the deployment vessel, the M/V *Clean Ocean*, with the onboard crane at the POLA/POLB. The M/V *Clean Ocean* will then travel to the offshore Project site and deploy the nodes at their designated locations. The nodes will be connected to each other by a line no greater than 0.65 in (1.6 cm) in diameter in accordance with National Marine Fisheries Service (NMFS) recommended protocol and manufacturer specifications. Installation of the nodes will be completed when sea state and weather conditions are conducive to safe operations and will be via "live-boat" (no anchoring is proposed), deployment being from the stern of the vessel while moving over the proposed locations at approximately 2 to 4 knots (3.7

to 7.4 km/h). Installation of the nodes is anticipated to take approximately seven operational days (one week).

After the nodes have been placed on the seafloor, recording will be conducted for the duration of the Project. At the end of the survey, the M/V Clean Ocean will retrieve each line of temporary nodes. Retrieval of the nodes following survey activities is also anticipated to take approximately seven operational days (one week).

2.3 PROJECT SCHEDULE

The proposed activities, including mobilization and demobilization, are expected to take approximately 42 operational days (6 weeks) to complete. Deployment of the nodes is expected to take approximately 14 days (2 weeks), and acquisition, shooting aerially, would take approximately 28 days. This estimate includes time for instrument deployment, profiling, instrument recovery, and demobilization. The survey is targeted for September 2018, following completion of all required environmental reviews and permitting. The September-November time window is the annually lowest population of marine mammals in the survey vicinity.

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3.0 SPECIES ACCOUNTS AND STATUS OF THE SPECIES IN THE ACTION AREA

Based on the species lists provided by the USFWS and NMFS (USFWS, 2017a; and NMFS, 2017a), an analysis of the range and habitat preferences was conducted. The descriptions in this section are confined to those listed species that have a potential to occur in the Project area (Tables 3.0-1). Certain species were eliminated from these analyses due to the absence of the preferred habitat within the Project site. Other species were eliminated from consideration because the Project site was beyond the recorded geographic range for the species.

Table 3.0-1. Special Status and Protected Species Within or Near the Project Area and Their Likelihood of Occurrence within the Project Area

Common Name	Scientific Name	Status[1]	Likelihood to occur
INVERTEBRATES			
White abalone	*Haliotis sorenseni*	FE	Unlikely to Occur
FISH			
Steelhead (southern CA ESU)	*Oncorhynchus mykiss*	FE	Possible
TURTLES			
Olive Ridley turtle	*Lepidochelys olivacea*	FT	Possible
Green turtle	*Chelonia mydas*	FT	Possible
Loggerhead turtle	*Caretta caretta*	FT	Possible
Leatherback turtle	*Dermochelys coriacea*	FE	Possible
BIRDS			
California least tern	*Sternula antillarum*	M, FP, FE, SE	Unlikely to Occur
Marbled murrelet	*Brachyramphus marmoratus*	M, FT, SE	Unlikely to Occur
Short-tailed albatross	*Phoebastria albatrus*	M, FE	Unlikely to Occur
MAMMALS			
Cetaceans			
Blue whale	*Balaenoptera musculus*	FE	Possible
Fin whale	*Balaenoptera physalus*	FE	Possible
Humpback whale	*Megaptera novaeangliae*	FE	Possible
Northern right whale	*Eubalaena glacialis*	FE	Unlikely to Occur
Sperm whale	*Physeter macrocephalus*	FE	Unlikely to Occur
Sei whale	*Balaenoptera borealis*	FE	Possible
Pinnipeds			
Guadalupe fur seal	*Arctocephalus townsendi*	FT, ST	Possible

Status[1]
M = Protected under the Federal Migratory Bird Treaty Act (MBTA)
FE = Federally endangered SE = California State endangered FC= Federal Candidate for Listing
FT = Federally threatened ST = California State threatened BCC = USFWS Bird of Conservation Concern
FDL = Federally Delisted

3.1 INVERTEBRATES

3.1.1 White Abalone (*Haliotis sorenseni*)

3.1.1.1 Status

Following the closure of the fishery for this species in 1996, the white abalone was listed as endangered in 2001. Critical habitat has not been designated (NMFS, 2017b).

3.1.1.2 Range and Habitat

NMFS (2008, and 2017b) states that the white abalone is a deep-water mollusk, usually found in water depths from 80 to 100 ft (25 to 30 m), but can be found as deep as 200 ft (60 m) making them the deepest occurring abalone species in California. White abalone are found in open low and high relief rock or boulder habitat that is interspersed with sand channels. Sand channels may be important for the movement and concentration of drift macroalgae and red algae, which white abalone are known to feed (NMFS, 2017b). The historic range of white abalone extended from Point Conception, California to Punta Abreojos, Baja California. In the northern part of the California range, white abalone were reported as being more common along the mainland coast. In the middle portion of the California range, they were noted to occur more frequently at the offshore islands (especially San Clemente and Santa Catalina islands). At the southern end of the range in Baja California, white abalone were reported to occur more commonly along the mainland coast, but were also found at a number of islands including Isla Cedros and Isla Natividad (NMFS, 2017b).

3.1.1.3 Natural History

Because the white abalone broadcast spawns, relatively dense aggregations of adults are necessary for successful egg fertilization. Spawning in white abalone occurs in winter months, but sometimes extends into the spring. Eggs hatch within one day of fertilization, and after 1 o 2 weeks the free-swimming larvae settle to the seafloor (Cox, 1960). White abalone grow to approximately 25 centimeters (cm) (10 inches [in]), but are usually 12 to 21.5 cm (5 to 8 in) in diameter (NMFS, 2016a). Like all abalone, white abalone are herbivorous with the young feeding on diatoms and filamentous algae on the surface of the rock substrate. Adults depend on drift algae, especially deteriorating kelp. *Laminaria* spp. and *Macrocystis* spp. (brown algae) are believed to make up a large portion of the diet. The reddish-brown color of the shell indicates that white abalone also consume species of red algae throughout their life (NMFS, 2016a).

3.1.1.4 Population Trends

No definitive population data is known; however, current studies suggest that the current population ranges from approximately 1,600 to 2,500 individuals (NMFS, 2016a).

3.2 FISH

3.2.1 Steelhead (*Oncorhynchus mykiss*)

3.2.1.1 Status

The Southern California Steelhead Distinct Population Segments (DPS) was listed as a Federally endangered species on January 5, 2006 and critical habitat was designated on September 2, 2005 (NMFS, 2017b). No critical habitat within the Project area has been identified for this species (NMFS, 2017b).

3.2.1.2 Range and Habitat

The Southern California steelhead DPS encompasses any existing or potential native *O. mykiss* populations in watersheds from the Santa Maria River (just north of Point Conception) south to the Tijuana River at the U.S. Mexico border (NMFS, 2014). Critical habitat was designated for this species in 2005, and a recovery plan was issued in 2014 (NMFS, 2017b). Primary constituent elements of steelhead critical habitat include: 1) freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation, and larval development; 2) freshwater rearing sites with water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; water quality and forage supporting juvenile development; and natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks; 3) freshwater migration corridors free of obstruction with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival; 4) estuarine areas free of obstruction with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater; natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels; and juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation; 5) nearshore marine areas free of obstruction with water quality and quantity conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation; and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels; and, 6) offshore marine areas with water quality conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation. These features are essential for conservation because without them juveniles cannot forage and grow to adulthood.

3.2.1.3 Natural History

Adult steelhead spawn in coastal watersheds and their progeny rear in freshwater or estuarine habitats prior to migrating to the sea. They require cool clear water and gravel where the eggs mature between 3 weeks to 2 months. The alevins (juvenile steelhead) emerge from the gravel 2 to 6 weeks after hatching (NMFS, 2011a,b). Young steelhead remain in fresh water from less than 1 year to up to 3 years. Juveniles migrate to sea usually in spring, but throughout their range steelhead are entering the ocean during every month, where they spend 1 to 4 years before maturing and returning to their natal stream. Only winter steelhead are found in southern and south-central California. Winter steelhead enter their "natal" streams from about November to April and spawning takes place from March to early May. In freshwater, steelhead feed primarily on insects and larvae, while in the ocean their primary food source is "baitfish" such as herring and anchovies.

3.2.1.4 Population Trends

No definitive population data is known; however, according to the most current five-year status review the population has remained unchanged compared to the previous review (NMFS, 2016b).

3.3 MARINE BIRDS

3.3.1 California Least Tern (*Sternula antillarum*)

3.3.1.1 Status

The California least tern was listed as a Federally endangered species in 1970 (USFWS, 2017b). No critical habitat has been designated.

3.3.1.2 Range and Habitat

California least terns live along the coast from San Francisco to northern Baja California and migrate from the southern portion of their range to the north. Least terns begin arriving in southern California as early as March and depart following the fledging of the young in September or October (USFWS, 2017b). In Orange County there are only five breeding colonies of Least Terns: Bolsa Chica Ecological Reserve, Huntington State Beach, Upper Newport Bay, Seal Beach National Wildlife Refuge, and Burris Basin (Sea and Sage Audubon Society, 2017). California least terns forage for small epipelagic fish (anchovy, atherinids, and shiner surfperch) primarily in near shore ocean waters and in shallow estuaries (USFWS, 2017b).

3.3.1.3 Natural History

This species nest in colonies and utilize the upper portions of open beaches or inshore flat sandy areas that are free of vegetation. The typical colony size is 25 pairs. Most least terns begin breeding in their third year, and mating begins in April or May. The nest consists of a simple scrape in the sand or shell fragments and typically there are two eggs in a clutch. Egg incubation and care for the young are accomplished by both parents. Least terns can re-nest up to two times if eggs or chicks are lost early in the breeding season. Least terns dive to capture small fish and require clear water to locate their prey (i.e., anchovies) that is found in the upper water column in the nearshore ocean waters (USFWS, 2017b; Sea and Sage Audubon Society, 2017).

3.3.1.4 Population Trends

The species' population has increased from 600 in 1973 to roughly 7,100 pairs in 2005. The number of California least tern sites has nearly doubled since the time of listing. (USFWS, 2017b).

3.3.2 Marbled Murrelet (*Brachyramphus marmoratus*)

3.3.2.1 Status

The marbled murrelet was listed as a Federally threatened species in 1992. Critical habitat has been designated North of Monterey, but none in the Project area (USFWS, 2017c).

3.3.2.2 Range and Habitat

The marbled murrelet is a small sea bird that spends most of its life in the nearshore marine environment, but nests and roosts inland in low-elevation old growth forests, or other forests with remnant large trees. It is generally confined to the marine fog belt near the coast. Nesting generally occurs in the marine fog belt within 25 mi (40.2 km) of the coast in coast redwood, Douglas fir, western red cedar, western hemlock, and Sitka spruce. The species nests from Washington to central California (Monterey Bay area). This bird is rare in southern California and is only found in the non-breeding season (late fall, winter, and early spring) in Orange County (USFWS, 2017c).

3.3.2.3 Natural History

Nesting season for this species is late March to late September; downy young, and fledged juveniles have been observed June to September. Activity in forest nesting areas is highest from mid-April through late July in California and Oregon, early May through early August in Washington, and mid-May through early August in Alaska. Clutch size is one and incubation lasts about 30 days. Murrrelet's diet includes fishes (sandlance, capelin, herring, etc.), crustaceans (mysids, euphausiids), mollusks (NatureServe Explorer, 2017).

3.3.2.4 Population Trends

No definitive population data is known; however, current studies suggest that the current population exhibits a long-term downward trend (USFWS, 2017c).

3.3.3 Short-tailed Albatross (*Diomedea albatrus*)

3.3.3.1 Status

The Short-tailed albatross was listed as a Federally endangered species in 1970 (USFWS, 2017d). No critical habitat has been designated.

3.3.3.2 Range and Habitat

As of 2008, 80 to 85 percent of the known breeding short-tailed albatross use a single colony, Tsubamezaki, on Torishima Island. The remaining population nests on other islands surrounding Japan. During the non-breeding season, short-tailed albatross range along the Pacific Rim from southern Japan to northern California, primarily along continental shelf margins (USFWS, 2008).

3.3.3.3 Natural History

Nests consist of a divot on the ground lined with sand and vegetation with eggs hatch in late December and January. The diet of this species is not well studied; however, research suggests at sea during the non-breeding season that squid, crustaceans, and fish are important prey (USFWS, 2017d).

3.3.3.4 Population Trends

No definitive population data is known; however, current studies suggest that the current population exhibits a downward trend (USFWS, 2017d).

3.4 TURTLES

3.4.1 Green Turtle (*Chelonia mydas*)

3.4.1.1 Status

The East Pacific DPS was listed as Federally threatened on April 6, 2016. Critical habitat has been designated for the species in Puerto Rico, but none in the Project area (NMFS, 2017c).

3.4.1.2 Range and Habitat

Green turtles generally occur worldwide and generally found in tropical and subtropical waters along continental coasts and islands between 30° North and 30° South. In the eastern North Pacific, green turtles have been sighted from Baja California to southern Alaska, but most commonly occur from San Diego south (NMFS, 2017c). Green turtles are sighted year-round in marine waters off the southern California coast, with the highest concentrations occurring July through September. (NMFS, 2017c).

3.4.1.3 Natural History

Green turtles can weigh 300 to 350 pounds (lbs) (135 to 160 kilograms [kg]) and three feet (one meter) in length. They are herbivorous, feeding primarily on algae and sea grasses (NMFS, 2017c). Nesting season varies depending on location, but in the southeastern U.S., females generally nest in the summer between June and September; peak nesting occurs in June and July. During the nesting season, females nest at approximately two-week intervals, laying an average of five clutches. In Florida, green turtle nests contain an average of 135 eggs, which will incubate for approximately 2 months before hatching. Females will return to their natal beaches to lay eggs every 2 to 4 years. Sexual maturity in green turtles may occur anywhere between 20 and 50 years (NMFS, 2017c). In the U.S., green turtles nest primarily along the central and southeast coast of Florida where an estimated 200-1,100 females nest annually. There are no known nesting sites along the west coast of the U.S., and the only known nesting location in the continental U.S. is on the east coast of Florida.

3.4.1.4 Population Trends

Recent minimum population estimates for green turtles indicate that at least 20,112 individuals are known to occur in the eastern Pacific (NMFS, 2017c).

3.4.2 Loggerhead Turtle (*Caretta caretta*)

3.4.2.1 Status

The loggerhead was first listed as endangered throughout its range on July 28, 1978. In September 2011, NMFS and USFWS listed 9 DPS of loggerhead turtles under the ESA. At that time, the North Pacific loggerhead turtle DPS was Federally listed as an endangered species (NMFS, 2017c). No critical habitat has been designated for the North Pacific DPS (NMFS, 2017c).

3.4.2.2 Range and Habitat

Loggerheads are circumglobal, occurring throughout the temperate and tropical regions of the Atlantic, Pacific, and Indian Oceans. Loggerheads are the most abundant species of sea turtle found in coastal waters (NMFS, 2017c). Loggerhead turtles breed of the coasts of Central and South America, and prefer nesting on beaches that are steeply sloped, high energy, with coarse-grained sands. Southern California is considered to be the northern limit of loggerhead turtle distribution in the eastern Pacific. However, loggerhead turtles have been stranded on beaches as far north as Alaska (NMFS 2017c). Loggerhead turtle abundance in southern California waters is higher in the winter during warm years than cold years. However, during the summer months (July through September), abundance is similar in warm and cold years. In the U.S., nesting occurs only in Florida (NMFS, 2017c).

3.4.2.3 Natural History

Loggerhead turtles weigh on average 250 lbs (113 kg) and are approximately 3 ft (1 m) in length. Their lifespan is unknown, but they reach sexual maturity around 35 years. Loggerhead turtles primarily occur in subtropical to temperate waters and are generally found over the continental shelf (NMFS, 2017c). In the southeastern U.S., mating occurs in late March to early June and females lay eggs between late April and early September. Females can lay 3 to 5 nests during a single nesting season. The eggs incubate approximately 2 months before hatching in late June through mid-November. The only known nesting areas for loggerheads in the North Pacific are found in southern Japan. Loggerhead sea turtles are omnivorous and feed on a wide variety of marine life including shellfish, jellyfish, squid, sea urchins, fish, and algae (NMFS, 2017c).

3.4.2.4 Population Trends

The north Pacific population of nesting females is estimated at 7,138 (NMFS, 2017c).

3.4.3 Leatherback Turtle (*Dermochelys coriacea*)

3.4.3.1 Status

The leatherback turtle was listed as Federally endangered in 1970. NMFS designated critical habitat to provide protection for endangered leatherback sea turtles along the U.S. West Coast in January 2012 (NMFS, 2017c). Critical habitat within California extends to a depth of 80 m (262.5 ft) from the ocean surface and out to the 3,000 m (98,423 ft) isobath between Point Arguello and Point Arena. The Project area is not within designated critical habitat.

3.4.3.2 Range and Habitat

Leatherback turtles are the most common sea turtle off the west coast of the U.S. Leatherback turtles have been sighted as far north as Alaska and as far south as Chile (Dept. of the Navy, 2000; NMFS 2017c) and their extensive latitudinal range is due to their ability to maintain warmer body temperatures in colder waters (NMFS, 2017c). Off the U.S. west coast, leatherback turtles are most abundant from July to September; however, their presence off the U.S. west coast is “two pronged” with sightings occurring in northern California, Oregon, Washington, and southern California, with few sightings occurring along the intermediate (central California) coastline. In southern California waters, leatherback turtles are most common from July through September, and in years when water temperatures are above normal.

3.4.3.3 Natural History

The leatherback turtle can reach 2,000 lbs (900 kg) and get 6.5 ft (2 m) in length. NMFS (2017c) indicates that the leatherback is the largest turtle and the largest living reptile in the world. Their lifespan and age of sexual maturity are both unknown. Leatherback turtles are omnivores, but feed principally on soft prey items such as jellyfish and planktonic chordates (e.g., salps) (NMFS, 2017c). The leatherback turtle lacks a hard shell, and instead has a thick, leathery carapace consisting of connective tissue covering dermal bones. Female leatherbacks lay clutches of approximately 100 eggs on sandy, tropical beaches. Females nest several times during a nesting season, typically at 8 to 12-day intervals. The eggs will incubate for 60-65 days before hatching (NMFS, 2017c).

3.4.3.4 Population Trends

Recent leatherback turtle eastern Pacific population estimates indicate that at least 361 nesting females are known to occur (NMFS, 2007c). This population is believed to be decreasing worldwide (NMFS, 2017c).

3.4.4 Olive Ridley Turtle (*Lepidochelys olivacea*)

3.4.4.1 Status

In 1978, the breeding populations of the olive ridley turtle, on the Pacific coast of Mexico were listed as Federally endangered, while all other populations were listed as Federally threatened. No critical habitat has been designed for the species (NMFS, 2017c).

3.4.4.2 Range and Habitat

This species is considered to be the most common of the marine turtles and is distributed circumglobally (NMFS, 2017c). Within the eastern Pacific Ocean, the normal range of olive ridley turtle is primarily from Southern California to Northern Chile (NMFS, 2017c). The olive ridley is mainly a "pelagic" sea turtle, but has been known to inhabit coastal areas, including bays and estuaries. Ships have observed olive ridleys over 2,400 miles (4,000 km) from shore (NMFS, 2017c). The olive ridley is omnivorous, meaning it feeds on a wide variety of food items, including algae, lobster, crabs, tunicates, mollusks, shrimp, and fish. Olive ridleys dive to depths of about 500 feet (150 m) to forage on benthic invertebrates (NMFS, 2017c).

3.4.4.3 Natural History

Olive ridley turtles weigh on average 100 lbs (45 kg) and are 22 to 31 in (55 to 80 cm) in length. Their lifespan is unknown, but they reach sexual maturity around 15 years. According to NMFS website (2017c). The olive ridley turtle has one of the most extraordinary nesting habits in the natural world, large groups of turtles gather offshore of nesting beaches. Then vast numbers of turtles come ashore and nest in what is known as an "arribada" during which hundreds to thousands of females come ashore to lay their eggs. At many nesting beaches, the nesting density is so high that previously laid egg clutches are dug up by other females excavating the nest to lay their own eggs. Major nesting beaches are located on the Pacific coasts of Mexico and Costa Rica (NMFS, 2017c).

3.4.4.4 Population Trends

The eastern Pacific population is estimated at 1.1 million, which is consistent with the dramatic increases of olive ridley nesting populations that have been reported (NMFS, 2017c).

