REQUEST FOR

RULEMAKING and LETTERS OF AUTHORIZATION UNDER SECTION 101(a)(5)(A) OF THE MARINE MAMMAL PROTECTION ACT FOR THE TAKE OF MARINE MAMMALS INCIDENTAL TO FISHERIES AND ECOSYSTEM RESEARCH ACTIVITIES CONDUCTED BY NOAA FISHERIES SOUTHWEST FISHERIES SCIENCE CENTER WITHIN THE CALIFORNIA CURRENT ECOSYSTEM, EASTERN TROPICAL PACIFIC ECOSYSTEM, AND ANTARCTIC ECOSYSTEM

Table of Contents

List of Figures

List of Tables

1. DETAILED DESCRIPTION OF THE SPECIFIC ACTIVITY OR CLASS OF ACTIVITIES THAT CAN BE EXPECTED TO RESULT IN INCIDENTAL TAKING OF MARINE MAMMALS

This application, submitted to the National Marine Fisheries Service (NMFS) Office of Protected Resources, requests rulemaking and subsequent letters of authorization under the Marine Mammal Protection Act (MMPA) of 1972 for the incidental take of marine mammals during fisheries surveys and related research activities conducted by the Southwest Fisheries Science Center (SWFSC), National Marine Fisheries Service (NMFS), NOAA. Management of certain protected species falls under the jurisdiction of the NMFS under the MMPA and Endangered Species Act (ESA). Mechanisms exist under both the ESA and MMPA to assess the effect of incidental takings and to authorize appropriate levels of take.

The Federal government has a trust responsibility to protect living marine resources in waters of the United States (U.S.), also referred to as federal waters. These waters generally lie 3 to 200 nautical miles (nm) from the shoreline [those waters 3-12 nm offshore comprise territorial waters and those 12 to 200 nm offshore comprise the Exclusive Economic Zone (EEZ)]. The U.S. government has also entered into a number of international agreements and treaties related to the management of living marine resources in international waters outside of the U.S. EEZ (i.e., the high seas). To carry out its responsibilities over federal and international waters, Congress has enacted several statutes authorizing certain federal agencies to administer programs to manage and protect living marine resources. Among these federal agencies, NOAA has the primary responsibility for protecting marine finfish and shellfish species and their habitats. Within NOAA, the NMFS has been delegated primary responsibility for the science-based management, conservation, and protection of living marine resources.

Within the area covered by this MMPA application to incidentally take marine mammals, NMFS manages finfish and shellfish harvest under the provisions of several major statutes, including the Magnuson-Stevens Fishery Conservation and Management Act (MSA)[1], the Tuna Conventions Act, the ESA, the International Dolphin Conservation Program Act, and the Antarctic Marine Living Resources Convention Act. Accomplishing the requirements of these statutes requires the close interaction of numerous entities in a sometimes complex fishery management process. In the Southwest, the entities involved are a NMFS Regional Fisheries Science Center; NMFS Regional Office; NMFS Offices of Protected Resources, Sustainable Fisheries and Science and Technology; a Fisheries Management Council; a Fisheries Commission; and five International Fisheries Management Organizations.

1.1 Fisheries Science Centers

Six Regional Fisheries Science Centers direct and coordinate the collection of scientific information needed to inform fisheries management decisions[2]. Each Fisheries Science Center is a distinct entity and is the scientific focal point for a particular region (Figure 1.1). The Southwest Fisheries Science Center (SWFSC) conducts research and provides scientific advice

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[1] 16 U.S.C. §§ 1801-1884, (MSA 2007).

[2] The six Regional Fisheries Science Centers are: 1) Northeast, 2) Southeast, 3) Southwest, 4) Northwest, 5) Alaska, and 6) Pacific Islands.

to manage fisheries and conserve protected species along the U.S. west coast, throughout the eastern tropical Pacific Ocean, and in the Southern Ocean off Antarctica (Figure 1.2). SWFSC provides scientific information to support the Pacific Fishery Management Council and other domestic and international fisheries management organizations.

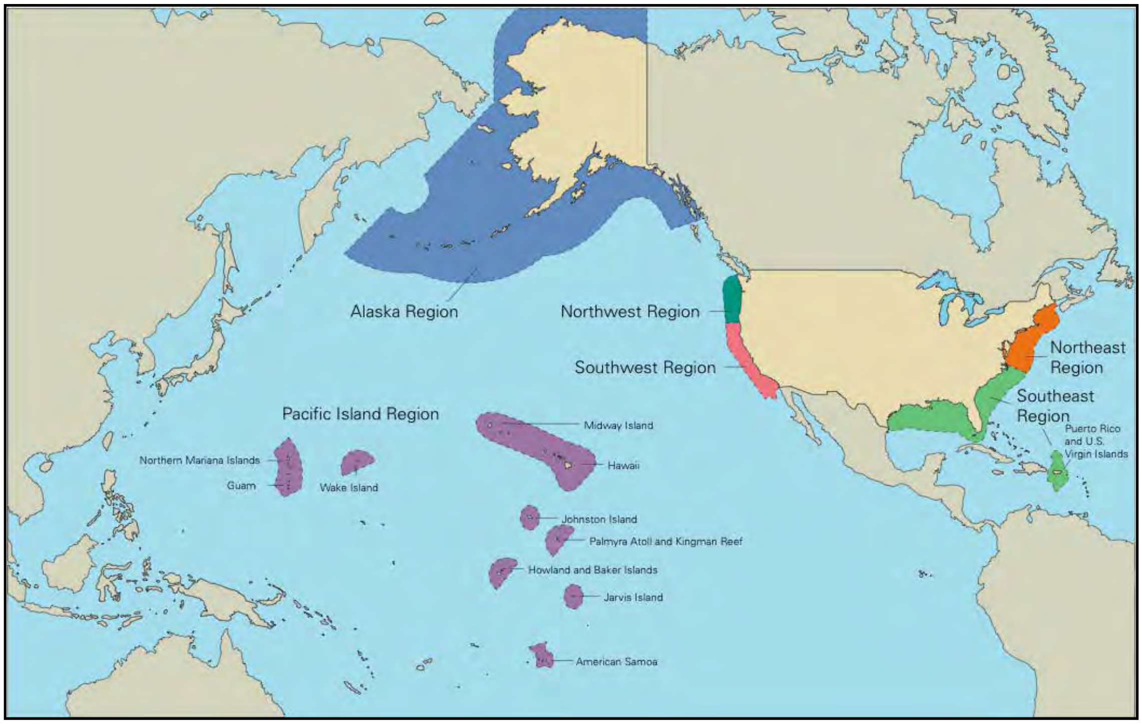

Figure 1.1 NMFS's Fisheries Science Center Regions.