3.5 MARINE MAMMALS (MYSTICETI)

3.5.1 Blue Whale (*Balaenoptera musculus*)

3.5.1.1 Status

The blue whale was listed as Federally endangered throughout its range in 1970 under the Endangered Species Conservation Act (Act) of 1969 prior to the passage of the endangered Species Act in 1973. No critical habitat has been designated (NMFS, 2017d).

3.5.1.2 Range and Habitat

Blue whales are distributed worldwide in circumpolar and temperate waters, and although they are found in coastal waters, they are thought to occur generally offshore compared to other baleen whales (Allen *et al*, 2011). Like most baleen whales, they migrate between warmer water breeding and calving areas in winter and high-latitude feeding grounds in the summer. Feeding grounds have been identified in coastal upwelling zones off the coast of California primarily within two patches near the Gulf of the Farallones and at the western part of the Channel Islands (Allen *et al*, 2011). They migrate seasonally between summer and winter, but some evidence suggests that individuals remain in certain areas year-round. Off of California, sightings are made seasonally between June and December in the Southern California Bight (Allen *et al,* 2011).

3.5.1.3 Natural History

Blue whales on average are 75 to 80 ft (21 to 24 m) in length and weigh 100 to 150 tons (90,000 to 136,000 kg) making it the largest animal on Earth (Allen *et al*, 2011). Blue whales have no known social structure, and can be seen traveling alone or in groups of 19 to 80 individuals. Most reproductive activity, including births and mating, takes place during the winter in southern warm waters (NMFS, 2017d). Blue whales feed primarily on euphausid shrimp (krill). In the North Pacific, blue whales prey mainly on *Euphausia pacifica* and secondarily on *Thysanoëssa spinifera*. While other prey species, including fish and copepods, have been mentioned in the scientific literature, these are not likely to contribute significantly to the diet of blue whales (NMFS, 2017d).

3.5.1.4 Population Trends

The most recent estimates of the blue whale indicate that at a minimum of 1,551 individuals are known to occur off the west coast (NMFS, 2017e).

3.5.2 Fin Whale (*Balaenoptera physalus*)

3.5.2.1 Status

The fin whale was listed as a Federally endangered species in 1973, but no critical habitat has been identified for this species to date (NMFS, 2017e).

3.5.2.2 Range and Habitat

Fin whales are found in deep, offshore waters of all major oceans, primarily in temperate to polar latitudes, and less commonly in the tropics. Aggregations of fin whales are found year-round off southern and central California (NMFS, 2017d). Fin whales are migratory, moving seasonally into and out of high-latitude feeding areas, but the overall migration pattern is complex, and specific routes have not been documented (NMFS, 2017d). They are mostly commonly seen feeding over the continental shelf in areas of high productivity. Peak abundances of fin whales in the Southern California Bight (SCB) occur after periods of maximum upwelling, in summer and fall (Allen *et. al*., 2011).

3.5.2.3 Natural History

Fin whales are on average 59 ft (18 m) in length and weigh 50-70 tons (45,000 to 64,000 kg) (Allen *et.* al., 2011). Little is known about the social and mating systems of fin whales. Males become sexually mature at 6-10 years of age; and females at 7-12 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 feed on euphasid shrimp, copepods, and small fish. Fin whales are usually found in groups of 2-7 whales and are considered fast swimmers (NMFS, 2017d).

3.5.2.4 Population Trends

The most recent estimates of the fin whale population indicate that at least 2,598 individuals are known to occur off California, Oregon, and Washington (NMFS, 2017e).

3.5.3 Humpback Whale (*Megaptera novaeangliae*)

3.5.3.1 Status

The humpback whale was listed as Federally endangered in 1970 (NMFS, 2017d). In September 2016, NMFS revised the ESA listing for the humpback whale to identify 14 DPS, list one as threatened, four as endangered, and identify nine others as not warranted for listing. The humpback whale Central America DPS is listed as Federally endangered and the Mexico DPS is listed as a Federally threatened population, both DPS feed offshore of California (NMFS, 2017d). No critical habitat has been designated.

3.5.3.2 Range and Habitat

Humpback whales are distributed worldwide and travel great distance during their seasonal migration, the farthest migration of any animal (NMFS, 2017d). Humpback whales spend the winter and spring months offshore of Central America and Mexico for breeding and calving, and then migrate to their summer and fall range between California and southern British Columbia to feed (Allen *et al*., 2011). Although humpback whales typically travel over deep, oceanic waters during migration, their feeding and breeding habitats are in shallow, coastal waters over continental shelves. Cold and productive coastal waters characterize feeding grounds (NMFS, 2017d). In the North Pacific, the California/Oregon/Washington stock winters in coastal Central America and Mexico, and migrates to areas ranging from the coast of California to southern British Columbia in summer/fall (NMFS, 2017d).

3.5.3.3 Natural History

Humpback whales are on average 42 ft (13 m) in length and weigh 25-40 tons (22,000-36,000 kg). Humpback whales are well known for their long pectoral fins, which can be up to 15 ft (4.6 m) long. These extensive fins give them increased maneuverability and they can be used to slow down or even go backwards. During the summer months, humpbacks spend the majority of their time feeding and building up fat stores (blubber) that they will live off of during the winter. Humpbacks filter feed on tiny crustaceans (mostly krill), plankton, and small fish and can consume up to 3,000 pounds (1,360 kg) of food per day (NMFS, 2017d). They will annually alternate between feeding grounds in the North Pacific near Washington and Alaska, down to their breeding grounds in Baja or Hawaii. They are also well known for their complex songs, which are only sung by the males of the species (Allen *et al*, 2011).

3.5.3.4 Population Trends

The most recent population estimates of humpback whales indicate that at least 1,876 individuals occur off California, Oregon, and Washington (NMFS, 2017e). This population appears to be increasing (NMFS, 2017e).

3.5.4 North Pacific Right Whale (*Eubalaena japonica*)

3.5.4.1 Status

The northern Pacific right whale was listed as Federally endangered in 2008. In April 2008, NMFS designate critical habitat in the Gulf of Alaska and within the Bering Sea (NMFS, 2017d). The Project area is not within designated critical habitat.

3.5.4.2 Range and Habitat

Northern right whales inhabit the Pacific Ocean, particularly between 20 and 60 degrees N latitude. They primarily occur in coastal or shelf waters, although movements over deep waters are known. For much of the year, their distribution is strongly correlated to the distribution of their prey. During winter, right whales occur in lower latitudes and coastal waters where calving takes place. However, the whereabouts of much of the population during winter remains unknown. Right whales migrate to higher latitudes during spring and summer (NMFS, 2017d). Few sightings of right whales occur in the central North Pacific and Bering Sea. Sightings have been reported as far south as central Baja California in the eastern North Pacific, as far south as Hawaii in the central North Pacific, and as far north as the sub-Arctic waters of the Bering Sea and sea of Okhotsk in the summer. (NMFS, 2017d).

3.5.4.3 Natural History

North Pacific right whales weigh up to 70 tons (63,500 kg) and can be 45 to 55 ft (13.7 to 16.7 m) in length (NMFS, 2017d). They are slow swimmers, reaching top speeds of 8 kilometers per hour (5 miles per hour), and spend a lot of time on the surface; These characteristics may contribute to their high incidence in ship strikes (Allen *et al*, 2011). Females give birth to their first calf at an average age of 9-10 years. Gestation lasts approximately 1 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, 2017d).

3.5.4.4 Population Trends

Photographic recapture rate population estimates for this species remain low, with only 23 individuals being photographed (NMFS, 2017e). No long-term population trends have been determined at this time (NMFS, 2017e).

3.5.5 Sei Whale (*Balaenoptera borealis*)

3.5.5.1 Status

The sei whale was listed as an endangered species in 1973. No critical habitat has been designated for the species (NMFS, 2017d).

3.5.5.2 Range and Habitat

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 a*l., 2011). Sei whales are associated with areas of strong upwelling and mixing, where copepod densities would be high. Sei whales are most common offshore southern California from May through October, peaking in July (Allen, 2011).

3.5.5.3 Natural History

Sei whales are up to 40 to 60 ft (12 to 18 m) in length and can weigh up to 100,000 lbs (45,000 kg). Sei whales are among the fastest of all the rorqual whales, reaching speeds of 35 miles per hour (mph) (56 kilometer per hour [km/h]). 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; NMFS, 2017d). Sei whales tend to avoid ships, and therefore are rarely sighted (Allen *et. al*., 2011).

3.5.5.4 Population Trends

The most recent estimates of the sei whale northern Pacific stock population indicate that at least 83 individuals are known to occur off California, Oregon, and Washington (NMFS, 2017e).

3.6 MARINE MAMMALS (*ODONTECETI*)

3.6.1 Sperm Whale (*Physeter macrocephalus*)

3.6.1.1 Status

The sperm whale was listed as a Federally endangered species in 1970 under the endangered Species Conservation Act of 1969. No critical habitat has been designated (2017d).

3.6.1.2 Range and Habitat

Sperm whales tend to inhabit areas with a water depth of 1968 ft (600 m) or more, and are uncommon in waters less than 984 ft (300 m) deep. Female sperm whales are generally found in deep waters (at least 3280 ft [1,000 m]) of low latitudes (less than 40°, except in the North Pacific where they are found as high as 50°). These conditions generally correspond to sea surface temperatures greater than 15°C, and while female sperm whales are sometimes seen near oceanic islands, they are typically far from land. 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 (Allen *et al*., 2011, NMFS, 2017c).

3.6.1.3 Natural History

Sperm whales are on average 36 to 53 ft (11 to 16 m) in length and weigh 50 tons (45,000 kg). Female sperm whales reach sexual maturity around 9 years of age when they are roughly 29 ft (9 m) long. One calf is produced every 5 years after a 14 to 16-month gestation period. Males reach physical maturity around 50 years and when they are 52 ft (16m) long. Sperm whales are the deepest divers of any marine mammals reaching depths of 1.2 mi (2 km) remaining under water for around one hour (Allen *et. al*., 2011). There are no known mating or birthing grounds, but both more than likely occur in lower latitudes between April and August (Allen *et. al*., 2011). Sperm whales feed on squid, octopus, and fish (NMFS, 2017c).

3.6.1.4 Population Trends

The most recent estimates indicate that at least 1,332 individuals are known to occur off California, Oregon, and Washington (NMFS, 2017e). No long-term population trends have been determined at this time (NMFS, 2017e).

3.7 MARINE MAMMALS (PINNIPEDS)

3.7.1 Guadalupe Fur Seal (*Arctocephalus townsendi*)

3.7.1.1 Status

The Guadalupe fur seal was listed as a Federally threatened species in 1985 due to the near extinction by commercial seal hunting in the 19th century. No critical habitat has been designated.

3.7.1.2 Range and Habitat

The Guadalupe fur seal range is from Guadalupe Island, Mexico 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. During breeding season, they are found in coastal rocky habitats and caves. Little is known about their whereabouts during the non-breeding season (NMFS, 2017c). Presently, the species breed 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).

3.7.1.3 Natural History

Guadalupe fur seals are on average 4 to 8 ft (1.2 to 2.4 m) and weight110 to 375 lbs (50 to 170 kg), with highly dimorphic appearances (Allen *et al*., 2011; NMFS, 2017d). Guadalupe fur seals are solitary, non-social animals. Males are "polygamous" and may mate with up to 12 females during a single breeding season. Males form small territories that they defend by roaring or coughing. Breeding season is June through August. Females arriving in early June, and pups are born a few days after their arrival (NMFS, 2017d). Guadalupe fur seals feed mainly at night on squid, mackerel, and lantern fish by diving up to depths of 65 feet (20 m) (NMFS, 2017d).

3.7.1.4 Population Trends

Recent population estimates for the Guadalupe fur seal in Mexico is 3,028 individuals, with “a few” observed on the Channel Islands (NOAA, 2017e).

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4.0 IMPACT ASSESSMENT

This Biological Assessment has been prepared to provide information to the Federal lead agencies, NMFS and the USFWS, to determine the potential to affect threatened or endangered species, based on one of three possible findings for each species potentially affected:

- No effect: the proposed action will not affect the listed species or critical habitat;
- Not likely to adversely affect: effects of the listed species are expected to be discountable (extremely unlikely to occur), insignificant (minimal impact without take), or beneficial; and
- Likely to adversely affect: adverse effect may occur as a direct or indirect result of the proposed action, and the effect is not discountable, insignificant or beneficial.

Potential impacts due to Project activities includes acoustically related impacts from 24/7 operations, damage to seafloor habitats from placement of nodes, degradation of water quality or seafloor habitats from the discharge of petroleum in the event of an accidental spill, and accidental collisions with marine wildlife. Potential impacts are described below.

4.1 NOISE IMPACTS OF GEOPHYSICAL SURVEY ON MARINE WILDLIFE

4.1.1 Invertebrates

The white abalone is the only listed marine invertebrate with the potential to occur in the survey area. No specific data were found concerning the effect of acoustic noise on white abalone. The only data found generally involved crustaceans and cephalopods, but not mollusks.

4.1.1.1 Pathological Effects

Controlled seismic sound experiments have been conducted on adult crustaceans and adult cephalopods (Christian et al., 2003, 2004; DFO, 2004; McCauley et al., 2000a,b). No significant pathological impacts were found. It has been suggested that exposure to seismic survey activities had injured giant squid (Guerra et al., 2004), but there is no evidence to support such claims.

4.1.1.2 Physiological Effects

Primary and secondary stress responses in crustaceans, as measured by changes in hemolymph levels of enzymes, proteins, etc., were noted several days and months after exposure to acoustic sounds (L-DEO, 2011).

4.1.1.3 Behavioral Effects

In a study by McCauley et al., 2000a,b, in L-DEO, 2011), squid exhibited a startle response during exposure to acoustic sounds. 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 acoustic 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 acoustic surveys.

4.1.2 Fish

Seismic surveys using underwater geophones and high-energy geophysical systems can disturb and displace fishes and interrupt feeding, but displacement may vary among species. Pelagic or nomadic fishes leave seismic survey areas, and displace up to 20.5 mi (33 km) from the survey center (Engås et al., 1996; Lokkeborg and Soldal, 1993, in MMS, 2005). Lamont-Doherty Earth Observatory [L-DEO] (2011) noted that the potential effects of seismic surveys on fish include: (1) pathological; (2) physiological; and (3) behavioral.

4.1.2.1 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 that the Australasian snapper (Pagrus auratus) exposed to operating high-energy geophysical systems 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 3.2 to 6.4 ft (1 to 2 m) of the array.

Popper et al. (2005, in MMS, 2005) investigated the effects of a 730 in^3 source 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 1μPa2●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 source 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 Mead fault system by the National Park Service (Paulson et al., 1993, in USGS, 1999). The sound source was suspended 11.4 ft (3.5 m) above a school of threadfin shad in Lake Mead and was fired three successive times at a 30-second 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 high-energy geophysical systems 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-source system, 5,828 in^3 source array. Brezina and Associates were hired to monitor the effects of the surveys, and concluded that geophysical operations were not responsible for the death of any of the fish carcasses observed, and the geophysical profiling did not appear to alter the feeding behavior of sea lions, seals, or pelicans observed feeding during the surveys.

Fish eggs and larvae are distributed throughout the water column and are more sensitive to sound waves than adults. Some studies have reported, some equivocally, that mortality of fish, fish eggs, or larvae can occur at close range to seismic sources (Kostyuchenko, 1973; Dalen and Knutsen, 1986; Boorman et al., 1996; Dalen et al., 1996, in L-DEO, 2011). Some of the reports claimed seismic 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.

4.1.2.2 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 biochemical changes to return to normal are variable and depend on numerous aspects of the biology of the species and the sound stimulus.

4.1.2.3 Behavioral Effects

Behavioral effects include changes in the distribution, migration, and mating of exposed fish. 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-source arrays ranging from

1,500 to 2,500 in^3. MMS (2005) noted that the impact to fish populations in the survey area and adjacent waters would likely to very low and temporary. Seismic surveys may displace the pelagic fishes from the area temporarily when active sources are in use. However, fishes displaced and avoiding the sound are likely to backfill the survey area in minutes to hours after cessation of seismic testing. Fishes not dispersing from the sound (e.g., demersal species) may startle and move short distances to avoid source emissions.

The effects of sound on the habitat is expected to be less than significant and is expected to affect only those organisms that are in close proximity of the sound source. Studies have shown that the most common effects of seismic surveys on fish have been behavioral modifications. Results of seismic survey trials in Estero Bay, California, found that sound levels caused changes in rockfish swimming behaviors. There were significant differences in vertical distributions, and startle responses were also observed (Pearson, et al. 1992). Fish returned to pre-exposure behavior after only a few minutes which suggest that the effects on fish would be temporary. Boeger et al. (2006) observed coral reef fishes in field cages before, during, and after exposure to an 8-active source seismic array. There was no result of mortality or external damage to fishes throughout the study. The results did show that most source discharges caused a startle response in the fish, although these behavioral changes lessened with repeated exposure, suggesting habituation.

Wardle et al. (2001) used video and telemetry to observe behavioral responses of marine fishes. The source discharges also caused a startle response in the fish, but Wardle noted that there was no affect to their diurnal migrations or their distribution around the reef. There were also indications of responses to visual stimuli; if the seismic source was visible to the fish they would swim away from it. However, if the source was out of the fish's line of sight, they would continue to swim towards the sound source.

4.1.3 Marine Birds

There are no underwater acoustic guidelines for diving birds and diving birds are especially vulnerable approaching a sound source not only because birds have higher thresholds of hearing (i.e., less sensitive hearing) than humans, but also because the sound-reflecting nature of the air-sea interface tends to trap waterborne sounds beneath the sea surface. Birds are likely to detect lower-level sound source energy only shortly before encountering the water when surveys are in progress, and there likely would be few or no indicators of underwater noise until a bird lands upon or dives into the water. Birds on the water or diving in the area have the potential to be exposed to the maximum sound energy.

The duration of underwater sound exposure for diving birds is expected to be short (~0.1 s); therefore, TTS and PTS resulting from survey activities are unlikely. Impacts to birds above water would likely be limited to startle responses and avoidance of the area during survey activities. Further, the Project does not occur near shore or nesting habitat, so breeding and nesting activities would not be impacted.

4.1.4 Turtles

There have been few studies on the effects of geophysical survey noise on sea turtles, and little is known about the sound levels that result in behavioral changes or reactions. There have been some directed studies that focused on short-term behavioral responses of sea turtles in enclosures to a single high-energy source. However, comparisons of the results of these studies are difficult because experimental designs and reporting procedures varied, and few studies provided specific information on the sound levels received by the turtles. Although monitoring studies are now providing some information on responses of free-ranging sea turtles to seismic surveys, we are not aware of any directed studies on responses of free-ranging sea turtles to seismic sounds, or on the long-term effects of seismic, or other sounds on sea turtles. Adults of only two species (loggerhead and green sea turtles) and one juvenile have undergone auditory studies. Auditory testing and behavioral studies show that turtles can detect low-frequency sounds such as those produced by geophysical surveys (LGL, 2012).

Current NMFS noise exposure standards are that marine turtles should not be exposed to pulsed underwater noise at received levels exceeding 190 dB re 1 μPa (rms) (Fahy, personnel communication).

4.1.4.1 Behavioral Disturbance

In captive enclosures, sea turtles generally respond to seismic noise by startling, increasing swimming speed, and/or swimming away from the noise source. Animals resting on the bottom often become active and move toward the surface where received sound levels normally will be reduced, although some turtles dive following exposure. Quantitative data for free-ranging sea turtles exposed to seismic pulses are very limited, and potential long-term behavioral effects of seismic exposure have not been investigated. The lack of data precludes clear predictions of sea turtle responses to seismic noise. Available data suggests that localized behavioral and distributional effects on sea turtles are likely during seismic operations, including responses to the seismic vessel, source arrays, and other gear (Pendoley, 1997; Weir, 2007; LGL, 2012). Pendoley (1997) summarized potential effects of seismic operations on the behavior and distribution of sea turtles, and identified biological periods and habitats considered most sensitive to potential disturbance. The possible responses of free-ranging sea turtles to seismic pulses could include:

- Avoiding the entire seismic survey area to the extent that turtles move to less preferred habitat;
- Avoiding only the immediate area around the active seismic vessel (i.e., local avoidance of the source vessel but remain in the general area); and
- Exhibiting no appreciable avoidance, although short-term behavioral reactions are likely.

Complete avoidance of an area, if it occurred, could exclude sea turtles from their preferred foraging area and could displace them to areas where foraging is sub-optimal. Avoidance of a preferred foraging area may prevent sea turtles from obtaining preferred prey.