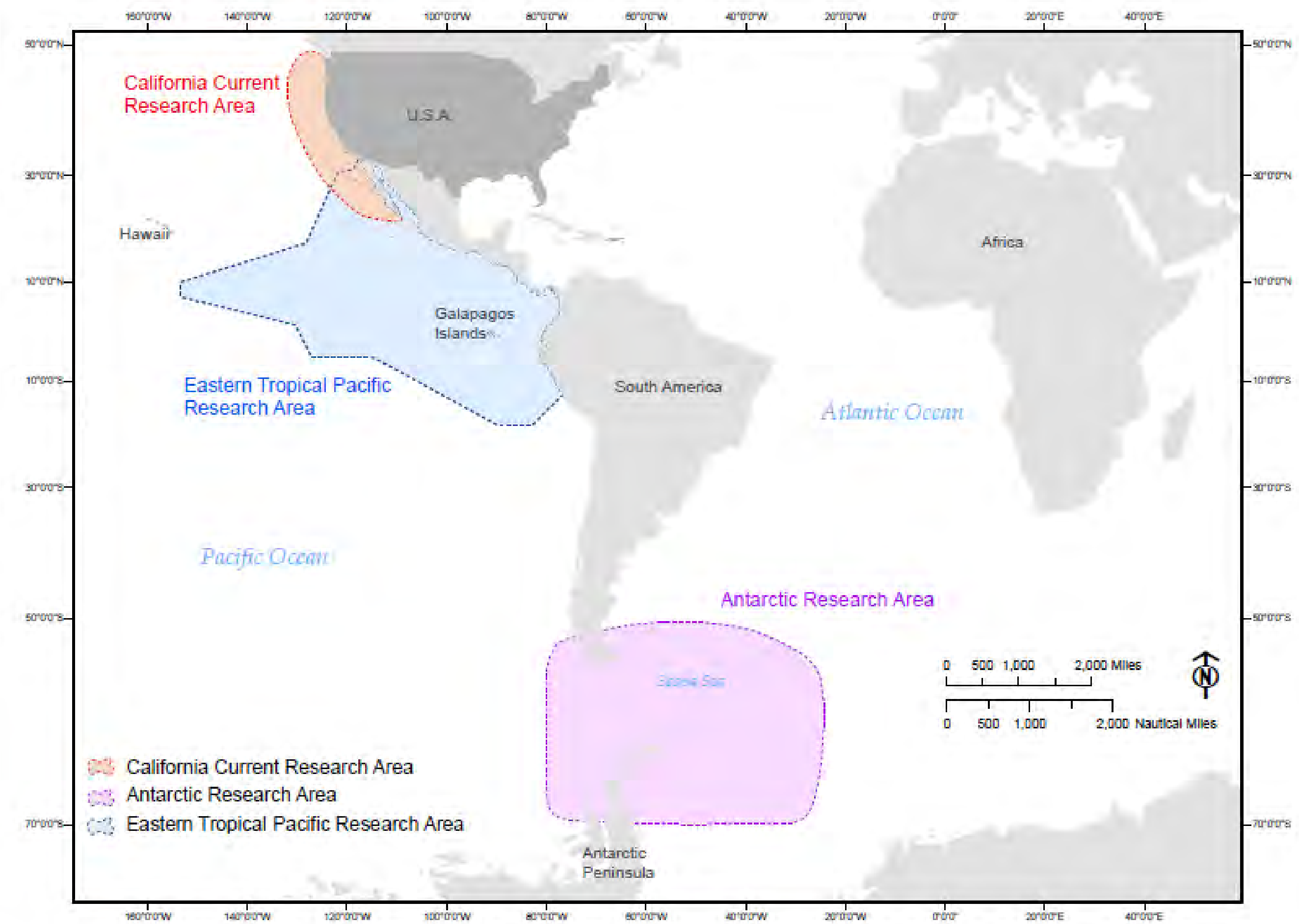

Figure 1.2 SWFSC research areas.

1.2 Role of Fisheries Research in Federal and Regional Fisheries Management

The SWFSC provides scientific information and advice to assist with the development of FMPs prepared by the Pacific Fishery Management Council (PFMC), Western Pacific Regional Fishery Management Council (WPRFMC), and a variety of federal and non-federal entities. The councils, which include fishing industry representatives, fishers, scientists, government agency representatives, federal appointees, and others, are designed to provide all resource users and managers a voice in the fisheries management process. Under the MSA, the Councils are charged with developing Fishery Management Plans (FMPs) and management measures for the fisheries occurring within the EEZ adjacent to their constituent states. Data collected by Fisheries Science Centers are often used to inform FMPs, as well as to inform other policies and decisions promulgated by the Fishery Management Councils. Such policies and decisions sometimes affect areas that span the jurisdictions of several Fishery Management Councils, and make use of data provided by multiple Fisheries Science Centers.

Fisheries managers use a variety of techniques to manage trust resources, a principal one being the development of FMPs. FMPs are used to articulate fishery goals as well as the methods used to achieve those goals, and their development is specifically mandated under the MSA.