The potential alteration of a migration route might also have negative impacts. However, it is not known whether avoidance by sea turtles would ever be on a significant geographic scale, or be sufficiently prolonged, to prevent turtles from ultimately reaching the destination.

Available evidence suggests that the zone of avoidance around seismic sources is not likely to exceed a few kilometers (McCauley, et al. 2000a,b). Avoidance reactions on that scale could prevent sea turtles from using important coastal areas or bays if there was a prolonged seismic operation in the area, particularly in shallow waters (Pendoley, 1997). Sea turtles might be excluded from the area for the duration of the seismic operation, or they might remain but exhibit abnormal behavioral patterns (e.g., lingering longer than normal at the surface where received sound levels are lower). Whether those that were displaced would return quickly after the seismic operation ended is unknown.

It is unclear whether exclusion from a particular nesting beach by seismic operations, if it occurred, would prevent or decrease reproductive success. If a sea turtle is excluded from a particular beach, it may select a more distant, undisturbed nesting site in the general area (Miller, 1997). Bjorndal et al. (1983) reported a maximal intra-seasonal distance between nesting sites of 290 km (56 mi), indicating that turtles use multiple nesting sites spaced up to a few hundred kilometers apart. Also, it is uncertain whether a turtle that failed to go ashore because of seismic survey activity would abandon the area for that full breeding cycle, or would simply delay going ashore until the seismic vessel moved to a different area.

Shallow coastal waters can contain relatively high densities of sea turtles during nesting, hatching, and foraging periods. Thus, seismic operations in these areas could correspondingly impact a relatively higher number of turtles during sensitive biological periods. Samuel et al. (2005) noted that anthropogenic noise in vital sea turtle habitats, such as a major coastal foraging area off Long Island, NY, could affect sea turtle behavior and ecology. There are no specific data that demonstrate the consequences to sea turtles if seismic operations with large or small arrays occur in important areas at biologically important times of year (Pendoley, 1997).

4.1.4.2 Temporary Threshold Shift

Few studies have directly investigated hearing or noise-induced hearing loss in sea turtles. However, Moein et al. (1994) used an evoked potential method to test the hearing of loggerhead sea turtles exposed to a few hundred pulses from a single acoustic source. Turtles were tested for stress levels and hearing thresholds before and after the seismic trials. A temporary alteration of blood chemistry values after exposure to the sound source indicated that these turtles might have been affected by exposure to repeated acoustic stimuli. Values indicated both an increase in the stress level of the animal as well as damage to tissues. However, the magnitude of the changes did not indicate significant injury to the turtle's organs, and levels returned to normal in approximately 2 weeks. The results are consistent with the occurrence of TTS upon exposure of the turtles to source pulses. Unfortunately, the report did not state the size of the source used, or the received sound levels at various distances. Thus, the levels of source sounds that apparently elicited TTS are not known. However, it is noteworthy that there was evidence of TTS from exposure to pulses from a single source.

Lenhardt (2002), exposed loggerhead turtles in a large net enclosure to sound pulses. A TTS of >15 dB was evident for one loggerhead turtle, with recovery occurring in two weeks. Turtles in the open sea might move away from an operating source at a fixed location, and in the more typical case of a towed source array, very few shots would occur at or around one location. Thus, exposure to underwater sound during net-enclosure experiments was not typical of that expected during an operational seismic survey.

Studies with terrestrial reptiles have demonstrated that exposure to airborne impulse noise can cause hearing loss. For example, desert tortoises (Gopherus agassizii) exhibited TTS after exposure to repeated high-intensity sonic booms (Bowles et al. 1999). Recovery from these temporary hearing losses was usually rapid (<1 hr), which suggested that tortoises can tolerate these exposures without permanent injury (Bowles et al., 1999).

The results from captive, restrained sea turtles exposed repeatedly to seismic sounds in enclosed areas indicate that TTS is possible under these artificial conditions, but may not accurately represent the effects of the proposed survey.

4.1.4.3 Permanent Threshold Shift

There is no data to indicate whether there are any plausible field situations in which exposure to repeated sound pulses at close range could cause PTS or hearing impairment in sea turtles. Hearing impairment (whether temporary or permanent) from seismic sounds is considered unlikely to occur at sea because turtles are unlikely to be exposed to more than a few strong pulses close to the sound source, as individuals are mobile, and the vessel travels relatively quickly compared to the swimming speed of a sea turtle. If sea turtles exhibit little or no behavioral avoidance, or if they acclimate to seismic noise to the extent that avoidance reactions cease, sea turtles might sustain hearing loss if they are close enough to seismic sources.

The avoidance reactions of many marine turtles, along with commonly applied monitoring and mitigation measures (See Section 5.0) would reduce the already low probability of exposure of marine turtles to sounds strong enough to induce PTS.

4.1.4.4 Non-auditory Effects

Other potential direct non-auditory effects to sea turtles during seismic operations include entanglement with seismic gear (e.g., cables, buoys, streamers, etc.) and ship strikes (Pendoley, 1997; Ketos Ecology, 2007; Weir, 2007; Hazel et al., 2007). Entanglement of sea turtles with marine debris, fishing gear, and other equipment has been documented; turtles can become entangled in cables, lines, nets, or other objects suspended in the water column and can become injured or fatally wounded, drowned, or suffocated (Lutcavage et al., 1997). Seismic-survey personnel have reported that sea turtles) became fatally entrapped between gaps in tail-buoys associated with industrial seismic vessel gear deployed off West Africa in 2003 (Weir, 2007). However, no incidents of entanglement of sea turtles have been documented during NSF-funded seismic surveys, which since 2003 have included dedicated ship-based monitoring by trained biological observers, and in some cases in areas with high population densities (Holst et al., 2005a,b; Holst and Smultea, 2008; Hauser et al., 2008).

4.1.5 Marine Mammals

4.1.5.1 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 mysticetes and toothed whales, and (less frequently) pinnipeds, have been shown to react behaviorally to sound source 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.

4.1.5.2 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 sound sources is low, and the sound source sounds are pulsed, with relatively quiet periods between pulses. In most situations, strong underwater sounds will only be received for a brief period (less than one second), separated by at least several seconds of relative silence, and longer in the case of deep-penetration surveys or refraction surveys. A single sound source array might cause appreciable masking when propagation conditions are such that sound from each sound source pulse reverberates strongly and persists between sound source 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 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.

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 high energy sounds would not be expected to mask sperm whale calls given the intermittent nature of sound source pulses. Dolphins and porpoises are also commonly heard calling while seismic sound sources 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 high energy sounds.

Pinnipeds and fissipeds have the most sensitive hearing and/or produce most of their sounds at frequencies higher than the dominant components of high energy sound, but there is some overlap in the frequencies of the sound source pulses and the calls. However, the intermittent nature of sound source 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).

4.1.5.3 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).

4.1.5.4 Marine Mammals (*Mysticeti*)

Mysticetes generally tend to avoid operating seismic surveys, 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 seismic arrays at distances beyond a few kilometers, even though the sound source pulses remain well above ambient noise levels out to much longer distances. However, mysticetes exposed to strong sound pulses from seismic surveys often react by deviating from their normal migration route and/or interrupting their feeding and moving away. Although mysticetes often show only slight overt responses to operating seismic survey arrays (Stone and Tasker, 2006; Weir, 2008), strong avoidance reactions by several species of mysticetes have been observed at ranges from 3.7 to 5.0 mi (6.0 to 8.0 km) and occasionally as far as 12.4 to 18.6 mi (20.0 to 30.0 km) from the source vessel when large arrays were used. Experiments with a single sound source showed that bowhead, humpback, and gray whales all showed localized avoidance to a single sound source of 20 to 100 cubic inches (in3) (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 diminish to those levels at distances ranging from 2.5 to 9.3 mi (4.0 to 15.0 km) from the source. More recent studies have shown that some species of mysticetes (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-sound source, 2,678-in^3 array, and to a single 20-in^3 sound source. McCauley et al. (1998) documented that avoidance reactions began at 3.0 to 5.0 mi (5.0 to 8.0 km) from the array, and that those reactions kept most pods approximately 1.8 to 2.5 mi (3.0 to 5.0 km) from the operating seismic boat. McCauley et al. (2000a) noted localized displacement during migration of 2.5 to 3.1 mi (4.0 to 5.0 km) by traveling pods and 4.3 to 7.5 mi (7.0 to 12.0 km) by more sensitive resting pods of cow-calf pairs. Avoidance distances with respect to the single sound source 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 sound source was 140 dB re 1 μPa (rms) for humpback pods containing females, and at the mean closest point of approach distance, the received level was 143 dB re 1 μPa (rms). The initial avoidance response generally occurred at distances of 3.1 to 5.0 mi (5.0 to 8.0 km) from the sound source array and 1.2 miles (2.0 kilometers) from the single sound source. However, some individual humpback whales, especially males, approached within distances of 328 to 1,312 feet (100 to 400 meter), 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) sound source (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 sound sources 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 (International Whaling Commission (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-in3 sound source 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 ten 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 sound source pulses (Stone, 2003; MacLean and Haley, 2004; Stone and Tasker, 2006), and calls from blue and fin whales have been localized in areas with seismic survey 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 visibility, sighting rates for mysticetes (mainly fin and sei whales) were similar when large arrays were operating vs. silent (Stone, 2003; Stone and Tasker, 2006). However, these whales tended to exhibit localized avoidance, remaining significantly further (on average) from the seismic array during 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 seismic survey.

Ship-based monitoring studies of mysticetes (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). Mysticetes 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 as reported by Johnson et al. (2007). The history of coexistence between seismic surveys and mysticetes suggests that brief exposures to sound pulses from any single seismic survey are unlikely to result in prolonged effects.

4.1.5.5 Marine Mammals (*Odonteceti*)

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 seismic arrays, but, in general, there is a tendency for most delphinids to show some avoidance of operating seismic vessels (Lamont-Doherty Earth

Observatory [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 are operating (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 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 array, received levels typically diminish to 170 dB within 0.62 to 2.5 mi (1.0 to 4.0 km), whereas levels typically remain above 160 dB out to 2.5 to 9.3 mi (4.0 to 15.0 km) (Tolstoy et al., 2009). Reaction distances for delphinids are more consistent with the typical 170 dB re 1 µPa (rms) distances (L-DEO, 2011).

Most studies indicate that the sperm whale shows considerable tolerance of sound source 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 high energy sounds (Jochens et al., 2008; Miller et al., 2009; Tyack, 2009).

Results can be species or hearing group specific. The limited available data for high-frequency cetaceans 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 seismic 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 other acoustic sources (Richardson et al., 1995; Southall et al., 2007).

Overall, odontocete reactions to large arrays 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. Reactions at longer distances may be particularly likely when sound propagation conditions are conducive to transmission of the higher frequency components of source's sound to the animals' location (DeRuiter et al., 2006; Goold and Coates, 2006; Tyack et al. 2006; Potter et al., 2007).

4.1.5.6 Marine Mammals (Pinnipeds)

Pinnipeds are not likely to show a strong avoidance reaction to a seismic array. Visual monitoring from seismic vessels has shown only slight (if any) avoidance of arrays by pinnipeds, and only slight (if any) changes in behavior (L-DEO, 2011). In the Beaufort Sea, some ringed seals avoided an area of 328 ft (100 m) to approximately 660 ft (200 m) around seismic vessels, but many seals remained within 328 to 656 ft (100 to 200 m) of the trackline as the operating sound source 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 sound sources were operating (Calambokidis and Osmek, 1998).

During seismic exploration off Nova Scotia, gray seals exposed to noise from sound sources and linear explosive charges did not react strongly (J. Parsons, in Greene et al. 1985). An sound source 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.

4.1.5.7 Hearing Impairment on Marine Mammals

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 may (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.

The sections below are a summary of recent findings presented in NOAA's Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing and Auditory Weighting Functions and TTS/PTS Exposure Functions for Marine Mammals exposed to Underwater Noise (NOAA, 2016c; Finneran, 2016). 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.

Hearing Groups. Five separate marine mammal hearing groups are identified in National Oceanic and Atmospheric Administration's (NOAA) *Technical Guidance on Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing* (Guidance); hearing groups were created based on each the known hearing sensitivity ranges of cetacean and pinnipeds (low- [LF], mid- [MF], and high- [HF] frequency cetaceans, and otariid [OW] and phocid [PW] pinnipeds) (Table 4.1-1) (NOAA, 2016). Outside the generalized hearing range, the risk of auditory impacts from sound is considered unlikely or very low (the exception would be if a sound above or below the range has the potential to cause physical injury because of high energy levels). The Guidance excludes species protected by the USFWS (i.e. Sea otter, sea turtles) and avian species.

Table 4.1-1. Marine Mammal Hearing Groups

Hearing Group	Generalized Hearing Range*
Low-Frequency (LF) cetacean (mysticetes)	7 Hz to 35 kHz
Mid-Frequency (MF) cetacean (dolphins, toothed whales, beaked whales, bottlenose whales)	150 Hz to 160 kHz
High-Frequency (HF) cetaceans (true porpoises, *Kogia*, river dolphins, cephalorhynchid, *Lagenorhynchus cruciger,* and *Lagenorhynchus australis*)	275 Hz to 160 kHz
Phocid pinnipeds (PW) (underwater) (true seals)	50 Hz to 86 kHz
Otariid pinnipeds (OW) (underwater) (sea lions and fur seals)	60 Hz to 39 kHz

Source: NMFS 2016

* Represents the generalized hearing range for the entire group as a composite (i.e., all species within the group), where individual species' hearing ranges are typically not as broad. Generalized hearing range chosen based on ~65 decibel (dB) threshold from normalized composite audiogram, with the exception for lower limits for LF cetaceans and PW pinniped (approximation).

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, on the frequency, and the species exposed (Kryter, 1985; Richardson *et al.*, 1995; Southall *et 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. New data on marine mammal hearing, marine mammal equal latency contours, and the effects of noise on marine mammal hearing have been obtained since Southall's (2007) publication, and these data have been incorporated into NOAA's Technical Guidance (2016) and Finneran (2016). As a result, new weighting functions and TTS and PTS thresholds have been developed. Table 4.2-1 identifies the new TTS thresholds for impulsive sound sources for both weighted sound exposure levels (SEL) and peak sound pressure levels (SPL) thresholds.

For toothed whales, experiments on a bottlenose dolphin and beluga whale showed that exposure to a single impulse at a received level of 207 kilopascal (kPa) (or 30 psi) peak-to-peak (p-p), which is equivalent to 228 dB re 1 µPa (p-p), resulted in a 7.0 and 6.0 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 four minutes of the exposure (Finneran et al., 2002).

Table 4.2-1. TTS Thresholds for Impulsive Sound Sources

Hearing Group	SEL (weighted) (dB SEL)	Peak SPL (dB SPL)
LF	168	213
MF	170	224
HF	140	196
OW	188	226
PW	170	212

Note: SEL thresholds are in dB re 1 μPa2s and peak SPL thresholds are in dB re 1 μPa.

Source: Finneran, 2016, Table AE-1

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 seconds, with hearing tested at 4.5 kHz. For one second exposures, TTS occurred with sound exposure limits (SELs) of 197 dB, and for exposures greater than one second, SEL greater than 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 minutes [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 one to eight seconds (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 (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 SPLs of 130 to 178 dB re 1 μPa for periods of 1.88 to 30 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 (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.

Although there are no direct measurements of hearing sensitivity in any mysticete species, an audible frequency range of approximately 10 Hz to 30 kHz has been estimated from observed vocalization frequencies, observed reactions to playback sounds, and anatomical analyses of the auditory system. In the absence of data for mysticetes (LF), their frequency of best hearing is assumed to be the median threshold at the frequency of best hearing for the other hearing groups (MF, HF, PW, and OW), which is 54 dB re 1 µPa; therefore, the estimated TTS threshold for mysticetes was set at 180 dB re 1 μPa^2s (Finneran, 2016). However, no cases of TTS are expected given the strong likelihood that mysticetes would avoid the approaching sound sources (or vessel) before being exposed to levels high enough for there to be any possibility of TTS, and the special provisions for endangered low-frequency whales.

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 array. It is unlikely that these cetaceans would be exposed to sound source 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 array. 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 seismic arrays, they would be exposed to strong sound pulses, possibly repeatedly (NMFS, 2010).

If some cetaceans did incur mild or moderate TTS through exposure to seismic survey 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, 2010).

Some pinnipeds show avoidance reactions to sound sources, 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, 2010). 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 exposed for a prolonged time of a large array could incur TTS (NMFS, 2010).

It has been shown that most marine mammals show at least localized avoidance of ships and/or seismic operations. In addition, ramping up sound sources, which is standard operational protocol for many seismic operators, should allow cetaceans near the survey area 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 sound sources. Thus, most mysticetes likely will not be exposed to noise at high energy levels provided the ramp-up procedure is applied and effective. Likewise, many odontocetes close to the track line 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 mysticetes or odontocetes that show avoidance of ships or sound sources to be close enough to a survey array to experience TTS. Therefore, it is not likely that marine mammals in the vicinity of the proposed marine seismic surveys by Beta would experience TTS as a result of these activities with implementation of the mitigation measures detailed in Section 5.0.

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 sound sources in seismic surveys can cause PTS in any marine mammal, even with large, high energy arrays. However, given the possibility that mammals close to a seismic 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 sound sources 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. Table 4-2.2 details the new PTS thresholds for impulsive sound sources for weighted SEL and SPL thresholds.

Table 4.2-2. PTS Thresholds for Impulsive Sound Sources

Hearing Group	SEL (weighted) (dB SEL)	Peak SPL (dB SPL)
LF	183	219
MF	185	230
HF	155	202
OW	203	232
PW	185	218

Note: SEL thresholds are in dB re 1 μPa2s and peak SPL thresholds are in dB re 1 μPa.
Source: Finneran, 2016, Table AE-1

Since marine mammal PTS data from impulsive noise exposures do not exist, onset-PTS levels for impulsive exposures were estimated by adding 15 dB to the SEL-based TTS threshold and adding 6 dB to the peak pressure based thresholds. These relationships were derived by Southall et al. (2007) from impulse noise TTS growth rates in chinchillas. The appropriate frequency weighting function for each functional hearing group is applied only when using the SEL-based thresholds to predict PTS (refer to Table 7-2) (Finneran, 2016). 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 decibels higher than the level causing slight TTS; however, the rise time of sound source pulses are 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.

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.

It is unlikely that an odontocete would remain close enough to a large seismic array for sufficiently long to incur PTS. As detailed in Section 11.0, within the proposed monitoring and mitigation measures, the sound source would quickly be shut down if an animal were to enter the Exclusion Zone, 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 the image interference effect of Lloyd's mirror and surface release effects (Carey, 2009). The presence of the vessel between the sound source 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). It is assumed that mysticetes generally avoid the immediate area around operating seismic vessels. So, it is unlikely that a mysticete, low-frequency whale could incur PTS from exposure to sound source pulses. The TTS (and PTS) thresholds of pinnipeds, as well as the members of the family Delpinidae, are higher, and therefore the potential exposure areas extend to a somewhat greater distance for those animals (Kastak et al., 2005; Southall et al., 2007; Lucke et al., 2009). Again, Lloyd's mirror and surface release effects will ameliorate the effects for animals at or near the surface.

Although it is unlikely that sound source 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 mysticetes 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 5.1 – Measures to Reduce Potential Noise Impacts on Marine Wildlife), would reduce the already low probability of exposure of marine mammals to sounds strong enough to induce PTS.

4.1.5.8 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 a sound source 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 sound source 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 or 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 (NMFS, 2016, Southall *et al.*, 2007), or any meaningful quantitative predictions of the numbers (if any) of marine mammals that might be affected in those ways.

The potential effects of noise on marine wildlife, may be significant; however, to reduce the possibility of impacts to marine wildlife some Project-specific mitigations are recommended as further described in Section 5.1 – Measures to Reduce Seafloor Impacts from Noise Impacts.

4.2 DAMAGE OR DISTURBANCE TO SEAFLOOR HABITATS FROM PLACEMENT OF AUTONOMOUS NODES

Placement of autonomous nodes (nodes) has the potential to create localized turbidity and affect nearby soft-bottomed seafloor habitat, and/or rocky substrate. Potentially significant impacts could occur if nodes create turbidity that would reduce water clarify and increase sediment deposition, or if the cable/rope, tethering the nodes, are placed onto or cut across sensitive habitats. Deeper water rock habitats are considered more sensitive in that they are not routinely subjected to natural disturbances (i.e., storm waves) and they support long-lived, slow-growing organisms that are particularly sensitive to disturbance. Further, placing nodes onto habitats could crush attached organisms and tether lines that cross habitat features could abrade and remove or damage attached epibiota.