In addition to providing information to domestic fisheries management councils, the SWFSC provides scientific advice to support numerous international fisheries councils, commissions, and conventions including the Western and Central Pacific Fisheries Commission, International Scientific Committee for Tuna and Tuna-like Species, Inter-American Tropical Tuna Commission and the Convention for the Conservation of Antarctic Marine Living Resources. Research conducted by the SWFSC has also been critical in the development and successful implementation of ecosystem-based management in Antarctica in order to fulfill the conservation objectives of the Antarctic Treaty.

1.3 SWFSC Research Divisions

The SWFSC is the research arm of NMFS in the Southwest Region. The SWFSC plans, develops, and manages a multidisciplinary program of basic and applied research to inform management of the region's marine and anadromous fish and invertebrate populations to ensure they remain at sustainable and healthy levels. Responsibilities include maintaining healthy fish stocks for commercial and recreational fishing; sustaining ecosystem services; and coordinating with domestic and international organizations to implement fishery agreements and treaties.

The SWFSC research efforts are divided among five research divisions that are tasked with different roles in collecting scientific information on living marine resources and the ecosystems that sustain them. The SWFSC headquarters is located in La Jolla, California. The Fisheries Ecology Division is based in Santa Cruz, California, adjacent to UC Santa Cruz's Long Marine Laboratory, and the Environmental Research Division is based in Pacific Grove, California. The SWFSC operates two field stations in California located in Arcata and Granite Canyon. On the Antarctic Peninsula, the SWFSC’s Antarctic Ecosystem Research Division maintains two field stations located at Cape Shirreff on Livingston Island and at Copacabana in Admiralty Bay on King George Island.

1.3.1 Fisheries Resources Division

The SWFSC Fisheries Resources Division (FRD) develops the scientific foundation for the conservation and management of marine resources in the California Current and Eastern Tropical Pacific Ocean. The division conducts seagoing surveys, genetic and morphometric research to define stock structure, life history studies to estimate production of eggs and larvae and adult vital rates, engineering work to develop advanced survey technologies, oceanographic studies to define critical habitat and population response to climate change, quantitative population assessments, and economic studies to define the value of fisheries and alternative management options. The division responds to the information needs of the PFMC’s Coastal Pelagic Species FMP, Highly Migratory Species FMP and Groundfish FMP. FRD scientists also participate on international working groups and provide scientific advice to the ISC, IATTC and WCPFC.

1.3.2 Fisheries Ecology Division

The Fisheries Ecology Division (FED) conducts research on the ecology of groundfish, economic analysis of fishery data, Pacific salmon studies (including 10 endangered salmon and steelhead runs), and coastal habitat issues affecting the San Francisco Bay and the Gulf of Farallones. Results from FED research are used by the PFMC to manage fisheries, and by NMFS to manage threatened and endangered species. FED scientists study causes of variability in abundance and health of fish populations, analyze ecological relationships in marine communities, and study the economics of exploiting and protecting natural resources. They also assess the stocks of species targeted by various fisheries, and assist in evaluating potential impacts of human activities on threatened or endangered species.

1.3.3 Antarctic Ecosystem Research Division

The Antarctic Ecosystem Research Division (AERD) manages the U.S. Antarctic Marine Living Resources Program (AMLR), which provides information for U.S. policy on the management and conservation of Antarctic living resources and supports U.S. participation in international efforts to protect the Antarctic and its marine life. Research is directed toward gathering ecological and biological information to quantify the functional relationships between finfish and krill, their environment and their predators; to develop an ecosystem approach to ensure sustained harvesting of krill, fish and crabs; and to protect predator populations of seals, penguins, and pelagic seabirds resident in the Southern Ocean surrounding Antarctica.