The potential effects of node placement on sensitive marine habitat, particularly on hard bottom substrate, are expected to be minimal, if any; however, to reduce the possibility of impacts to sensitive habitats, some Project-specific mitigations are recommended as further described in Section 5.2 – Measures to Reduce Seafloor Impacts from Node Placement.

4.3 LIGHTING IMPACTS

The following is a summary of studies on the effects of lighting on marine and aquatic wildlife. Saleh (2007), Schaar (2002), Anonymous (2002), and Harder (2002) summarize several of the more recent studies on the effects of light on wildlife, including those on birds, turtles, fish, and insects. These studies suggest that light effects include disorientation, structural-related mortality due to disorientation, and interruption of natural behaviors. Recommended mitigations include the elimination of “bare bulbs” and upward-pointing lights, shielding or cantering light sources, and minimizing overall light level to that which is needed for safe operations (Saleh, 2007).

Several studies (i.e., Cochran and Graber, 1958; Bruderer, et al., 1999; and Reed, et al, 1985) have shown that migrating birds are affected by artificial light on buildings. Effects range from attraction to disorientation, as well as alteration of flight patterns, and can result in an increase in mortality from striking buildings, and/or exhaustion and, ultimately, increased predation. The results of these studies tend to indicate that birds are “trapped” by light beams and are generally reluctant to leave the beam once entering it. Indirect light sources of more than approximately 0.5 mi (804.6 m) away, tend to be less attractive than direct sources. Gauthreaux and Belser (2002) suggest that night-migrating birds showed “nonlinear flight” near towers with white and red strobe lights; however, they also stated that the attraction may have been more attributable to the constant tower lighting with the red strobe lights. Podolsky (2002) indicates that artificial lighting appears to “confuse” seabirds, particularly during their migration between urbanized nesting sites and their offshore feeding grounds. Longcore and Rich (2001) reported that migrating birds can be attracted to tall, well-lit structures, which can result in collisions.

It is assumed that migrating birds use visual cues to orient while flying, ultimately affecting their course of action. Poot et al. (2008), hypothesize that artificial light can interfere with the magnetic compass of the birds, which is an important orientation mechanism especially during overcast nights. Magnetic orientation is thought to be based on specific light receptors in the eye which have been shown to be light and wavelength-dependent. Poot et al. (2008) found that white and red light interfere with the magnetic compass of migrating birds, where they caused disorientation at low light intensity, compared to a high-intensity green light that caused less disorientation. The researchers concluded that the disorientation is due to the wavelength; green and blue lights have a short wavelength resulting in very little observable impact to bird's orientation. In 2007, lights on gas-production platform L15 were replaced with green lighting. The platform is still visible from a distance with the new lighting and the platform crew has commented that the lighting is less blinding, and they have increased contrast vision during crane operations (Poot et al., 2008).

Moor and Kohler (2002) found that the spectra of artificial light that strikes urban lakes was dominated by the yellow region (wave length of approximately 590 nm), which corresponded to the emission spectra of high pressure sodium lamps and was of a similar intensity as that of a full moon. They also found that artificial light was detectable to a water depth of about 10 feet by crustacean grazers and fish. Nightingale and Simenstad (2002) report that juvenile chum salmon and their predators (hake, dogfish, sculpin, and large Chinook and coho salmon) tend to congregate below night security lights in the rivers and estuaries of the Pacific Northwest. Also, juvenile herring and sand lance appear to be attracted to night-lit water areas and are apparently "heavily preyed upon" during those periods. That report also indicates that there is insufficient data to allow conclusive evidence that the increased predation due to night-lighting is affecting species abundance or distribution. Juell and Fosseidengen (2004) found that Atlantic salmon responded positively to artificial light and suggest that it might be used to reduce exposure of those fish to undesirable water conditions. Studies by Oppedal, et al. (2001) suggest that vertical migration and feeding characteristics of caged Atlantic salmon were modified by exposing them to extended periods of light.

Very little data on the potential effects of existing platform lighting on marine species including marine birds and fish species have been documented. According to Reitherman and Gaede (2010), who conducted 20 all-night observations of avian activities on southern California oil production platforms (including Edith and Elly) observed no cases of birds being entrained around or confused by particular lights on the platform. Reitherman and Gaede (2010) also did not observe birds deviating significantly from their migratory pathway within their 300-foot observable radius. In addition, Project-area platform operators have not reported any significant incidents of bird mortalities resulting from nighttime operations; however, nighttime roosting, and in one case of nesting, has been reported on platforms in the Santa Barbara Channel. Black (2005) describes two incidents of bird strikes on vessels operating in the Southern Ocean (South Georgia Island off the southern tip of South America) wherein vessels operating at night experienced relatively large numbers (~900 and 62) of bird strikes. The vessels were either moored or in transit during foggy and rainy conditions and both had "ice lights", which are used to assist in observations of floating ice too small to be detected by radar. As a result of these incidents, some vessel operators instituted the use of blackout curtains overnight-lit port holes and further focused deck lighting onto smaller areas.

The platforms are currently and will continue to be lit for compliance with USCG navigational hazard requirements. Shielding of the lighting to direct it downward and to limit the area will reduce the potential impacts to flying seabirds by precluding horizontal light. Lighting on the platform will be sufficient to assure safe operations and to be in compliance with USCG navigation hazard requirements but are not expected to result in significant impacts to the marine wildlife found in the region. Nighttime marine construction is anticipated and therefore lit Project vessels are expected to be present along the survey route or while transiting between the port and the site. USCG-required vessel lighting will be onboard and on deck lighting will be shielded and directed inward to avoid over-water lighting.

The potential effects of lighting on marine wildlife, particularly birds, are expected to be minimal, if any; however, to reduce the possibility of bird strikes during night operations, some Project-specific mitigations are recommended as further described in Section 5.3 (Measures to Reduce Lighting Impacts to Marine Birds). During the Beta's Platform Elly to Platform Eureka Pipeline Replacement Project no impacts to birds was observed from vessel lights during pipeline replacement activities (Padre, 2011).

4.4 VESSEL COLLISION

Collisions of Project-related vessels would be expected to most likely affect marine mammals and sea turtles. Such collisions have been documented in southern California; however, those collisions are typically associated with large ship interactions with slower-moving marine wildlife on the ocean surface rather than smaller work vessels. Impacts from vessel operations can range from a change in the animal's travel route or time on the surface to direct mortality.

NMFS (2017c) reports 54 known or possible ship strikes of large whales from 2007 through 2016 off of California. Strikes are usually fatal when vessel speed exceeds 10 knots, (POLB, 2008). Offshore California, gray whales are the most commonly reported, 14 recorded collisions from 2007 to 2016. Humpback whales constituted the next highest species for recorded ship strikes, (13 records), then fin whale (12 recorded), blues whale (10 record), and minke, sei and Baird's beaked whale (one record). Some collision incidents were reported as "unidentified species" (two records).

Vessel strikes involving pinnipeds and sea otters primarily involve small, fast boats. Propeller slashes to these smaller animals have been proportionally small, and collision reports have come from small vessels (NMFS, 2017c).

NMFS (2017c) reports 22 known or possible ship strikes of marine turtles from 2007 through 2016 off of California. Offshore California, green turtles are the most commonly reported, 21 recorded collisions and one recorded leatherback sea turtle. The risk to marine turtles from boat strikes increases with an increase in vessel speed. Hazel et al. (2007) analyzed behavioral responses of turtles to approaching vessel and found that turtles fled frequently in encounters with slow vessels (2 knots), infrequently with moderate vessels (6 knots), and rarely in encounters with fast vessels (10 knots).

The Project vessel will progress slowly along transit routes during mobilization and during survey activities, interactions with whales are, therefore, not expected. Therefore, the vessel collision impacts on marine wildlife will not be significant. In addition, the Beta has proposed additional mitigation measures to further reduce any potential impact (refer to Section 5.4 – Measures to Reduce Vessel Collision Impacts).

4.5 OIL SPILL POTENTIAL

The unintentional release of petroleum into the marine environment from proposed Project activities could result in potentially significant impacts to the marine biota, particularly avifauna and early life stage forms of fish and invertebrates, which are sensitive to those chemicals. Refined products (i.e., diesel, gasoline.) are more toxic than heavier crude or Bunker-type products, and the loss of a substantial amount of fuel or lubricating oil during survey operations could affect the water column, seafloor, intertidal habitats, and associated biota, resulting in their mortality or substantial injury, and in alteration of the existing habitat quality. The release of petroleum into the marine environment is considered a potentially significant impact.

Although many marine organisms have created adaptive strategies to survive in their environment, when these marine organisms are introduced to oil, it adversely affects them physiologically. For example, physiological effects from oil spills on marine life could include the contamination of protective layers of fur or feathers, loss of buoyancy, and loss of locomotive capabilities. Direct lethal toxicity or sub-lethal irritation and temporary alteration of the chemical make-up of the ecosystem can also occur. Oil spills have many variables to consider when dealing with the impact of the spill including: oil type, season of occurrence, animal behavior, oceanographic and meteorological conditions, and the cleanup methods employed (MMS, 1983).

The possible effects of oil on marine wildlife has been studied and discussed by Federal and State agencies such as the NMFS and the CDFG. In 1995, the Office of Oil Spill Prevention and Response (OSPR) organized California's existing oiled wildlife centers into the Oiled Wildlife Care Network (OWCN). OSPR is an office within the CDFG charged with oil spill prevention and response. The office directs spill response, cleanup, and natural resource damage assessment activities (SBWCN, 2010). The research and experiments conducted by these agencies is a cumulative ongoing effort to better understand what potential effects an oil spill of any magnitude will or may have on special status and protected species that includes invertebrates, fish, turtles, marine birds, cetaceans, pinnipeds, and fissipeds. The following text provides a brief summary of the potential impacts from exposure to oil spills.

4.5.1 Marine Invertebrates

Oil spill impacts on sensitive marine invertebrates, including the black abalone, would likely result from direct contact, ingestion of contaminated water and food (algae), and secondary impacts associated with response operations. In the event of a spill related to the proposed Project activities, the oil could undergo some weathering before reaching the mainland, which could limit toxicity.

Fish Resources. The effects of oil on fish have been well documented both in the field and within a laboratory. This research shows that fish that are unable to avoid hydrocarbons and take them up from food, sediments, and surrounding waters. Once these hydrocarbons are in the organism's tissues, they will affect the life span through a variety of behavioral, physiological, or biochemical changes. Also, exposure to oil will affect a species' ability to search, find, and capture food, which will affect its nutritional health. Early development life stages, such as larvae, will be especially impacted (Jarvela et al., 1984). Small amounts of oil can impact fish embryos by causing physical deformities, damage to genetic material, and mortality (Carls, et. al., 1999). Fishes experience the highest mortalities due to oil exposure when they are eggs or larvae. However, these deaths would not be significant in terms of the overall population in offshore water (Jarvela et al, 1984). Brief encounters with oil by juvenile and adult fish species would not likely be fatal.

While a release of petroleum would be expected to have some short-term effect on the habitats and fish within the Project area, the likelihood of such an event occurring and the existing mitigations that have been built into the Project design reduce the possibility to less than significant.

4.5.2 Turtles

Oil spills are not considered a high cause for mortality for sea turtles, although recent reports from the Gulf of Mexico Deepwater Horizon spill indicate a possible increase in strandings of oil impacted turtles. Since sea turtle species have been listed as threatened or endangered under the FESA, there is very little direct experimental evidence about the toxicity of oil to sea turtles. Sea turtles are negatively affected by oil at all life stages: eggs on the beach, post hatchings, young sea turtles in near shore habitats, migrating adults, and foraging grounds. Each life stage varies depending on the rate, severity, and effects of exposure.

Sea turtles are more vulnerable to oil impacts due to their biological and behavior characteristics including indiscriminate feeding in convergence zones, long pre-dive inhalations, and lack of avoidance behavior (Milton et al., 1984). This type of diving behavior puts sea turtles at risk because they inhale a large amount of air before diving and will resurface over time. During an oil spill, this would expose sea turtles to long periods of both physical exposure and petroleum vapors, which can be the most harmful during an oil spill.

4.5.3 Marine Birds

Marine birds can be affected by direct contact with oil in three ways: (1) thermal effects due to external oiling of plumage; (2) toxic effects of ingested oil as adults; and (3) effects on eggs, chicks, and reproductive abilities.

The loss of waterproofing is the primary external effect of oil on marine birds. Buoyancy is lost if the oiling is severe. A main issue with oil on marine birds is the damage oil does to the arrangement of feathers, which is responsible of water repellency (Fabricius, 1959). When this happens, the water can go through the dense layers of feathers to the skin causing a loss of body heat (Hartung, 1964). To survive, the bird must metabolize fat, sugar, and eventually skeletal muscle proteins to maintain body heat. The cause of oiled bird deaths can be the result from exposure and loss of these energy reserves as well as the toxic effects of ingested oil (Schultz et al., 1983).

The internal effect of oil on marine birds varies. Anemia can be the result of bleeding from inflamed intestinal walls. Oil passing into the trachea and bronchi could result in the development of pneumonia. A bird's liver, kidney, and pancreatic functions can be disturbed due to internal oil exposure. Ingested oil can inhibit a bird's mechanism for salt excretion that enables seabirds to obtain fresh water from salt water and could result in dehydration (Holmes and Cronshaw, 1975).

Studies have shown that ingested oil may alter egg yolk structure, reduce egg hatchability, and reduce egg-laying rate for seabirds (Grau et al., 1977; Hartung, 1965). When oil contacts the exterior of eggs, it could reduce the hatching success (Hartung, 1965; Albers and Szaro, 1978; King and Lefever, 1979; Patten and Patten, 1979; Coon et al., 1979; McGill and Richmond, 1979).

A bird's vulnerability to an oil spill depends on each individual species' behavioral and other attributes. Some of the more vulnerable species are alcids and sea ducks due to the large amount of time they spend on the ocean surface, the fact that they dive when disturbed, and their gregarious behavior. Also, alcids and other birds have low reproductive rates, which result in a lengthy population recovery time. A bird's vulnerability depends on the season as well. For example, colonial seabirds are most vulnerable between early spring through autumn because they are tied to breeding colonies.

4.5.4 Marine Mammals (Cetaceans)

The documentation of the effects of oil on whales, dolphins, and porpoises is limited due to the difficult reclusive nature and migratory behavior (Australian Maritime Safety Authority, 2010). The impact of direct contact with oil on the animal's skin varies by species. Cetaceans have no fur. Therefore, they are not susceptible to the insulation effects of hypothermia in other mammals. However, external impacts to cetaceans from direct skin contract with oil could include: eye irritation, burns to mucous membranes of eyes and mouth, and increase vulnerability to infection.

Baleen whales skim the surface of water for feeding and are particularly vulnerable to ingesting oil and baleen fouling. Adult cetacean would most likely not suffer from oil fouling of their blowholes because they spout before inhalation, clearing the blowhole. Younger cetaceans are more vulnerable to inhale oil. It has been suggested that some pelagic species can detect and avoid contact with oil (Australian Maritime Safety Authority, 2010). This still presents a problem for those animals that must come up to the surface to breathe and to feed (MMS, 1983).

Internal injury from oil is more likely for cetaceans due to oil. Oil inhaled could result in respiratory irritation, inflammation, emphysema, or pneumonia. Ingestion of oil could cause ulcers, bleeding, and disrupt digestive functions. Both inhalation and ingested chemicals could cause damage in the liver, kidney, lead to reproductive failure, death, or result in anemia and immune suppression.

4.5.5 Marine Mammals (Pinnipeds)

Seals and sea lions that come in contact with oil could experience a wide range of adverse impacts including: thermoregulatory problems, disruption of respiratory functions, ingestions of oil as a result of grooming or eating contaminated food, external irritation (eyes), mechanical effects, sensory disruption, abnormal behavioral responses, and loss of food by avoidance of contaminated areas.

Guadalupe fur seals and northern fur seals could experience thermoregulatory problems if they come into contact with oil (Geraci and Smith, 1976). Oil makes hair of a fur seal lose its insulating qualities. Once this happens, the animal's core body temperature may drop and increases its metabolism to prevent hypothermia. This could potentially be fatal to a distressed or diseased animal and highly stressful for a healthy animal (Engelhardt, 1983).

Pinnipeds rely on blubber for insulation (California sea lion, harbor seal, northern elephant seal, and Stellar sea lion) and do not experience long-term effects to exposure to oil (Geraci and St. Aubin, 1982). Newborn harbor seal pups, which rely on a dense fur for insulation, would be subject to similar thermoregulatory problems of the previously discussed fur seal species (Oritsland and Ronald, 1973; and Blix et al., 1979).

When pinnipeds are coated with viscous oil, it may cause problems in locomotion and breathing. Pinnipeds that are exposed to heavy coating from oil will experience swimming difficulties, which may lead to exhaustion (Engelhardt, 1983; Davis and Anderson, 1976), and possible suffocation from breathing orifices that are clogged. The viscosity of the oil is a major factor in determining the effects on pinnipeds. Severe eye irritation is caused by direct contact with oil but non-lethal (Engelhardt, 1983). Skin absorption, inhalation, and ingestion of oil while grooming are all possible pathways of ingestion. However, there have not been enough studies on the long-term effects of chronic exposure to oil on pinnipeds.

Project activities are not expected to have long-term, significant effects on open water habitat because a Project-specific oil spill prevention and recovery plan has been developed and will be used to direct the containment and recovery of Project-related petroleum products that are accidentally released into the marine waters. In addition, onboard and supporting equipment and the procedures specified in the spill plan are expected to reduce the effects of accidentally discharged petroleum by facilitating rapid response and cleanup operations. The Project vessels will adhere to a zero-discharge policy. Refer to Section 5.5 for more information on applicant proposed mitigation measures.

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5.0 PROJECT INCORPORATED MEASURES

The applicant proposed mitigation measures detailed in the following section will be implemented to further minimize the potential disturbance of marine wildlife during Project operations. The Project incorporates both design and operational procedures for minimizing potential impacts to marine wildlife and other special-status species.

5.1 PROJECT INCORPORATED MEASURES TO REDUCE POTENTIAL NOISE IMPACTS ON MARINE WILDLIFE

5.1.1 Scheduling

Beta proposes to conduct the offshore survey during September 2018 to coincide with the reduced number of cetaceans in the area, and outside the peak humpback whale migration period. The humpback whales are most common offshore southern California during April through October. Then in late autumn, humpback whales will begin their migration southward to warmer Mexican waters for calving. This time frame also is outside breeding and pupping periods for phocid and otariid species (March to June) which have rookeries adjacent to the Project area.

Survey timing was chosen to: 1) reduce risks from unsafe sea conditions, and 2) reduce the potential impacts to Federally listed and/or protected species that could occur within the Project vicinity. Fall and winter months are the best time to avoid highly mobile species, particularly whales and breeding birds, which could occur within the Project vicinity. Species seasonality is variable from year to year; however, Table 5.1-1 provides a guideline of when threatened or endangered species could occur within the Project vicinity.

5.1.2 Pre-Activity Environmental Orientation

A marine biologist will present an environmental orientation for all Project personnel prior to conducting work. The purpose of the orientation is to educate Project personnel on identification of wildlife in the Project area and to provide an overview of the APMs that will be implemented during the Project. Specifically, the orientation will include, but not be limited to, the following:

- Identification of wildlife expected to occur in the Project area and periods of occurrence along the central coast;
- Overview of the Marine Mammal Protection Act (MMPA), Federal Endangered Species Act (FESA), and California Endangered Species Act (CESA) regulatory agencies responsible for enforcement of the regulations, and penalties associated with violations;
- Procedures to be followed during mobilization and demobilization, transiting of Project vessels, and the implementation of shutdowns and ramp-ups throughout the duration of the Project; and

Table 5.1-1. Marine Wildlife Species and Periods of Occurrence

TAXON Common Name	Month of Occurrence											
	J	F	M	A	M	J	J	A	S	O	N	D
INVERTEBRATES												
White abalone (E)												
FISH												
Steelhead (Southern California ESU) (T)												
REPTILES												
Cryptodira												
Pacific olive Ridley sea turtle (T)(1)												
Green sea turtle (T)(1)												
Leatherback sea turtle (E)(1)												
Loggerhead sea turtle (T)												
BIRDS												
California least tern (breeding) (E)												
Marbled Murrelet (T)												
Short-tailed Albatross (E)												
MAMMALS												
Mysticeti												
Blue whale (E)												
Fin whale (E)												
Humpback whale (E)												
Sei whale (E)												
North Pacific right whale (E)												
Odontoceti												
Sperm whale (E)												
Pinnipedia												
Guadalupe fur seal (T)												

Likely seasonal distribution | Relative uniform distribution | Not expected to occur

(E) Federally listed endangered species.
(C) Candidate species.
(T) Federally listed threatened species.
(1) Rarely encountered, but may be present year-round. Greatest abundance during July through September.
(2) Only nearshore (diving limit 100 feet).
Note: Species considered outside of the geographic range or depth requirements are excluded from this table.
Sources: Bonnell and Dailey (1993); NCCOS (2007); Allen *et al*, 2011

- Reporting requirements in the event of an inadvertent collision and/or injury to a marine wildlife or sensitive habitats.

Prior to Project activities briefings will be held between the Beta representatives, the vessel captains, vessel representatives and the Protected Species Observers (PSOs). Topics will include personnel safety, identification of key personnel, communication protocol, and lines of authority.

5.1.3 Reducing Sound Source

The discharge pressure of the array is approximately 2,000 pounds per square inch (psi). To reduce potential noise, the sound source will be operated in "distributed or popcorn mode". During discharge, a brief (~0.1 seconds) pulse of sound is emitted. The sound sources would be silent during the intervening periods. Because the actual source is a distributed sound source (11 sound sources in each of the three sub-array) rather than a single point source, the highest sound levels measurable at any location in the water will be significantly less than the nominal single point source level emitted (as would be the case during other non-related "typical" geophysical surveys). Specifically, rather than activating all sound sources at the same time to generate a sharp source peak, the sound sources are initiated independently over a short period of time to generate a firing sequence with reduced peak amplitudes. As only one sound source would be firing at any given time, the effective (perceived) source level for sound propagating would be substantially lower than the nominal source level because of the distributed nature of the sound from the sound source array. The sound source array is designed to focus maximum energy downwards rather than in the horizontal directions.

5.1.4 Sound Source Verification

Prior to the start of survey operations, a sound source verification (SSV) will be conducted by the source vessel to ensure actual acoustic energy levels from the sound source array are consistent with previous modeling. The results of the SSV will be used to adjust the Exclusion and Buffer Zones as necessary.

5.1.5 Exclusion and Buffer Zones

The PSOs will establish and monitor a 1,640 ft (500 m) Exclusion Zone radius and 3,280 ft (1,000 m) Buffer Zone. These Zones will be based on the radial distance from any element of the sound source array, rather than being based on based on the center of the array or around the vessel itself. The Exclusion Zone is a defined area within an occurrence of a marine mammal triggers mitigation action intended to reduce potential for harassment or injury. If marine wildlife appear within, enters, or appears on a course to enter this Zone, the acoustic source will be shut down. If a marine mammal is detected acoustically, the acoustic source will be shut down, unless the PAM operator is confident that the animal detected is outside the Exclusion Zone or that the detected species is not subject to the special shutdown requirements (refer to Section 5.1.7). Disturbance or behavioral effects to marine mammals may occur after exposure to underwater sound at distances greater than the designated Exclusion Zone (Richardson et al., 1995). In addition, a Buffer Zone has been designated to provide an adequate buffer to allow for the initial reduction in sound levels prior to the potential entry of animals into the Exclusion Zone.

The Buffer and Exclusion Zone for marine wildlife is customarily defined as the distance within which received sound levels are above specific harassment levels defined by NOAA and NMFS. "Level A" harassment has been historically correlated with impacts to marine mammals within the Exclusion Zone, while "Level B" harassment is correlated with impacts within the Buffer Zone. This criterion is based on an assumption that sound energy received at lower received levels outside of each respective Zone will not injure or impair the hearing abilities of these animals or effect their natural behaviors. Although the Exclusion and Buffer Zones are not directly based on the acoustic modeling and the "Level A" or "Level B" harassment criteria, it is Beta's intent to provide a standard monitoring distances that will:

1. Encompass zones for most species within which auditory injury could occur on the basis of instantaneous exposure;

2. Provide additional protection from the potential for more severe behavioral reactions for marine wildlife at close range to the acoustic source;

3. Provide consistency for PSOs; and

4. To define a distance within which detection probabilities are reasonably high for most species under typical conditions. In addition, standard zones have been proven as a feasible measure through prior implementation by operators in the Gulf of Mexico (NMFS, 2017f).

5.1.6 Equipment Shut Downs

The operating sound source(s) will be shut down completely if a marine mammal approaches or enters the Exclusion Zone to reduce exposure of the animal to less than radius of the Exclusion Zone. Full sound source array activity will not resume until the marine mammal or turtle has cleared the Exclusion Zone in accordance with the criteria above.

When four shut downs occur for mysticete whales (low-frequency cetacean) in the Exclusion Zone, a Project review will be initiated immediately with the BSEE 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 agencies.

5.1.7 Special Shut-Down Provisions

5.1.7.1 Special-Status Species Shutdowns

If at any time an endangered species (i.e. blue whale, fin whale, humpback whale, sei whale, north pacific right whale, or sperm whale) is visually or acoustically detected at any distance, the PSO and/or PAM operator on duty will call for the immediate shut down of the sound source. When the PSO or Passive Acoustic Monitor (PAM) operator on duty confirms that no marine mammal has been detected within the 1000-m (3,280-ft) Buffer Zone for at least a 30-minute period, a ramp up can commence, and survey operations can continue.

5.1.7.2 Delphinoid and Pinniped Shutdowns and Ramp ups

No mitigation action will be required if delphinoids (members of the family Delphinidae) or pinnipeds (otariids and/or phocids) are visually observed to be "voluntarily approaching" the survey vessel or towed source array. A voluntary approach is defined as a clear and purposeful approach toward the vessel by a dolphin or pinniped at a speed and vector that indicates the animal(s) intends to approach the vessel (BOEM 2014). NMFS (2001, p.9293) states that an exposure to a specific activity that does not disrupt an animal's normal behavioral pattern should not require a take authorization. Therefore, a delphinoid or pinniped voluntarily approaching the survey vessel during acquisition would not be considered to display an adverse behavioral reaction that is significant enough to constitute a disturbance. A shutdown will be observed when a delphinoid or pinniped is:

- Visually detected not exhibiting a travelling behavior. If animals are stationary for any reason and the vessel approaches the animals then a shutdown will occur (NMFS, 2017c); or
- Acoustically detected entering the Exclusion Zone and a visual observation to determine the dolphin's intent is not possible.

If a delphinoid or pinniped comes within 10 m (32 ft) of the source array where received sound levels are estimated to be ≥185 dB (mid-frequency cetacean PTS criteria) then a shutdown will commence immediately. A ramp-up will be initiated when the animal is confirmed to have moved at least 10 m (32 ft) away from the source. Full power will resume when the PSO and/or PAM operator can confirm the dolphins or otariid pinniped have left the 500 m (1,640 ft) mitigation zone or are engaged in bow riding or wake riding.

In addition, no shut down will be required for pinnipeds if they are hauled out on or in the water adjacent to Beta platforms within the survey area. If a otariid pinniped comes within 10 m (32 ft) of the source array where received sound levels are estimated to be ≥203 dB (otariid PTS criteria) then a shutdown will commence immediately. A ramp-up will be initiated when the animal is confirmed to have moved at least 10 m (32 ft) away from the source, or the vessel has moved greater than 10 m (32 ft) from the associated platform. These measures are proposed in an effort to reduce the cumulative sound energy input into the marine environment, decrease the total duration of active surveys, and therefore, reduce the total impact to marine wildlife populations in the region.

5.1.8 Speed and Course Alterations

If a marine mammal or turtle is detected outside the applicable Exclusion Zone and, based on its position and direction of travel, is likely to enter the Exclusion Zone, changes in the vessel's speed or course will be considered if this does not compromise operational safety. For surveys using large streamer arrays, course alterations are more difficult; therefore, the proposed Project does not include use of streamers to obtain data. After any such speed and/or course alteration is begun, the animal's activities and movements relative to the survey vessel will be closely monitored to ensure that it does not enter into the Exclusion Zone. If the mammal or turtle appears likely to enter the Exclusion Zone, further mitigation actions will be taken, including a full shut down of the sound sources.

The survey vessel and other Project support vessels will transit to and from Long Beach Harbor or near-by mooring buoys when their assistance is requested. All Project support vessels will have a transit speed limit of 3 to 5 knots maximum while assisting the survey vessel in the Project area. When whales are observed in the Project area and/or are observed proximal to the any Project vessel during transit periods the vessel operator will observe the following guidelines:

- Maintain a minimum distance of 330 ft (100 m) from sighted whales;
- Do not cross directly in front of or across the path of sighted whales;
- Transit parallel to whales and maintain a constant speed that is not faster than the whale's speed;
- Do not position the vessel in such a manner to separate a female whale from her calf;
- Do not use the vessel to herd or drive whales; and,
- If a whale engages in evasive or defensive action, slow the vessel and move away from the animal until the animal calms or moves out of the area.

5.1.9 Ramp Up of Equipment

The ramping up of the sound source array provides a gradual increase in sound levels, and involves a step-wise increase in the number and total volume of sound sources firing until the full volume is achieved. The purpose of a ramp up (or soft start) is to "warn" cetaceans, pinnipeds and other sensitive wildlife in the vicinity of the array by generating lower level noise thus providing the animals time for them to leave the area and thus avoid any potential injury or impairment of their hearing abilities.

Anytime survey operations require an increase in noise/energy production, the survey operator will ramp up the sound source cluster slowly (6 dB/5 min). Full ramp ups (i.e., from a cold start after a shut down, when no sound sources have been firing) will begin by firing a single sound source in the array. The minimum duration of a shut-down period, which must be followed by a ramp up, is typically the amount of time it will take the source vessel to travel across the Exclusion Zone. Full power will be obtained no sooner than 30 minutes from restarting the equipment.

A full ramp up, after a shut down, will not begin until there has been a minimum of 45 minutes of observation of the Exclusion Zone with no marine mammals or turtles present. The entire Exclusion Zone must be visible during the 45-minute 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) or turtle is sighted within the Exclusion Zone during the 45-minute watch prior to ramp up, ramp up will be delayed until the marine mammal(s) or turtle are sighted outside of the Exclusion Zone or the animal(s) has/have not been sighted for at 30 minute for small odontocetes and pinnipeds, or 45 minute for baleen whales and large odontocetes. PSOs will be on duty during both day and night 45-minute observation periods prior to and during ramp-ups. The survey operator and PSOs will maintain records of the times when ramp-ups start, and when the sound source arrays reach full power.

5.1.10 Entanglement

To minimize the risk of entanglement with marine wildlife, lines and cables necessary to perform the survey tasks will be left in the water only as long as necessary to perform the task and then be retrieved back on deck. All other non-essential lines and cables will be kept clear of the water when not in use. All lines and cables will be kept as short as possible and with a minimum amount of slack. In addition, while the sound source array is being deployed, the survey vessel speed will be limited to two knots. Line and cables associated with the sound source array and autonomous nodal system will be greater than 0.25 in (0.64 cm) in diameter or will be modified to increase the diameter and rigidity of the lines.

The seafloor nodal system is autonomous and would not require electrical cable connection for operation, though nodes are physically tethered together by cable/rope, which dimensions would be approved by NMFS to reduce the likelihood of entanglement. Autonomous nodes would be deployed and recovered by the M/V *Clean Ocean* utilizing commercial deployment methods.

5.1.11 Marine Wildlife Carcasses

If an injured or dead marine mammal, turtle or bird is sighted within an area where sound sources 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 geophysical survey 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 or the NMFS Southwest Regional Office. The sound source 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.

5.1.12 Monitoring

5.1.12.1 Vessel-based Marine Wildlife Contingency Plan

Beta will implement a Marine Wildlife Contingency Plan (MWCP) that includes measures designed to reduce the potential impacts on marine wildlife, particularly marine mammals, by the proposed operations. This program will be implemented in compliance with measures developed in consultation with the NMFS and will be based on anticipated Exclusion and Buffer Zones derived from modeling of the selected source levels. These proposed Exclusion and Buffer Zones would be reviewed in context with the Incidental Harassment Authorization (IHA) to be issued by NMFS as part of the Project review under the Federal Endangered Species Act (ESA) and Marine Mammal Protection Act (MMPA).

The MWCP will be implemented by a team of experienced Protected Species Observers (PSOs). PSOs will be stationed aboard the survey vessels throughout 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 and LOA.

The vessel-based work will provide:

- The basis for real-time mitigation, if necessary, as required by the various permits issued to Beta;
- 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 acoustic activity.

5.1.12.2 Protected Species Observers

Vessel-based, and as needed platform-based, monitoring for marine wildlife will be performed by trained PSOs throughout the period of survey activities to comply with expected provisions in the IHA and LOA that Beta receives. Visual monitoring will occur primarily during daylight. However, when Passive Acoustic Monitoring (PAM) and/or thermal imaging cameras detects marine mammals in the survey area at night, visual monitors will be deployed to attempt visual detection. The monitors will monitor the occurrence and behavior of marine wildlife near the survey vessels during all operations. PSO duties will include watching for and identifying marine wildlife; recording their numbers, distances, and reactions to the survey operations; and, documenting “take by harassment” as defined by NMFS. A sufficient number of PSOs will be required onboard the survey vessel to meet the following criteria:

- 100 percent monitoring coverage during all periods of survey operations in daylight;

- Maximum of 4 consecutive hours on watch per PSO; and,
- Maximum of ~12 hours of watch time per day per PSO.

An experienced field crew leader will supervise the PSO team onboard the survey vessels. Crew leaders and most other biologists will be individuals with experience as observers during similar monitoring projects in California, or other offshore areas in recent years. Resumes for those individuals will be provided to NMFS and USFWS for review and acceptance of their qualifications.

PSOs will have the appropriate safety and monitoring equipment to conduct their observations, including night-vision equipment, low light reticulated binoculars, and thermal imaging cameras for 24/7 operations. In addition, bigeye binoculars will be mounted on the survey vessel for PSO observation purposes. PSOs will utilize a handheld global positioning system (GPS) or the ship's navigation system to record latitude and longitude for each marine wildlife observation. Each PSO will have a handheld radio for communication with the bridge, other Project vessels, and Beta platforms, as necessary. In addition, cell phones, VHS radio, and email capabilities will be available to communicate with onshore personnel.

5.1.12.3 Vessel Based Monitoring

Vessel-based monitoring of marine wildlife will consist of both visual and acoustic observations. Visual observations will be completed by qualified onboard PSO throughout the daylight periods of the survey. Acoustic monitoring will occur during both day and night operations and will utilize onboard acoustic equipment.

***Visual Monitoring*.** The PSOs will coordinate with the captain of the survey vessel or his representative to select an appropriate monitoring position where they can monitor the Exclusion Zone radius and will have a clear view of the area of ocean that is in the direction of the course of travel while the vessel is transiting. The PSOs will observe marine wildlife and will request procedures to shut-down or ramp-up sound source operations, and/or avoid potential collisions and/or entanglement with marine wildlife. The PSOs will be on station at least 30 minutes before survey activities begin and will remain on duty until at least 30 minutes after all survey activities have been completed. The PSOs will arrange their own schedules to ensure complete coverage while Project activities are occurring.

The PSOs will establish and monitor a 1,640 ft (500 m) Exclusion Zone radius and 3,280 ft (1,000 m) Buffer Zone. These Zones will be based on the radial distance from any element of the sound source array, rather than being based on based on the center of the array or around the vessel itself. If a PSO should observe marine wildlife within the Exclusion Zone of the survey vessel, the monitor will immediately report that observation to the vessel operator who will shut-down the survey operations, slow the vessel and/or change course in order to avoid contact, as deemed necessary by the PSO, unless those actions will jeopardize the safety of the vessel or crew. The path of the marine animal will be closely monitored to determine when it has safely passed through the designated impact zone and Project activities can be ramped up as detailed in Section 5.1.9. The PSO will have the authority to stop any activity that could result in harm to marine wildlife.

If the PSO should observe marine wildlife within the Buffer Zone, the behavior of marine animal will be monitored, and the survey operator will be alerted of the potential for an imminent shut down. If the marine animal within the Buffer Zone displays abnormal behaviors or distress, the monitor will immediately report that observation to the vessel operator who will shut-down the sound source operations, slow the vessel and/or change course in order to avoid contact, as deemed necessary by the PSO, unless those actions will jeopardize the safety of the vessel or crew. Distress can be defined as any abnormal behavior that appears to be related to Project operations such as sudden change in direction, rapid breathing, and sudden or erratic changes in behavior.

Passive Acoustic Monitoring. PAM will be used to detect cetacean species and will complement the visual monitoring program. 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. Acoustic monitoring can be used in addition to visual observations to improve detection, identification, and location of vocalizing cetaceans. Acoustic monitoring will be conducted in real time so that the visual observers can be advised when cetaceans are detected. Detection distance will depend on the target species and hardware used during monitoring.

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 approximately 800 ft (250 m) long, and the hydrophones are fitted in the last 32.0 ft (10.0 m) of cable. A depth gauge is attached to the free end of the cable, and the cable is typically towed at depths <66.0 ft (20.0 m). The array will be deployed by a winch located on the aft deck and 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, or a comparable, preferred software. The system can detect marine mammal vocalizations at frequencies up to 250 kHz.

At least one acoustic PAM operator (in addition to the four visual PSOs) will be onboard the survey vessel area during survey operations. The PAM operator will monitor the acoustic detection system 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 PAM operating shift can be from one to six hours long and PSOs are expected to rotate through the PAM operating position, although the lead operator will be on PAM duty more frequently.

When a vocalization is detected inside the Exclusion Zone during daylight operations, the PAM operator 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 sound source shut down to be initiated, if required. In addition, PAM shall be performed during night-time operations and may be supplemented by visual monitoring using equipment to enhance detection rates, including advanced infrared equipment, sodium lighting, and/or millimeter waves radar. When a cetacean is detected by acoustic monitoring within the Exclusion Zone during non-daylight hours, a visual PSO, the geophysical crew, and the captain of the survey vessel will be notified immediately so that APMs may be implemented. The PAM operator will continue to monitor the hydrophones and inform a visual PSO, 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, types and nature of sounds heard (e.g., clicks, continuous, sporadic, whistles, creaks, burst pulses, strength of signal, etc.); and, any other notable information.

Thermal Imaging Cameras. Thermal imaging cameras will be utilized during hours of darkness to assist with nighttime ramp up pre-clearance searches. The dual camera system enables consistent visual monitoring in low visibility and night time conditions. Real-time monitoring stations can be set up on the vessel and/or image data can be recorded for later playback analysis. The camera system consists of two modules: a High Definition (HD) camera and a thermal imaging camera configured for maritime use with pan and tilt functionality. The system uses Seiche proprietary software Real-time Automated Distance Estimate at Sea (RADES) to stabilize image and enable accurate distance estimation. Various configuration options are available to ensure optimal visual coverage of up to 360 degrees. Three Cameras would be installed for full 360 degrees coverage. In addition, Buffer and Exclusion Zone distances can be overlaid onto thermal images to assist in monitoring wildlife within impact zones.

5.1.12.4 Platform Based Monitoring

To achieve complete observation of both the Exclusion and Buffer Zones, additional monitoring will be implemented from Project platforms during active sound source operations, as necessary based on the presence and density of marine wildlife observed. PSOs stationed on platforms will be in direct contact with PSOs stationed on the survey vessel through VHF radios or cell phones, whichever provides better service based on the survey vessel's location. The PSO on duty will be stationed on the highest deck (i.e., helideck or approximately 100 ft [37 m] above sea level) of the platform where he/she can safely monitor the entire range of the Exclusion and Buffer Zone. In addition, PSOs will be able to monitor the behavior and reactions of pinnipeds in the water adjacent to the platform during active sound source operations. If a PSO on a platform should observe marine wildlife within the Buffer or Exclusion zone of the survey vessel, the monitor will immediately report that observation to the on duty PSO on the survey vessel. The vessel-based PSO will notify the vessel operator and/or survey team, who will shut-down the survey operations, slow the vessel and/or change course in order to avoid contact, as deemed necessary by the PSO, unless those actions will jeopardize the safety of the vessel or crew. The path of the marine animal will be closely monitored to determine when it has safely passed through the designated impact zone. Daily observation records will be cross-referenced between the platform and vessel-based PSOs field reports to ensure observations are not duplicated.