1.3.4 Protected Resources Division

The Protected Resources Division (PRD) promotes and conducts research that contributes to the conservation and management of U.S. and international populations of marine mammals and their designated critical habitats. Provisions of the MMPA and the ESA guide the division's activities, which include monitoring the abundance of pinniped and cetacean stocks and sea turtles, assessing and helping to minimize the effect of fishing operations and other human activities on these populations, determining stock structure and population dynamics, and conducting research on "dolphin-safe" tuna fishing methods. Research efforts span the entire migratory range of marine mammal and turtle populations. PRD monitors the life history, condition and health of populations, performs regular abundance estimates, advances studies of marine mammal acoustics, and strives to interpret these results in an ecosystem context. To do this, ecosystem data are collected to characterize habitat and its variation over time and on distribution and abundance of prey fishes and squids, seabirds, and marine turtles further characterize the ecosystem in which marine mammals and other protected species live.

1.3.5 Environmental Research Division

The Environmental Research Division (ERD) conducts a flexible research program to assess, understand, and predict climate and environmental variability and its impacts on marine fish populations and ecosystems. ERD provides science-based, globally integrated, fisheries-relevant environmental data, products, and information to meet the research and management needs of the SWFSC, NMFS, and NOAA.

1.4 SWFSC Fisheries Research Activities

Following is a summary of activities conducted by the SWFSC that have the potential to take marine mammals incidental to fisheries and ecosystem research activities. The SWFSC is requesting rulemaking and subsequent Letters of Authorization for the proposed activities. The descriptions below include the location, time of year the surveys occur and gear used. Additional information and detail for each survey and its associated mitigation measures for marine mammals are in Table 1.1 and Appendix A. In general, all SWFSC surveys are set in an ecological context. That is, the Center conducts concurrent hydrographic, oceanographic, and meteorologic sampling in addition to the marine resource surveys.

A component of SWFSC fisheries research is conducted cooperatively with commercial fisheries to address questions of mutual interest, often utilizing commercial vessels as research platforms. Because SWFSC staff are present for all components of its fisheries research activities, it does not distinguish in this application between research activities that are or are not considered cooperative. However, for clarity the following surveys are conducted cooperatively with commercial fisheries: ROV habitat surveys for rockfish and white abalone, adult rockfish, thresher shark longline survey, HMS longline survey, sablefish life history survey and deep-set buoy gear for swordfish tagging.

1.4.1 Surveys conducted in the California Current Ecosystem (CCE)

Coastal Pelagic Species Surveys (e.g. Sardine surveys). This survey is conducted annually in the spring (April-May) or the summer (June-July) and extends from San Diego, CA, to Cape Flattery, WA; it is broken into southern and northern portions on two survey vessels. The southern portion is done in conjunction with the spring or summer CalCOFI survey. Possible marine mammal takes during these conjoined CalCOFI/Sardine surveys are the direct result of trawl operations for the sardine component of the survey. Results of the sardine survey inform the annual assessment of sardine and the corresponding harvest guidelines. It is conducted on either two NOAA ships or a NOAA ship and a charter vessel. The survey requires about 70 survey days per year (Table 1.1).

The protocol for the sardine survey includes deploying a NETS Nordic 264 two-warp rope trawl in the upper 10 m of the water column at night in order to sample adult sardines (*Sardinops sagax*). Estimates of daily fecundity are derived from the samples and combined with estimates of daily egg production to produce an estimate of spawning stock biomass. Additional protocols for this survey are similar to the CalCOFI surveys described below.

The NETS Nordic 264 rope trawl is deployed for 30-minute tows at the target depth at 3 knots during dark hours when sardines are dispersed and near the surface. Directed trawling during daytime on sardine schools deeper in the water column is ineffective. Marine mammals may be caught infrequently while using these nets. Mitigation measures include attachment of a marine mammal excluder device in the net mesh, attachment of acoustic pingers, and a move-on rule to minimize chances for gear to be deployed with marine mammals within 1 nm (see section 13 below for additional information on mitigation and monitoring).

Juvenile Salmon Survey. This survey is conducted annually in June and September and extends from central CA to southern OR and complements similar surveys conducted by the NWFSC. This survey measures ocean survival of juvenile salmon (Coho; *Oncorhynchus kisutch* and Chinook; *Oncorhynchus tshawytscha*) and produces early estimates of adult salmon returns. The juvenile salmon survey is usually conducted on a charter vessel and requires about 30 survey days.