5.1.13 Data Recording

5.1.13.1 Visual Monitoring Data

Information to be recorded by onboard PSOs will include data which has been documented during recent monitoring programs associated with other marine geophysical surveys completed offshore California. When a mammal sighting is made, the following information about the sighting will be recorded:

- Species, group size, age/size/sex categories (if determinable), behavior when first sighted and after initial sighting, heading (if determinable), bearing and distance from sound source array, apparent reaction to activities (e.g., none, avoidance, approach, paralleling, etc.), closest point of approach, and pace;
- Time, location, speed, and activity of the vessel, sea state, and visibility; and,
- The positions of other vessel(s) near the observer location.

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

The PSOs will record their observations onto datasheets or directly into handheld computers. Between watches and during 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 against the original raw data on the field sheets. These procedures will allow initial summaries of data to be prepared during and shortly after the field season, 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-season training session; (2) subsequent supervision by the onboard field crew leader; and, (3) ongoing data checks during the field session.

5.1.13.2 Acoustic Monitoring Data

Each vocalization detected by the PAM operator will be entered into a database that will include: a unique acoustic encounter identification number; whether the vocalization was linked to a visual sighting; date and time when vocalization was first and last heard; position and water depth when vocalization was first detected; bearing from the vessel, if determinable; species or species group, if possible; type(s) and nature of sounds (e.g., clicks, continuous, sporadic, whistles, creaks, burst pulses) and strength of signal; and, any other notable information. Each vocalization sound will be recorded on the computer for further analysis.

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

5.1.14 Reporting

5.1.14.1 Field Reports

Throughout the survey program, observers will prepare a daily report summarizing the recent results of the monitoring program or at such other intervals as required by regulatory and resource agencies. The reports will summarize the species, number of marine wildlife sighted, and any required actions taken.

5.1.14.2 Injured or Dead Animal

If an injured or dead animal is sighted within an area where the geophysical survey 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 survey or Project vessel 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 lead PSO 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 or the NMFS Southwest Regional Office. The sound source 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.

5.2 MEASURES TO REDUCE SEAFLOOR IMPACTS FROM NODE PLACEMENT

5.2.1 Pre-Project Seafloor Clearance

A pre-Project seafloor clearance will be conducted to confirm habitat type that the nodes will be placed on. In addition, this will provide information on what debris currently exists within the survey area.

5.2.2 Post-Project Seafloor Clearance

A post-Project seafloor clearance will be completed by a remote operated vehicle (ROV) once the Project is complete and all nodes are removed from the seafloor. This seafloor clearance will aid in confirmation that no debris was left behind and to help access if damage occurred as a result of node placement.

5.3 MEASURE TO REDUCE LIGHTING IMPACTS TO MARINE BIRDS

To minimize the potential for seabirds to be attracted to the vessel, lighting on the work areas will be directed inboard and downward. Where feasible, the vessel cabin windows will be equipped with shades, blinds or shields that block internal light during nighttime operations. In addition, the vessel will carefully contain and remove garbage and food waste to minimize attracting predatory and scavenging birds.

The onboard monitors will routinely inspect the vessel for birds that may have been attracted to the lighted vessel. The monitors shall make every effort for the vessel to maintain a distance of 300 feet from aggregations of feeding or resting marine birds. The monitors shall maintain a log of all birds found onboard the vessels which are incapacitated (dead or alive) and noting the status and health of birds upon retrieval and release. The log will be provided to BOEM when the Project has been completed.

If an injured bird is discovered on a vessel, the bird will be transported on the next returning work vessel to an approved wildlife care facility. The nearest approved wildlife care facility will be contacted upon transport of the bird. The incapacitated bird will be reported on the daily summary report, and added to a cumulative log, which will be sent to BOEM at the completion of the Project.

5.4 MEASURES TO REDUCE POTENTIAL VESSEL COLLISION IMPACTS ON MARINE WILDLIFE

Because of the procedures described for Exclusion and Buffer Zones during survey operations and the slow speed at which the survey vessel will maintain during survey operations, collisions with marine wildlife are very unlikely. However, the potential exists for such collisions when transiting to the Project site by the survey vessel and support vessels. The following measures and procedures will be implemented to minimize the possibility of such collisions.

On-board personnel, including the onsite MWMs, will be watchful for marine mammals and turtles during transit and Project activities. Pinnipeds, the most common marine mammals within the vessel transit corridors, are "nimble" enough to avoid these vessels. Slower moving and surface dwelling turtles and larger cetaceans could potentially be affected. Blue and humpback whales are not common within the Project site and transit corridor. More common marine mammals in the Project area, such as dolphins and pinnipeds, would be agile enough to avoid vessels. Irrespective, all vessel operators shall observe the following guidelines:

- Make every effort to maintain the appropriate separation distance from sighted whales and other marine wildlife (e.g., sea turtles);
- Do not cross directly in front of (perpendicular to) migrating whales or any other marine mammal or turtle;
- When paralleling whales, vessels will operate at a constant speed that is not faster than that of the whales;
- Care will be taken to ensure that female whales are not be separated from their calves; and,
- If a whale engages in evasive or defensive action, vessels will reduce speed or stop until the animal calms or moves out of the area.

If a collision with a marine mammal or turtle occurs, the vessel operator must document the conditions under which the accident occurred, including the following:

- Location of the vessel when the collision occurred (latitude and longitude);
- Date and time;
- Speed and heading of the vessel;
- Observation conditions (e.g., wind speed and direction, swell height, visibility in miles or kilometers, and presence of rain or fog);
- Species of marine wildlife contacted;
- Whether an observer was standing watch for the presence of marine wildlife; and,
- Name of vessel, operator (the company), and captain or officer in charge of the vessel at time of accident.

Following an unanticipated strike, the vessel will stop if safe to do so. The vessel is not obligated to stand by and may proceed after confirming that it will not further damage the animal by doing so. The vessel will then communicate by radio or telephone all details to the vessel's base of operations. From the vessel's base of operations, a telephone call will be placed to the Stranding Coordinator, NMFS, Southwest Region, Long Beach, to obtain instructions (see below).

Alternatively, the vessel captain may contact the NMFS' Stranding Coordinator directly using the marine operator to place the call or directly from an onboard telephone, if available. It is unlikely that the vessel will be asked to stand by until NMFS or CDFG personnel arrive, but that will be determined by the Stranding Coordinator. Under the MMPA, the vessel operator is not allowed to aid injured marine wildlife or recover the carcass unless requested to do so by the NMFS Stranding Coordinator. The Stranding Coordinator will then coordinate subsequent action, including enlisting the aid of marine mammal rescue organizations, if appropriate.

Although NOAA Fisheries has primary responsibility for marine wildlife in both State and Federal waters, the CDFW will also be advised if an incident has occurred in State waters affecting a protected species. Reports will be communicated to the Federal and State agencies listed in Table 5.5-1.

Table 5.5-1. Collision Contact Information

Federal	State
Justin Viezbicke Stranding Coordinator NOAA Fisheries Service Long Beach, California (562) 980-3230	Enforcement Dispatch Desk California Department of Fish and Wildlife Los Alamitos, California (562) 598-1032

As proposed, and with the existing measures incorporated into the vessel operations, vessel strikes could, but are not likely to, affect Federally listed marine species.

5.5 MEASURES TO REDUCE POTENTIAL OIL SPILL IMPACTS

The current oil spill prevention plan will be used to avoid any release of oil-based products into the marine environment, and the existing oil spill response and recovery plan will be used to reduce the effects of accidentally discharged petroleum by facilitating rapid response and cleanup operations. The following mitigations have been incorporated into the proposed plan of operation and will result in reducing the chances of a spill occurring:

- **Beta Unit Oil Spill Prevention and Response.** All Project activities will be subject to the requirements and guidelines included within the "Beta Unit Complex (Platforms Elly, Ellen & Eureka, Beta Pipeline and Beta Pump Station) Oil Spill Prevention and Response Plan (OSPRP) - Revision 3" (2016), (Appendix H).
- **Vessel Specific Oil Spill Response Plan.** The Geophysical Survey will occur via the use of the M/V *Silver Arrow* or equivalent and will be subject to the requirements and guidelines included within the vessel-specific Oil Spill Response Plan.
- **Vessel Discharges.** All vessel discharges will comply with the requirements of the Clean Water Act under the USCG regulation including the proper treatment and monitoring of vessel effluents as necessary.

6.0 CUMULATIVE EFFECTS

FESA Regulations at 50 CFR 402.14(g)(3)(4) require Federal agencies to "evaluate the effects of the action and cumulative effects on the listed species or critical habitat" and "formulate its biological opinion as to whether the action, taken together with cumulative effects, is likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of critical habitat."

According to the Endangered Species Consultation Handbook (USFWS and NMFS, 1998), cumulative effects include the effects of future State, local or private actions that are reasonably certain to occur in the action area considered in a biological opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to Section 7 of FESA. Indicators of effects "reasonably certain to occur" may include, but are not limited to: approval of the action by State or local agencies or governments (e.g., permits, grants); indications by granting authorities that an action is imminent; assurances by project sponsors that an action will proceed; the obligation of venture capital; and/or initiation of contracts. Speculative non-Federal actions that may never be implemented are not factored into cumulative effects analyses.

The following is a summary of the seismic/geophysical surveys conducted or proposed in the Project area.

6.1 COMPLETED PROJECTS

The last geophysical surveys completed in the Project area were conducted in 1977 and 1984.

6.2 PROPOSED PROJECTS

No other projects are proposed in the area.

6.3 CUMULATIVE ANALYSES

The National Science Foundation and U.S. Geological Survey (NSF/USGS, 2011), in their programmatic EIS for marine seismic research, indicated that noise-producing activities that must be considered when analyzing the cumulative impacts of proposed seismic surveys include commercial shipping, oil and gas exploration and production, aircraft flights, naval operations, research, commercial fishing, and recreational activities.

In comparison to commercial shipping, NSF/USGS (2011) noted that its proposed 5 to 7 surveys trips per year proposed for the Northwest Atlantic, Southern California, and Gulf of Mexico represents less than 0.001 percent of the total vessel traffic. The geophysical survey represented by the proposed Project would constitute an even smaller percentage of total vessel traffic and, consequently, an insignificant contribution to the vessel noise generation.

6.3.1 Cumulative Effects on Marine Fish, Sea Turtles, and Seabirds

Based on the analyses conducted by NSF/USGS (2011), the adverse pathological and physiological effects of acoustic sources on marine invertebrate, would only occur within a few meters of active sources operating at high levels. Behavioral effects could extend to greater ranges. However, on a population level, these potential effects are considerate insignificant

The principal impacts on marine fish identified by NSF/USGS (2011) were expected to be short-term behavioral or physiological from sound arrays. NSF/USGW (2011) indicated that impacts to marine fish were not predicted to be significant.

These taxa may be impacted by vessel traffic, noise from commercial shipping, oil and gas operations, military activities, commercial and recreational fishing, and other activities.

The proposed Project is a very minor and short-term incremental increase in the overall level of human activity in the area. The planned monitoring and mitigation measures, including avoidance of sensitive habitats, seasonal restrictions, visual monitoring, and establishment of Exclusion and Buffer Zones, would serve to reduce the level of impact and the likelihood of cumulative effects. The impacts to marine invertebrates and fish from the proposed Project in combination with other cumulative activities are expected to be limited, consisting of primarily short-term behavior, and not expected to be significant (NSF/USGS, 2011).

Acoustic impacts of acoustic sources or sonar devices on seabirds are unlikely to occur due to the distance for nesting areas and the timing of activities.

NSF/USGS (2011) note that there is some overlap between sea turtle hearing and the frequencies used in seismic surveys, but no mortality has been documented during seismic operations funded by NSF or conducted by USGS. NSF/USGS predict that any acoustic impact would consist of short-term behavioral disturbance if a sea turtle ventured close to an operating source array.

NSF/USGS (2011) note that commercial and recreational vessel traffic, fishing, oil and gas exploration and development, coastal development, and hunting could lead to direct sea turtle mortality. Oil spills, ship strikes, entanglement in fishing gear, and ingestion of marine garbage, are among threats to sea turtles, and could occur in the Project area. Survey activities would represent a minor incremental, short-term increase in the overall human activity and combined with avoidance, minimization, and mitigation measures, would reduce the level of impact on sea turtles such that cumulative impacts would be negligible (NSF/USGS, 2011).

6.3.2 Cumulative Effects on Cetaceans and Pinnipeds

NSF/USGS (2011) modeled the impacts of seismic surveys to marine mammals from 13 areas around the world, including Southern California. Impacts were expected to be localized and short-term behavioral changes, with no impacts at the regional population level. Based on the duration and location of proposed NSF/USGS seismic surveys, which are considered similar to the proposed Project, cumulative effects on marine mammals at the individual or population level would be negligible unless conducted at a time and location of large mammal concentrations, such as at a breeding colony (NSF/USGS, 2011). However, because of increased human activities in Southern California, there is an elevated, potential for cumulative impacts, though still considered negligible. Implementation of avoidance, minimization, and mitigation measures would further minimize potential cumulative effects.

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7.0 CONCLUSION AND DETERMINATION

Implementation of the survey will involve impacts to marine species and habitats that could affect listed and/or proposed species in the Project area. A total of 16 listed marine species have been analyzed in this BA. Table 7.0-1 below provides an analysis of the potential Project effects on the following: habitat loss, mortality, harassment, loss of prey, loss of shelter/cover, loss of access to habitats, noise and light effects, habitat fragmentation, urbanization, increased predation, and critical habitat.

The proposed Project may affect, but is not likely to adversely affect the listed and proposed species for the following reasons:

- The Project would not involve temporary or permanent loss of habitat;
- The Project would be completed within a 28-day period;
- The Project would be of limited geographic effect; and,
- The Project will include avoidance, minimization, and mitigation measures, as detailed in Section 5.0, to avoid and minimize potential adverse effects.

7.1 POTENTIAL NUMBER OF "TAKES BY HARASSMENT"

The number of individuals of each listed marine mammal species potentially exposed to Level B and Level A harassment levels were estimated by multiplying the anticipated area to be ensonified by the expected species density (in number/km^2) and by duration of survey as detailed in the Incidental Harassment Authorization request.

Some of the animals estimated to be exposed might show avoidance reactions before being exposed to Level B or Level A harassment. Thus, these calculations actually estimate the number of individuals potentially exposed to these levels if there were no avoidance of the area ensonified to that level and, as such, may be overestimates.

Tables 7.1-1 shows the estimated number of listed marine mammals, by species that would be potentially exposed to sounds equal or greater than the Level B or Level harassment levels from data acquisition in the survey area.

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Table 7.0-1. Potential Effects Matrix for Protected Species

Species	Loss of Habitat[1]	Mortality[2]	Harassment[3]	Loss of Prey[4]	Loss of Cover[5]	Loss of Access[6]	Noise/Light[7]	Fragmentation[8]	Urbanization[9]	Predation[10]	Critical Habitat[11]	Effect Determination[12]
White abalone	a	a	a	a	a	a	a	a	a	a	a	b
Steelhead (Southern California DPS)	b	b,c,d	b	b	b	b	b	b	a	b	b	b
California Least Tern	b	b,d,e	c	b	b,c	b,c	c,d	b	a	c,d	a	b
Marbled Murrelet*	a	a	a	a	a	a	a	a	a	a	a	a
Short-tailed Albatross*	a	a	a	a	a	a	a	a	a	a	a	a
Green Turtle	b	b,c,d	b	b	b	b	b	b	a	b	b	b
Loggerhead Turtle	b	b,c,d	b	b	b	b	b	b	a	b	a	b
Olive Ridley Turtle	b	b,c,d	b	b	b	b	b	b	a	b	a	b
Leatherback Turtle	b	b,c,d	b	b	b	b	b	b	a	b	b	b
Blue Whale	b	b,c,d	b	b	b	b	b	b	a	c	a	b
Fin Whale	b	b,c,d	b	b	b	b	b	b	a	c	a	b
Humpback Whale	b	b,c,d	b	b	b	b	b	b	a	c	a	b
Northern Pacific Right Whale	b	b,c,d	b	b	b	b	b	b	a	c	b	b
Sei Whale*	b	b,c,d	b	b	b	b	b	b	a	c	a	b
Sperm Whale	b	b,c,d	b	b	b	b	b	b	a	c	a	b
Guadalupe Fur Seal	b	b,c,d	b	b	b	b	b	b	a	b	a	b

[1]Loss of Habitat Codes

a. Species not expected to occur in Project area.
b. No habitat will be temporarily or permanently lost.

[2]Mortality Codes

a. Species not expected to occur in Project area.
b. Mortality has not been observed from seismic operations.
c. Collisions with vessels resulting in the death of listed species have occurred in the recent past. However, due to low seismic vessel speed during operations, as well as mitigation measures proposed, collisions are a low probability event.
d. Oil spills or the release of other pollutants from the survey vessels is a low probability event based on the nature of the operation.
e. Project designed to avoid impacts to terrestrial species.

[3]Harassment

a. Species not expected to occur in Project area.
b. Species may be subject to harassment from noise. See Table 8.1-1 for estimate of numbers of marine mammals potentially occurring in the Project area.
c. Species not likely to be subject to noise harassment due to terrestrial habit.

[4]Loss of Prey

a. Species not expected to occur in Project area.
b. No permanent loss of prey expected. Short-term displacement of prey from immediate area of operations could occur.

[5]Loss of Shelter/Cover

a. Species not expected to occur in Project area.
b. Temporary displacement during survey operations, likely only when vessel and source arrays are in immediate area of shelter. No permanent loss of cover.
c. Project designed to avoid impacts to terrestrial species.

[6]Loss of Access

a. Species not expected to occur in Project area.
b. Temporary displacement during survey operations, likely only when vessel and source arrays are in immediate area. No permanent loss of access.
c. Project designed to avoid impacts to terrestrial species.

[7]Noise/Light Impacts

a. Species not expect to occur in Project area.
b. Harassment from noise is potential (see Harassment above).
c. Night operations could attract species to illuminated vessels.
d. Project designed to avoid impacts to terrestrial species.

[8]Habitat Fragmentation

a. Species not expected to occur in Project area.
b. No temporary or permanent loss of habitat will occur. Consequently, no fragmentation.

[9]Urbanization

a. Not applicable

[10]Increased Predation

a. Species not expected to occur in Project area.
b. Masking could increase vulnerability of certain species to increased predation, but avoidance and minimization measures would deter species of areas where masking could potentially occur.
c. Not likely to be vulnerable to increased predation due to species size, trophic status, or habit.
d. Project designed to avoid impacts to terrestrial species.

[11]Critical Habitat

a. No critical habitat designated for species.
b. Critical habitat designated for species, but none occurring in Project area.
c. Proposed or designated Critical habitat occurs within Project area. Project would not result in destruction or adverse modification of critical habitat.

[12]Effect Determination

a. No effect
b. May affect, but not likely to adversely affect
c. May affect and likely to adversely affect

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Table 7.1-1. Estimated Density of Marine Mammals by Species in Project Area and Potential "Takes" for Level A and Level B

Common Name	NMFS Density Data (No/Km^2)			Requested Mitigated Level A "Take"	Requested Mitigated Level B "Take"
	Min	Max	Mean		
Mysticeti					
Blue whale	0.007764	0.008181	0.007962	0	88
Fin whale	0.004013	0.004446	0.004231	0	47
Humpback whale	0.001075	0.001675	0.001370	0	15
Northern Pacific right whale			0.000061	0	1
Sei whale			0.000086	0	1
Odontoceti					
Sperm whale	0.000304	0.000326	0.000313	0	3
Pinnipedia					
Guadalupe fur seal[1]			0.007	0	77

Sources: SERDP, 2017, USN, 2008

[1] Density Data from USN, 2008

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8.0 REFERENCES

Adriguetto-Filho, J., A. Ostrensky, M. Pie, U. Silva, and W. Boeger. 2005. Evaluating the impact of seismic prospecting on artisanal shrimp fisheries. Continental Shelf. Research 25: 1720-177.

Albers, P.H. and R. Szaro. 1978. Effects of No. 2 Fuel Oil on Common Eider Eggs. Marine Pollution Bulletin. Vol.9.

Allen, S., J. Mortenson, and, S. Webb. 2011. Field Guide to Marine Mammals of the Pacific Coast: Baja, California, Oregon, Washington, British Columbia. University of California Press. Berkeley, California.

Anonymous. 2002. Effects of artificial light at night on wildlife. International Dark-Sky Association Information Sheet #187. 3 pp.