The protocols for this survey include deployment of a two-warp NETS Nordic 264 rope trawl for 30-minute tows at the target depth during daylight hours at 15-30 m depth. It should be noted that the deployment protocol for this trawl is different than the sardine surveys, such that these tows are conducted during the day and deeper in the water column. Depending on vessel capabilities, additional operations may include multi-frequency active acoustics, CTD profiles, Bongo plankton tows, and single-warp Tucker mid-water trawls.

Juvenile Rockfish Survey. This survey is conducted annually from May to mid-June and extends from southern CA to WA; it targets the pelagic phase of juvenile rockfish. Results of this survey inform assessments of several rockfish populations. It is either conducted on a NOAA ship or a charter vessel and requires about 45 survey days.

The protocols for this survey include underway multi-frequency active acoustics, two-warp midwater trawls, various plankton tows, and CTD profiles at fixed stations. The trawl is conducted using a Modified-Cobb mid-water trawl deployed for 15-minute tows at 2 knots during the dark hours at 15-30 m depth.

CalCOFI Survey - Winter. This survey is conducted annually during January and February and extends from San Diego to San Francisco; it captures early spawning hake and some rockfish. It is usually conducted on a NOAA ship and requires about 25 survey days; all four of the CalCOFI surveys require about 90 days total.

The survey describes the physical and biological characteristics of the southern portion of the California Current epipelagic habitat. Protocols include multi-frequency single-beam active acoustics (18, 38, 70, 120 and 200 kHz) (Table 1.1). These surveys also include a Continuous Underwater Fish Egg Sampler (CUFES), various plankton nets (Bongo, Pairovet, Manta, and PRPOOS), CTD with an array of vertically profiling instruments and bottles to collect water samples at discrete depths, marine mammal and bird observations, meteorological observations using a wide-range of passive sensors, trawls for sampling mesopelagic organisms at selected stations. See Appendix A and the CalCOFI website http://www.calcofi.org/ for additional information.

CalCOFI Survey - Spring. This survey is conducted annually in April. It also extends from San Diego to San Francisco and captures spring spawning (e.g., anchovy, sardine, jack mackerel, and several hundred others). In general, the Center uses a NOAA ship to conduct the survey.

The purpose of the survey and the protocol are the same as for the Winter CalCOFI Survey above. See Appendix A and the CalCOFI website http://www.calcofi.org/ for additional information.

CalCOFI Survey - Summer. This survey is conducted annually in July in the Southern California Bight solely on a Scripps Institution of Oceanography (SIO) University-National Oceanographic Laboratory System (UNOLS) vessel. The survey describes the physical and biological characteristics of the southern portion of the California Current epipelagic habitat. Protocols are the same as for the winter and spring CalCOFI surveys. See Appendix A and the CalCOFI website http://www.calcofi.org/ for additional information.

CalCOFI Survey - Fall. This survey is conducted annually in October in the Southern California Bight usually on a SIO (UNOLS) vessel. The survey describes the physical and biological characteristics of the southern portion of the California Current epipelagic habitat.

Protocols are the same as other CalCOFI surveys. See Appendix A and the CalCOFI website http://www.calcofi.org/ for additional information.

PaCOOS Central CA (MBARI). This survey is conducted annually in July and October. It incorporates the plankton and oceanographic surveys of CalCOFI survey line 66, extending offshore from the Monterey Bay Aquarium Research Institute (MBARI), and line 60, extending offshore from San Francisco Bay. It is usually conducted on Moss Landing Marine Laboratories Research Vessel (R/V) *Point Sur* and lasts about 6 survey days.

Protocols include the use of various plankton nets (Bongo, California Vertical Egg Tow (CalVET), Manta, Pairvet), CTD with an array of vertically profiling instruments and bottles to collect water samples at discrete depths, marine mammal and bird observations, and meteorological observations using a wide-range of passive sensors.

PaCOOS North CA Humboldt State University (HSU). This is monthly plankton and oceanographic surveys of a single line of stations off the university in northern CA. It is usually conducted on HSU R/V *Coral Sea* and takes about 12 survey days.