Australian Maritime Safety Authority. 2010. Effects of Maritime Oil Spills on Wildlife. http://www.amsa.gov.au/Marine_Environment_Protection/National_Plan/General_Information/Oiled_Wildlife/Oil_Spill_Effects_on_Wildlife_and_Non-Avian_Marine_Life.asp. Web: 13 July 2010.

Bain, D.E. and R. Williams. 2006. Long-range effects of airgun noise on marine mammals: responses as a function of received sound level and distance. Working Paper. SC/58/E35. International Whaling Commission. Cambridge, U.K. 13 p.

Barry, S.B., A.C. Cucknell, and N. Clark. 2010. A direct comparison of bottlenose and common dolphin behavior during seismic surveys when airguns are and are not being utilized. Abstract *In:* Second International Conference on The Effects of Noise on Aquatic Life, Cork, Ireland, August 15-20, 2010.

Bjorndal K.A., A.B. Meylan, and B.J. Turner. 1983. Sea turtles nesting at Melbourne Beach, Florida, I. Size, growth and reproduction. Biol. Conserv. 26(1):65-77.

Black, A. 2005. Light induced seabird mortality on vessels operating in the Southern Ocean: incidents and mitigation measures. Antarctic Science 17 (1), pp. 67-68.

Blix, A. S., H. Grav, and K. Ronald 1979. Some aspects of temperature regulation in newborn harp seal pups. Am. J. Physiol. 236.

Boeger, W.A., M.R. Pie, A. Ostrensky, and M.F. Cardoso. 2006. The effect of exposure to seismic prospecting on coral reef fishes. Braz. J. Oceanog. 54(4):235-239.

Bowles, A.E., M. Smultea, B. Würsig, D.P. DeMaster, and D. Palka. 1994. Relative abundance and behavior of marine mammals exposed to transmissions from the Heard Island Feasibility Test. Journal of the Acoustical Society of America 96(4):2469-2484.

Bruderer, B., D. Peter, and T. Steuri. 1999. Behavior of migrating birds exposed to x-band radar and a bright light beam. Journal of Experimental Biology 202: (9) 1015-1022.

Calambokidis, J. and S.D. Osmek. 1998. Marine mammal research and mitigation in conjunction with airgun operation for the USGS 'SHIPS' seismic surveys in 1998. Report by Cascadia Research, Olympia, WA, for U.S. Geological Survey and Minerals Management Service.

Carls, M., S. Rice, and J. Hose. 1999. Sensitivity of fish embryos to weathered crude oil: Part I. Low level exposure during incubation causes malformations, genetic damage, and mortality in larval Pacific herring (Clupea pallasii). Environmental Toxicology Chemistry 18: 481-493.

Carey, William. 2009. Lloyd's Mirror – Image Interference Effects. Acoustics Today, Vol. 5 Issue 2. pp. 14-20. April 2009.

Castellote, M., C.W. Clark, and M.O. Lammers. 2010. Acoustic compensation to shipping and airgun noise by Mediterranean fin whales (*Balaenoptera physalus*). Abstract. *In*: The Second International Conference on The Effects of Noise on Aquatic Life, Cork, Ireland, August 15-20, 2010.

Chapman, C.J. and A.D. Hawkins. 1969. The importance of sound in fish behavior in relation to capture by trawls. FAO Fisheries Report 62:717-729.

Christian, J.R., A. Mathieu, D.H. Thomson, D. White, and R.A. Buchanan. 2003. Effect of seismic energy on snow crab (*Chionoecetes opilio*). Rep. by LGL Ltd., St. John's, Nfld., for Environmental Studies Research Fund (ESRF), Calgary, Alta. 56 p.

Clark, C.W. and G.C. Gagnon. 2006. Considering the temporal and spatial scales of noise exposures from seismic surveys on baleen whales. Working Paper. SC/58/E9 presented to the International Whaling Commission 9 p.

Cochran, W. W. and R. R Graber. 1958. Attraction of nocturnal migrants by lights on a television tower. Wilson Bulletin 70 (4): 378-380.

Coon, N., P. Albers, and R. Szaro. 1979. No.2 Fuel Oil Decreases Embryonic Survival of Great Black-backed Gulls. Bulletin of Environmental Contamination and Toxicology. Vol. 21.

Cox, K. W., 1960. Review of the Abalone in California. Reprint from California Dept. of Fish and Game Vol. 46 (4). October 1960.

Cox, T.M., T.J. Ragen, A.J. Read, E. Vos, R.W. Baird, K. Balcomb, J. Barlow, J. Caldwell, T. Cranford, L. Crum, A. D'Amico, G. D'Spain, A. Fernandez, J. Finneran, R. Gentry, W. Gerth, F. Gulland, J. Hildebrand, D. Houser, T. Hullar, P.D. Jepson, D. Ketten, C.D. MacLeod, P. Miller, S. Moore, D.C. Mountain, D. Palka, P. Ponganis, S. Rommel, T. Rowles, B. Taylor, P. Tyack, D. Wartzok, R. Gisiner, J. Mead, and L. Benner. 2006.

Understanding the impacts of anthropogenic sound on beaked whales. Journal of Cetacean. Research. Management. 7(3):177-187.

Crum, L.A., M.R. Bailey, J. Guan, P.R. Hilmo, S.G. Kargl, and T.J. Matula. 2005. Monitoring bubble growth in supersaturated blood and tissue ex vivo and the relevance to marine mammal bioeffects. Acoustic Research Letters Online 6(3):214-220.

Dalen, J. and G.M. Knutsen. 1986. Scaring effects in fish and harmful effects on eggs, larvae and fry by offshore seismic explorations. p. 93-102 *In*: H.M. Merklinger (ed.) Progress in underwater acoustics. Plenum, NY. 839 p.

Davis, J. and S. Anderson. 1976. Effects of Oil Pollution on Breeding Gray Seals. Marine Pollution Bulletin 7(6).

Department of the Navy. 2000. NAWCWPNS Point Mugu Sea Range Draft Environmental Impact Statement.

DeRuiter, S. P. Tyack, Y. Lin, A. Newhall, J. Lynch, and P. Miller. 2006. Modeling acoustic propagation of airgun array pulses recorded on tagged sperm whales (*Physeter macrocephalus*). Journal of the Acoustical Society of America 120(6):4100-4114.

DFO (Fisheries and Oceans Canada). 2004. Potential impacts of seismic energy on snow crab. Dept. of Fisheries and Oceans Canadian. Science. Advisory. Section. Habitat Status Report 2004/003.

Di Iorio, L. and C. Clark. 2009. Exposure to seismic surveys alters blue whale acoustic communication. Biological Letter Doi.1098/rsbl.2009.0651

Dunn, R.A. and O. Hernandez. 2009. Tracking blue whales in the eastern tropical Pacific with an ocean-bottom seismometer and hydrophone array. Journal of the Acoustical Society of America 126(3):1084-1094.

Engås, A, S. Løkkeborg, E. Ona, and A.V. Soldal. 1996. Effects of seismic shooting on local abundance and catch rates of cod (*G. morhua*) and haddock (*M. aeglefinus*). Canadian. Journal of Fish and Aquatic Science 53:2238-2249.

Engel, M.H., M.C.C. Marcondes, C.C.A. Martins, F.O. Luna, R.P. Lima, and A. Campos. 2004. Are seismic surveys responsible for cetacean strandings? An unusual mortality of adult humpback whales in Abrolhos Bank, northeastern coast of Brazil. Working Paper SC/56/E28. International. Whaling Commission Cambridge, U.K. 8 p.

Engelhart, F. 1983. Petroleum Effects on Marine Mammals. Aquatic Toxicology, 4 (1983).

Fabricious, E. 1959. What Makes Plumage Waterproof? Tenth Annual Report of the Wildfowl Trust.

Finneran, J.J. 2016. Auditory weighting functions and TTS/PTS exposure functions for marine mammals exposed to underwater noise. Technical Report. May 2016

Finneran, J.J., C.E. Schlundt, R. Dear, D.A. Carder and S. H. Ridgway. 2002. Temporary shift in masked hearing thresholds (MTTS) in odontocetes after exposure to single underwater impulses from a seismic watergun. Journal of the Acoustical Society of America 111:2929-2940.

Finneran, J.J., D.A. Carder, C.E. Schlundt and R.L. Dear. 2010a. Growth and recovery of temporary threshold shift at 3 kHz in bottlenose dolphins: Experimental data and mathematical models. Journal of the Acoustical Society of America 127(5):3256-3266.

Finneran, J.J., D.A. Carder, C.E. Schlundt and R.L. Dear. 2010b. Temporary threshold shift in a bottlenose dolphin (*Tursiops truncatus*) exposed to intermittent tones. Journal of the Acoustical Society of America 127(5):3267-3272.

Finneran, J.J., D.A. Carder, C.E. Schlundt and S.H. Ridgway. 2005. Temporary threshold shift in bottlenose dolphins (*Tursiops truncatus*) exposed to mid-frequency tones. Journal of the Acoustical Society of America 118:2696-2705.

Gabriele, C. and B. Kipple. 2009. Measurements of near-surface, near bow underwater sound from cruise ships. p. 86 *In:* Abstracts of the 18th Biennial Conference on the Biology of Marine Mammals, 12-16 October 2009 Quebec City, Canada.

Gailey, G., B. Würsig, and T.L. McDonald. 2007. Abundance, behavior, and movement patterns of western gray whales in relation to a 3-D seismic survey, northeast Sakhalin Island, Russia. Environmental Monitoring and Assessment. 134(1-3):75-91. doi: 10.1007/s10661-007-9812-1.

Gauthreaux, Jr., S. A. and C G. Belser. 2002. The behavioral responses of migrating birds to different lighting systems on tall towers. In: Rich, C. and T. Longcore (eds) Ecological Consequences of Artificial Night Lighting. Abstracts from The Urban Wildlands Group and UCLA Conference in Los Angeles, February 23-24, 2002.

Gedamke, J., S. Frydman, and N. Gales. 2008. Risk of baleen whale hearing loss from seismic surveys: preliminary results from simulations accounting for uncertainty and individual variation. International Whaling Commission Working Pap SC/60/E9. 10 p.

Gentry, R. (ed). 2002. Report of the workshop on acoustic resonance as a source of tissue trauma in cetaceans. 24-25 April, NMFS, Silver Spring, MD. 19 p.

Geraci, J. and T. Smith. 1976. Direct and Indirect Effects of Oil on Ringed Seals (Phoca hispida) of the Beaufort Sea. Journal of Fish Research. Bd. Canada. 33: 1976-1984.

Geraci, J. and D. St. Aubin. 1982. Study of Effects on Oil on Cetaceans. Bureau of Land Management, U.S. Department of Interior, Contact No. AA551-CT9-29.

Goold, J. and R. Coates. 2006. Near Source, High Frequency Air-Gun Signatures. Paper presented to the International Whaling Commission Science Committee. SC/58/E30.

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

Grau, C. R., T. Roudybush, J. Dobbs, and J. Wathen. 1977. Altered yolk structure and reduced hatchability of eggs from birds fed single doses of petroleum oils. Science 195: 779-781.

Greene, C.R., Jr., N.S. Altman, and W.J. Richardson. 1999a. Bowhead whale calls. p. 6-1 to 6-23 *In*: Richardson, W.J. (ed.) Marine mammal and acoustical monitoring of Western Geophysical's open-water seismic program in the Alaskan Beaufort Sea, 1998. LGL Rep. TA2230-3. Rep. by LGL Ltd., King City, Ont., and Greeneridge Sciences Inc., Santa Barbara, CA, for Western Geophysical, Houston, TX, and U.S. Nat. Mar. Fish. Serv., Anchorage, AK, and Silver Spring, MD. 390 p.

Greene, C.R., Jr., N.S. Altman, and W.J. Richardson. 1999b. The influence of seismic survey sounds on bowhead whale calling rates. Journal of the Acoustical Society of America 106(4, Pt. 2):2280 (Abstract).

Greene, G.D., F.R. Engelhardt and R.J. Paterson (*eds.*). 1985. Proceedings of the Workshop on Effects of Explosives Use in the Marine Environment, Jan. 1985, Halifax, NS. Tech. Rep. 5. Can. Oil & Gas Lands Admin., Environ. Prot. Branch, Ottawa, Ont.

Guerra. A., A. Gonzalez, and F. Rocha. 2004. A review of the records of giant squid in the north-eastern Atlantic and severe injuries in *Architeuthis dux* stranded after acoustic explorations. ICES CM 2004/CC: 29.

Harder, B. 2002. Deprived of darkness, the unnatural ecology of artificial light at night. Science News Online, Week of April 20, 2002, Vol. 161, No. 16.

Harris, R.E., G.W. Miller, and W.J. Richardson. 2001. Seal responses to airgun sounds during summer seismic surveys in the Alaskan Beaufort Sea. Marine Mammal Science 17(4): 795-812.

Hartung, R. 1964. Some Effects of Oiling on Waterfowl. Doctoral Dissertation, University of Michigan.

Hassel, A., T. Knutsen, J. Dalen, S. Løkkeborg, K. Skaar, Ø. Østensen, E.K. Haugland, M. Fonn, Å. Høines, and O.A. Misund. 2003. Reaction of sand eel to seismic shooting: a field experiment and fishery statistics study. Institute of Marine Research, Bergen, Norway.

Hauser, D.D.W., M Holst, and V.M. Moulton. 2008. Marine mammal and sea turtle monitoring during Lamont- Doherty Earth Observatory's marine seismic program in the Eastern

Tropical Pacific, April – August 2008. LGL Rep. TA4656/7-1. Rep. from LGL Ltd., St. John's, Nfld, for Lamont-Doherty Earth Observatory of Columbia Univ., Palisades, NY, and Nat. Mar. Fish. Serv., Silver Spring, MD. 98 p.

Hazel, J., I.R. Lawler, H. Marsh, and S. Robson. 2007. Vessel speed increases collision risk for the green turtle Chelonia mydas. Endangered Species Research 3:105-113.

Holmes, W. and J. Cronshaw. 1975. Final Progress Report on Studies Completed During 1972 and 1975 on the Effects of Petroleum on Marine Birds. Submitted to the American Petroleum Institute, Washington, D. C.

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

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

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

Holst, M., W.J. Richardson, W.R. Koski, M.A. Smultea, B. Haley, M.W. Fitzgerald, and M. Rawson. 2006. Effects of large and small-source seismic surveys on marine mammals and sea turtles. Abstract. Presented at American Geophysical Union - Society Explorer Geophysical Joint Assembly on Environ. Impacts from Marine Geophysical & Geological Studies - Recent Advances from Academic & Industry Research. Program, Baltimore, MD, May 2006.

International Whaling Commission (IWC). 2007. Report of the standing working group on environmental concerns. Annex K to Report of the Scientific Committee. J. Cetacean Research Management 9 (Suppl.): 227-260.

Jarvela, L. K. Thorsteinson, and M. Pelto. 1984. Oil and Gas Development and Related Issues. In: The Navarin Basin Environment and Possible Consequences of Offshore Oil and Gas Development, L. Jarvela, ed. Chapter 9. Juneau and Anchorage, AK. USDOC, NOAA, OCSEAP, and USDOI, MMS.et. al. 1984.

Jochens, A., D. Biggs, K. Benoit-Bird, D. Engelhaupt, J. Gordon, C. Hu, N. Jaquet, M. Johnson, R. Leben, B. Mate, P. Miller, J. Ortega-Ortiz, A. Thode, P. Tyack, and B. Würsig. 2008. Sperm whale seismic study in the Gulf of Mexico: synthesis report. OCS Study MMS 2008-006. Rep. from Department. Oceanography., Texas A & M Univ., College Station, TX, for MMS Gulf of Mexico OCS Reg., New Orleans, LA. 341 p.

Johnson, S.R., W.J. Richardson, S.B. Yazvenko, S.A. Blokhin, G. Gailey, M.R. Jenkerson, S.K. Meier, H.R. Melton, M.W. Newcomer, A.S. Perlov, S.A. Rutenko, B. Würsig, C.R. Martin, and D.E. Egging. 2007. A western gray whale mitigation and monitoring program for a 3-D seismic survey, Sakhalin Island, Russia. Environmental Monitoring and Assessment 134 (1-3): 1-19. doi: 10.1007/s10661-007-9813-0.

Kastak, D., B.L. Southall, R.J. Schusterman, and C. Reichmuth. 2005. Underwater temporary threshold shift in pinnipeds: effects of noise level and duration. Journal of the Acoustical Society of America. 118(5): 3154-3163.

Kastak, D., R.L. Schusterman, B.L. Southall, and C.J. Reichmuth. 1999. Underwater temporary threshold shift induced by octave-band noise in three species of pinnipeds. Journal of the Acoustical Society of America 106(2): 1142-1148.

Ketten, D.R., J. Lien, and S. Todd. 1993. Blast injury in humpback whale ears: evidence and implications. Journal of the Acoustical Society of America. 94(3, Pt. 2): 1849-1850.

Ketos Ecology. 2007. Reducing the fatal entrapment of marine turtles in towed seismic survey equipment. Ketos Ecology report. Available at www.ketosecology.co.uk/KE2007.pdf. 11 p.

King, K. and C. Leferer. 1979. Effects of oil transferred from incubating gulls to their eggs. Marine Pollution Bulletin 10(11): 319-321.

Kostyuchenko, L.P. 1973. Effect of elastic waves generated in marine seismic prospecting on fish eggs on the Black Sea. Hydrobiology. J. 9: 45-48.

Kryter, K.D. 1985. The Effects of Noise on Man, 2nd ed. Academic Press, Orlando, FL. 688 p.

Kryter, K.D. 1994. The Handbook of Hearing and the Effects of Noise. Academic Press, Orlando, FL. 673 p.

Lamont-Doherty Earth Observatory. 2011. Request by Lamont-Doherty Earth Observatory for an Incidental Harassment Authorization to Allow the Incidental Take of Marine Mammals during a Marine Geophysical Survey by the R/V *Marcus G. Langseth* in the western Gulf of Alaska, July - August 2011. Submitted to: National Marine Fisheries Service, Office of Protected Resources, Silver Springs, MD.

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

LGL, Ltd. 2012. Environmental Assessment of Marine Geophysical Surveys by the R/V Marcus G. Langseth in the Northeastern Pacific Ocean, June–July 2012. submitted January 17, 2012, revised January 26, 2012.

Longcore, T. and C. Rich. 2001. A Review of the Ecological Effects of Road Reconfiguration and Expansion on Coastal Wetland Ecosystems. The Urban Wildlands Group, Inc. Los Angeles, CA.

Lokkeborg, S. and A. Soldal. 1993. The Influence of Seismic Exploration with Airguns on Cod (*Gadus morhua*) Behaviour and Catch Rates. ICES Marine Science Symposium 196: 62-67.

Lucke, K., U. Siebert, P.A. Lepper and M.A. Blanchet. 2009. Temporary shift in masked hearing thresholds in a harbor porpoise (*Phocoena phocoena*) after exposure to seismic airgun stimuli. Journal of the Acoustical Society of America 125(6): 4060-4070.

Lutcavage, M.E., P. Plotkin, B. Witherington, and P.L. Lutz. 1997. Human impacts on sea turtle survival. p. 387

MacLean, S.A. and B. Haley. 2004. Marine mammal monitoring during Lamont-Doherty Earth Observatory's seismic study in the Støregga Slide area of the Norwegian Sea, August - September 2003. LGL Rep. TA2822-20. Rep. from LGL Ltd., King City, Ont., for Lamont-Doherty Earth Observatory, Palisades, NY, and NMFS, Silver Spring, MD. 59 p.

Madsen, P.T., B. Mohl, B.K. Nielsen, and M. Wahlberg. 2002. Male sperm whale behavior during exposures to distant seismic survey pulses. Aquatic Mammalogy 28(3):231-240.

Madsen, P.T., M. Johnson, P.J.O. Miller, N. Aguilar de Soto, J. Lynch, and P.L. Tyack. 2006. Quantitative measures of airgun pulses recorded on sperm whales (*Physeter macrocephalus*) using acoustic tags during controlled exposure experiments. Journal of the Acoustical Society of America 120(4): 2366-2379.

Malme, C.I. and P.R. Miles. 1985. Behavioral responses of marine mammals (gray whales) to seismic discharges. p. 253-280 In: G.D. Greene, F.R. Engelhardt and R.J. Paterson (eds.), Proc. workshop on effects of explosives use in the marine environment, Jan. 1985, Halifax, N.S. Technical Report 5. Canadian Oil & Gas Lands Administration Environmental Protection Branch, Ottawa, Ont. 398 p.