Protocols include the use of various plankton nets (Bongo, CalVET, Manta), CTD with an array of vertically profiling instruments and water samples at discrete depths, marine mammal and bird observations, and meteorological observations using a wide-range of passive sensors.

Highly Migratory Species (HMS) Survey. This survey is conducted annually from June - July and extends from southern to central CA; it targets blue sharks, shortfin Mako sharks and swordfish and other highly migratory species. Historically it has been conducted on a NOAA ship but in recent years it has been conducted on a charter vessel and requires about 30 survey days.

Protocols include deployment of a pelagic longline at fixed stations with 2-4 hour soak times. Length of the mainline is 2-4 miles with 200-400 hooks spaced 50-100 feet apart, 18 foot long gangions and 9/0 J-type hooks. When targeting swordfish, the mainline may be up to 12 miles in length with 36 foot long gangions and 16/0 circle-type hooks and soak times may last up to 8 hours. Typical bait used is whole mackerel or market squid. Depending on vessel capabilities, additional protocols may include multi-frequency active acoustics, CTD profiles, and Bongo plankton tows.

Thresher Shark Survey. This survey is conducted annually in September. It targets thresher shark pupping areas from the Southern California Bight up to Central California and is usually conducted on charter vessel requiring about 20 survey days.

The protocols for this survey include deployment of an anchored longline at fixed stations with 2-4 hour soak times. Length of the mainline is 2-4 miles with 200-400 hooks spaced 50-100 feet apart, 12 foot long gangions and 16/0 circle-type hooks. Typical bait used is whole mackerel or market squid. Depending on vessel capabilities, additional protocols may include the use of multi-frequency active acoustics, CTD profiling systems, and Bongo plankton tows.

Survey to Research Reproductive Life History Analysis of Sablefish. This survey to research reproductive life history analysis of sablefish is conducted monthly each year near Bodega Bay off the Central California coast. The primary objective of the survey is to collect adult sablefish for reproductive studies using small scale bottom longline gear.

The gear is essentially a small scale longline with 75 hooks per line that are baited with squid and set at or near the bottom, usually at depths between 360 and 450m. Two to three sets are made per trip over the course of 30 days per year.

Swordfish Tagging Deep-Set Buoy Survey. The Swordfish tagging deep-set buoy survey is conducted annually June-November in the Southern California Bight region of the CCE. The survey's main objective is to investigate the use of this gear to capture swordfish while minimizing bycatch of non-target species. Approximately 300-600 sets are made annually.

The gear includes a buoy flotation system (i.e., a strike-indicator float/flag, a large, non-compressible buoy and a float affixed with a radar reflector). A set of "gear" consists of 250-400 m 500 pound (lb) mainline monofilament rigged with a 1-2 kilogram (kg) drop sinker to orient the mainline and terminal fishing gear vertically in the water column. Unlike longline gear which typically uses a long monofilament mainline suspended horizontally near the surface of the water, deep-set buoy gear does not involve the use of a horizontal mainline. Two monofilament gangions branch from the vertically oriented mainline at 250-400 m and are constructed of 400 lb monofilament leader containing a crimped 14/0 circle hook baited with either squid or mackerel.

The buoys are deployed in a restricted spatial grid such that all of the indicator buoys can be continuously monitored from the vessel (within a maximum 4 nm grid area). When an indicator flag rises, the buoy set is immediately tended and the animal caught is either released or tagged and released in order to increase post-hooking survivorship of all target and non-target animals.

Marine Mammal Ecosystem Surveys. This survey is conducted annually during August to December. These are large-scale surveys requiring substantial blocks of continuous time on two NOAA ships and about 60-120 survey days (Table 1.1). Results inform status assessments of marine mammal populations. Surveys rotate among geographic areas and include STAR (eastern tropical Pacific), ORCAWALE (west coast EEZ), HICEAS (Pacific Islands), and SPLASH (northern Pacific).