Malme, C.I., B. Würsig, J.E. Bird, and P. Tyack. 1986. Behavioral responses of gray whales to industrial noise: feeding observations and predictive modeling. Outer Cont. Shelf Environ. Assessment Program Final Report Princ. Invest, NOAA, Anchorage, AK 56(1988):393-600. BBN Rep. 6265. 600 p. OCS Study MMS 88-0048; NTIS PB88-249008.

Malme, C.I., B. Würsig, J.E. Bird, and P. Tyack. 1988. Observations of feeding gray whale responses to controlled industrial noise exposure. p. 55-73 *In*: Sackinger, W.M., M.O. Jeffries, J.L. Imm, and S.D. Treacy (eds.) Port and ocean engineering under arctic conditions, Vol. II. Geophysical Institution. Univ. Alaska, Fairbanks, AK. 111 p.

Malme, C.I., P.R. Miles, C.W. Clark, P. Tyack, and J.E. Bird. 1984. Investigations of the potential effects of underwater noise from petroleum industry activities on migrating gray whale behavior/Phase II: January 1984 migration. BBN Rep. 5586. Rep. by Bolt Beranek & Newman Inc., Cambridge, MA, for MMS Anchorage, AK. Var. page. NTIS PB86-218377.

Malme, C.I., P.R. Miles, P. Tyack, C.W. Clark, and J.E. Bird. 1985. Investigation of the potential effects of underwater noise from petroleum industry activities on feeding humpback whale behavior. BBN Rep. 5851; OCS Study MMS 85-0019. Report by BBN Labs Inc., Cambridge, MA, for MMS, Anchorage, AK. NTIS PB86-218385.

Marine Corps Base Camp Pendleton (MCBCP). Update 2012. Integrated Natural Resources Management Plan.

Mate, B. and J. Harvey. 1987. Acoustical deterrents in marine mammal conflicts with fisheries workshop. 17-18 February 1986. Newport, Oregon. Oregon State University, Publication No. ORESO-W-86-001.

McCauley, R.D., J. Fewtrell, A.J. Duncan, C. Jenner, M.N. Jenner, J.D. Penrose, R.I.T. Prince, A. Adhitya, J. Murdoch, and K. McCabe. 2000a. Marine seismic surveys: analysis of airgun signals; and effects of airgun exposure on humpback whales, sea turtles, fishes, and squid. Report from Centre for Marine Science and Technology, Curtin Univ., Perth, W.A., for Australian Petroleum. Production Association, Sydney, N.S.W. 188 p.

McCauley, R.D., J. Fewtrell, A.J. Duncan, M.-N. Jenner, M.N., C. Jenner, R.I.T. Prince, A. Adhitya, K. McCabe, and J. Murdoch. 2000b. Marine seismic surveys - a study of environmental implications. APPEA (Australian Petroleum. Production Association) J. 40:692-708.

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

McDonald, M.A., J.A. Hildebrand, and S.C. Webb. 1995. Blue and fin whales observed on a seafloor array in the Northeast Pacific. Journal of the Acoustical Society of America 98(2): 712-721.

McGill, P. and M. Richmond. 1979. Hatching Success of Great Black-backed Gull Eggs Treated with Oil. Bird-banding 50.

Miller, G.W., V.D. Moulton, R.A. Davis, M. Holst, P. Millman, A. MacGillivray, and D. Hannay. 2005. Monitoring seismic effects on marine mammals—southeastern Beaufort Sea, 2001-2002. p. 511-542. *In*: Armsworthy, S.L., P.J. Cranford, and K. Lee (eds.) Offshore oil and gas environmental effects monitoring, approaches and technologies. Battelle Press, Columbus, OH.

Miller, P. N. Biassoni, A. Samuels, P. Tyack. 2000. Whale song length in response to sonar. Nature 405: 903.

Miller, P.J.O., M.P. Johnson, P.T. Madsen, N. Biassoni, M. Quero, and P.L. Tyack. 2009. Using at-sea experiments to study the effects of airguns on the foraging behavior of sperm whales in the Gulf of Mexico. Deep-Sea Res. I 56(7):1168-1181.

Minerals Management Service (MMS). 2005. Environmental Assessment. Proposed Geophysical Survey Cosmopolitan Unit, Cook Inlet. Alaska OCS Region. OCS EIS/EA MMS 2005-045.

Milton, S, P. Lutz, and G. Shigenaka. 1984. Oil and Sea Turtles: Biology, Planning, and Response | Planning for Environmental Emergencies | Publications | NOAA's National Ocean Service Office of Response and Restoration." NOAA's Ocean Service Office of Response and Restoration. 23 Aug. 2004. Web. 14 July 2010. <http://response.restoration.noaa.gov/type_subtopic_entry.php?RECORD_KEY(entry_subtopic_type)=entry_id,subtopic_id,type_id&entry_id(entry_subtopic_type)=9&subtopic_id(entry_subtopic_type)=3&type_id(entry_subtopic_type)=2>.

Mooney, T. P. Nachtigall, M. Breese, S. Vlachos, and W. Au. 2009a. Predicting temporary threshold shifts in bottlenose dolphins (*Tursiops truncatus*): The effects of noise level and duration. Journal of the Acoustical Society of America 125(3): 1816-1826.

Mooney, T., P. Nachtigall, and, S. Vlachos. 2009b. Sonar-induced temporary hearing loss in dolphins. Biol. Lett. 2009(5): 566-567.

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

Moulton, V.D. and G.W. Miller. 2005. Marine mammal monitoring of a seismic survey on the Scotian Slope, 2003. p. 29-40. *In*: Lee, K., H. Bain and G.V. Hurley (eds.), Acoustic monitoring and marine mammal surveys in the Gully and Outer Scotian Shelf before and during active seismic programs. Environment Studies Research Funds Report. No. 151. 154 p.

Moulton, V.D. and J.W. Lawson. 2002. Seals, 2001. p. 3-1 to 3-48 *In*: Richardson, W.J. (ed.), Marine mammal and acoustical monitoring of WesternGeco's open water seismic program in the Alaskan Beaufort Sea, 2001. LGL Report TA2564-4. Report by LGL

Ltd., King City, Ont., and Greeneridge Sciences Inc., Santa Barbara, CA, for WesternGeco, Houston, TX, and NMFS Anchorage, AK, and Silver Spring, MD.

Moulton, V.D. and M. Holst. 2010. Effects of seismic survey sound on cetaceans in the northwest Atlantic. Environmental Studies Research Funds Report No. 182. St. John's, Newfoundland. 28 p.

Nachtigall, P. A. Supin, J. Pawloski, and W. Au. 2004. Temporary threshold shifts after noise exposure in the Atlantic bottlenose dolphin (*Tursiops truncatus*) measured using evolved auditory potential. Marine Mammal Science 24: 673-687.

Nachtigall, P. J. Pawloski, and W. Au. 2003. Temporary threshold shifts and recovery following noise exposure in the Atlantic bottlenose dolphin (*Tursiops truncatus*). Journal of Acoustic Society America 113: 3425-3429.

National Marine Fisheries Service (NMFS). 2016. Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing: Underwater Acoustic Thresholds for Onset of Permanent and Temporary Threshold Shifts. U.S. Dept. of Commer., NOAA. NOAA Technical Memorandum NMFS-OPR-55, 178 p.

______ 2011a. Steelhead Trout (Oncorhynchus mykiss) Fact Sheet from NOAA website: http://www.nmfs.noaa.gov/pr/species/fish/steelheadtrout.htm.

______ 2011b. endangered and threatened Species; 5-Year Reviews for 5 Evolutionarily Significant Units of Pacific Salmon and 1 Distinct Population Segment of Steelhead in California. Federal Register. 76(157): 50447-50448.

______ 2016a. White Abalone (Haliotis sorenseni) Website: http://www.fisheries.noaa.gov/pr/species/invertebrates/abalone/white-abalone.html Updated December 22, 2016 accessed September 2017.

______ 2016b. 5-Year Review: Summary and Evaluation of Southern California Coast Steelhead Distinct Population Segment. National Marine Fisheries Service. West Coast Region. California Coastal Office. Long Beach, California.

______ 2017a. endangered and threatened Marine Species Website: http://www.nmfs.noaa.gov/pr/species/esa/ Accessed on September 2017.

______ 2017b. Southern California Coast Steelhead. Website: http://www.westcoast.fisheries.noaa.gov/protected_species/salmon_steelhead/salmon_and_steelhead_listings/steelhead/southern_california/index.html Accessed on September 2017.

______ 2017c. Marine Turtles website: http://www.fisheries.noaa.gov/pr/species/turtles/index.html. Updated May 24, 2017. Accessed September 2017.

______ 2017d. Marine Mammal website: http://www.nmfs.noaa.gov/pr/species/mammals/ Updated May 24, 2017. Accessed September 2017.

______ 2017e. Marine Mammal Stock Assessment Reports by Species. Website: http://www.nmfs.noaa.gov/pr/sars/species.htm. Updated June 27, 2017 accessed September 2017.

National Science Foundation and U.S. Geological Survey (NSF/USGS). 2011. Final Programmatic Environmental Impact Statement/Overseas Environmental Impact Statement for Marine Seismic Research Funded by the National Science Foundation or Conducted by the U.S. Geological Survey.

NatureServe Explorer, 2017. NatureServe Explorer Species Reports Website: http://explorer.natureserve.org/index.htm. Accessed September 2017

Nieukirk, S.L., K.M. Stafford, D.K. Mellinger, R.P. Dziak, and C.G. Fox. 2004. Low-frequency whale and seismic airgun sounds recorded in the mid-Atlantic Ocean. Journal of the Acoustical Society of America 115(4): 1832-1843.

NOAA and USN (National Oceanographic and Atmospheric Administration and U.S. Navy). 2001. Joint interim report: Bahamas marine mammal stranding event of 15-16 March 2000. U.S. Dep. Commerce., NOAA Fisheries., Sec. Navy, Assist. Sec. Navy, Installations and Environ. 51 p. Available at http://www.nmfs.noaa.gov/ pr/pdfs/health/ stranding_ bahamas2000.pdf.

NOAA National Centers for Coastal Ocean Science (NCCOS). 2007. A Biogeographic Assessment off North/Central California: In Support of the National Marine Sanctuaries of Cordell Bank, Gulf of the Farallones and Monterey Bay. Phase II - Environmental Setting and Update to Marine Birds and Mammals. Prepared by NCCOS's Biogeography Branch, R.G. Ford Consulting Co. and Oikonos Ecosystem Knowledge, in cooperation with the National Marine Sanctuary Program. Silver Spring, MD. NOAA Technical Memorandum NOS NCCOS 40. 240 pp.

Padre Associates Inc., 201. Beta Offshore Platform Elly to Platform Eureka Intrafield Replacement Pipe—Log of all seabirds found onboard vessel.

Parente, C.L., M.C.C. Marcondes, and M.H. Engel. 2006. Humpback whale strandings and seismic surveys in Brazil from 1999 to 2004. Working Pap. SC/58/E41 prepared for the International Whaling Commission 16 p.

Parks, S. C. Clark, and P. Tyack. 2007. Short- and long-term changes in right whale calling behavior: the potential effects of noise on acoustic communication. J. Journal of the Acoustical Society of America 122: 3725-3731.

Parry, G.D. and A. Gason. 2006. The effect of seismic surveys on catch rates of rock lobsters in western Victoria, Australia Fish Research 79: 272-284.

Patten, S. and L. Patten. 1977. Effects of Petroleum Exposure on Hatching Success and Incubation Behavior of Glaucous-winged Gulls (Larus glaucescens) in the Northeast Gulf of Alaska. In: Environmental Assessment of the Alaskan Continental Shelf. Annual Reports of Principal Investigators Vol. III. NOAA Environmental Research Laboratory, Boulder, Co.

Payne, J.F., J. Coady, and D. White. 2009. Potential effects of seismic airgun discharges on monkfish eggs (*Lophius americanus*) and larvae. Environmental Studies Research Funds Report No. 170. St. Johns, NL. 35 p.

Pearson, W.H., J.R. Skalski, and C.I. Malme. 1992. Effects of sounds from a geophysical survey device on behaviour of captive rockfish (*Sebastes* spp.). Canadian Journal of Fish and Aquatic Science 49(7): 1343-1356.

Pendoley, K. 1997. Sea turtles and management of marine seismic programs in Western Australia. Petrol. Expl. Soc. Austral. J. 25:8-16.

Podolsky, R. 2002. Artificial lighting and the decline of seabirds. In: Rich, C. and T. Longcore (eds) Ecological Consequences of Artificial Night Lighting. Abstracts from The Urban Wildlands Group and UCLA Conference in Los Angeles, February 23-24, 2002.

Poot, H., B. J. Ens, H. de Vries, M. A. H. Donners, M. R. Wernand, and J. M. Marquenie. 2008. Green Light for Nocturnally Migrating Birds. Ecology and Society 13(2): 47. www.ecologyandsociety.org/vol13/iss2/art47/, accessed March 20, 2014

Popper, A.N., M.E. Smith, P.A. Cott, B.W. Hanna, A.O. MacGilvray, M.E. Austin, and D.A. Mann. 2005. Effects of exposure to seismic air gun use on hearing of three fish species. Journal of the Acoustical Society of America 117(6): 3958-3971.

Potter, J.R., M. Thillet, C. Douglas, M.A. Chitre, Z. Doborzynski, and P.J. Seekings. 2007. Visual and passive acoustic marine mammal observations and high-frequency seismic source characteristics recorded during a seismic survey. IEEE Journal of Oceanic Engineering 32(2): 469-483.

Reed, J. R., J. L. Sincock, and J. P. Hailman. 1985. Light attraction in endangered procellariiform birds: reduction by shielding upward radiation. Auk 102 (2): 377-383.

Reeves, R. R. Hofman, G. Silber, and D. Wilkinson. 1996. Acoustic deterrence of harmful marine mammal-fishery interactions. Proceedings of a workshop held in Seattle, Washington, 20-22 March 1996. NOAA Tech. Memo. NMFS-OPR-10.

Reitherman, B and P. Gaede. 2010. Summary Observation Log Notes: Fall 2010.

Richardson, W.J., B. Würsig, and C.R. Greene. 1986. Reactions of bowhead whales, *Balaena mysticetus*, to seismic exploration in the Canadian Beaufort Sea. Journal of the Acoustical Society of America 79(4): 1117-1128.

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

Saetre, R. and E. Ona. 1996. Seismike undersøkelser og på fiskeegg og -larver en vurdering av mulige effecter pa bestandsniva. [Seismic investigations and damages on fish eggs and larvae; an evaluation of possible effects on stock level]. Fisken og Havet 1996:1-17, 1-8. (In Norwegian, with an English summary).

Saleh, T. 2007. Effects of artificial light on wildlife. Wildlife CPR notes. www.wildlandscpr.org, accessed March 20, 2014.

Samuel, Y., S.J. Morreale, C.W. Clark, C.H. Greene, and M.E. Richmond. 2005. Underwater, low-frequency noise in a coastal sea turtle habitat. J. Acoust. Soc. Am. 117(3):1465-1472.

Samuel, Y., S.J. Morreale, C.W. Clark, M.E. Richmond, and C.H. Greene. 2006. Underwater noise and anthropogenic disturbance in critical sea turtle habitats. p. 93 In: N.J. Pilcher (ed.), Proc. 23rd Symp. on Sea Turtle Biology and Conservation. NOAA Tech. Memo. NMFS-SEFSC-536. 283 p.

Santulli, La A., A. Modica, C. Messina, L. Ceffa, A. Curatolo, G. Rivas, G. Fabi, and V. D'Amelio. 1999. Biochemical responses of European sea bass (*Dicentrarchus labrax* L.) to the stress induced by off shore experimental seismic prospecting. Marine Pollution Bulletin 38:1105-1114.

SBWCN. 2010. Oiled wildlife care facilities. http://sbwcn.org/wildlife-education/oil-wildlife/oiled-wildlife-care-facilities/.

Schaar, T. 2002. Artificial lighting and wildlife-a moth to a flame. International Dark-Sky Association, Information Sheet #182. 2 pp.

Sea and Sage Audubon Society, 2017. The Least Tern Project at Huntington State Beach. Website: http://www.seaandsageaudubon.org/Conservation/LeastTerns/LETE.htm Accessed September 2017.

Schultz, D., W. Johnson, A. Berkner. 1983. A Unique Oiled Bird Rehabilitation Operation - Myrtle Beach, South Carolina, February, 1981. In: Proceedings 1983 Oil Spill Conference (Prevention, Behavior, Control, Cleanup). February 29 March 3, 1983, San Antonio, TX. American Petroleum Institute Pub. No. 4356.

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

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

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

Stone, C.J. 2003. The effects of seismic activity on marine mammals in UK waters 1998-2000. JNCC Report 323. Joint Nature Conservancy, Aberdeen, Scotland. 43 p.

Stone, C.J. and M.L. Tasker. 2006. The effects of seismic airguns on cetaceans in UK waters. Journal of Cetacean Research Management. 8(3): 255-263.

Sverdrup, A., E. Kjellsby, P.G. Krüger, R. Fløysand, F.R. Knudsen, P.S. Enger, G. Serck-Hanssen, and K.B. Helle. 1994. Effects of experimental seismic shock on vasoactivity of arteries, integrity of the vascular endothelium and on primary stress hormones of the Atlantic salmon. Journal of Fish Biology. 45: 973-995.

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

Tyack, P., M. Johnson, and P. Miller. 2003. Tracking responses of sperm whales to experimental exposures of airguns. p. 115-120 *In:* Jochens, A.E. and D.C. Biggs (eds.), Sperm whale seismic study in the Gulf of Mexico/annual report: Year 1. OCS Study MMS 2003-069. Rep. by Texas A&M Univ., College Station, TX, for MMS., Gulf of Mexico OCS Reg., New Orleans, LA.

Tyack, P.L. 2009. Human-generated sound and marine mammals. Phys. Today 62(11, Nov.):39-44.

U.S. Fish and Wildlife Service (USFWS). 1998. Endangered Species Consultation Handbook: Procedures for Conducting Section 7 Consultations and Conference Activities Under Section 7 of the Endangered Species Act.

______ 2008. Short-tailed Albatross Recovery Plan. Anchorage, AK, 105 pp.

______ 2017a Listed Species believed to or known to occur in Califronia https://ecos.fws.gov/ecp0/reports/species-listed-by-state-report?state=CA&status=listed Accessed September 2017

______ 2017b. California least tern Species Profile USFWS website https://www.fws.gov/sacramento/es_species/Accounts/Birds/es_ca-least-tern.htm Accessed September 2017

______ 2017c. Marbled Murrlet Species profile USFWS website https://www.fws.gov/arcata/es/birds/MM/m_murrelet.html Accessed September 2017

______ 2017d. endangered Species Website: https://www.fws.gov/oregonfwo/articles.cfm?id=149489452 Accessed September 2017.

______ 2017e. Marine Mammals; Incidental Take During Specified Activities' Proposed Incidental Harassment Authorization. FR Vol 82 No. 12: 6627-6634. January 19, 2017.

U.S. Geological Survey. 1999. Negative Determination for a Marine Geophysical Survey.

Wardle, C.S., T.J. Carter, G.G. Urquhart, A.D.F. Johnstone, A.M. Ziolkowski, G. Hampson, and D. Mackie. 2001. Effects of seismic air guns on marine fish. Continental Shelf Research. 21(8-10): 1005-1027.

Weir, C.R. 2008. Overt responses of humpback whales (*Megaptera novaeangliae*), sperm whales (*Physeter macrocephalus*), and Atlantic spotted dolphins (*Stenella frontalis*) to seismic exploration off Angola. Aquatic Mammalogy 34(1): 71-83.

Würsig, B.G., D.W. Weller, A.M. Burdin, S.H. Reeve, A.L Bradford, S.A. Blokhin, and R.L Brownell, Jr. 1999. Gray whales summering off Sakhalin Island, Far East Russia: July-October 1997. A joint U.S.-Russian scientific investigation. Final Report. Rep. from Texas A&M Univ., College Station, TX, and Kamchatka Inst. Ecol. & Nature Manage., Russian Acad. Sci., Kamchatka, Russia, for Sakhalin Energy Investment Co. Ltd and Exxon Neftegaz Ltd, Yuzhno-Sakhalinsk, Russia. 101 p.

Yazvenko, S.B., T.L. McDonald, S.A. Blokhin, S.R. Johnson, H.R. Melton, and M.W. Newcomer. 2007a. Feeding activity of western gray whales during a seismic survey near Sakhalin Island, Russia. Environmental Monitoring Assessment 134(1-3): 93-106