Protocols include line transect surveys of marine mammals and seabirds. For marine mammals, observations are made of schools or aggregations of animals. For a subset of observations, survey effort is suspended and aggregations are approached for estimation of aggregation size and species composition. Directed research permits are obtained for marine mammal and seabird surveys as required; currently this work is authorized under MMPA/ESA permit 14097.

Additional protocols include the use of multi-frequency active acoustics (38, 70, 120 and 200 kHz) (Table 1.1), 2.5 m^2 single-warp Isaacs Kidd Midwater Trawl (IKMT) with 1 mm mesh net for sampling macro-zooplankton, 3 m^2 dip net with 2 mm mesh net for sampling flying fish, CTD with an array of vertically profiling instruments and bottles to collect water samples at discrete depths, and meteorological observations using a wide-range of passive sensors.

White Abalone Survey. This survey utilizes still and video camera observations using a remotely operated vehicle (ROV) to monitor population recovery of deep-water habitat for endangered white abalone. It is usually conducted on a charter vessel for about 25 survey days. The surveys are confined to offshore banks and island margins, 30-150 m depth, in the Southern California Bight. Since 2002, over 1,000 ROV transects have been conducted along the entire U.S. west coast. The average and maximum speed of the ROV was 0.49 and 2.43 kts, respectively. The tether that connects the ROV to the ship is 0.75 inches in diameter, and is securely attached to a stainless steel cable and down-weight to minimize slack in the tether and to prevent any loops.

Collaborative Optical Acoustical Survey Technology (COAST) Survey. These are multi-frequency acoustic and ROV optical surveys of offshore banks conducted in collaboration with charter boat fishing industry to monitor the recovery of rockfish. The COAST surveys are usually conducted on a NOAA ship augmented by a charter vessel and require about 40 survey days. The surveys are confined to offshore banks reported by fishermen as known rockfish habitat. Protocols include the use of multi-frequency active acoustics (38, 70, 120 and 200 kHz) and still and video camera observations using an ROV (Table 1.1 and Appendix A).

Habitat Surveys. The focus of these surveys include adult rockfish essential fish habitat and habitat use of a variety of other species. They are usually conducted on a NOAA ship for about 50 survey days. The protocols include visual observations from ships and submersibles.

Small Boats. Numerous field operations use small boats including for attaching tags to fish. These operations require about 75 survey days.

1.4.2 Surveys conducted in the Eastern Tropical Pacific (ETP)

Marine Mammal Ecosystem Surveys. These surveys are conducted annually during August to December. They are authorized under the MMPA (MMPA/ESA permit 14097); the Center is requesting an LOA for the incidental take of marine mammals associated with ecosystem sampling. As discussed previously for the marine mammal surveys in the CCE, these are large-scale surveys requiring substantial blocks of continuous time on two NOAA ships and about 60-120 survey days (Table 1.1). Results inform status assessments of marine mammal populations. Surveys rotate among geographic areas and include STAR (eastern tropical Pacific), ORCAWALE (west coast EEZ), HICEAS (Pacific Islands), and SPLASH (northern Pacific).

The protocols for these surveys include line transect surveys of marine mammals and seabirds. The marine mammal component of the surveys focuses on observations of schools or aggregations of animals. For a subset of observations survey effort is suspended and aggregations are approached for estimation of aggregation size and species composition. As noted above, MMPA and ESA research permits are obtained for these surveys, as required.

Additional protocols include the use of multi-frequency active acoustics (38, 70, 120 and 200 kHz) (Table 1.1), 2.5 m^2 single-warp Isaacs Kidd Midwater Trawl (IKMT) with 1 mm mesh net for sampling macro-zooplankton, 3 m^2 dip net with 2 mm mesh net for sampling flying fish, CTD with an array of vertically profiling instruments and bottles to collect water samples at specific depths, and meteorological observations using a wide-range of passive sensors.

Highly Migratory Species (HMS) Surveys. To date, these surveys have not been conducted in the ETP; however, the SWFSC believes they will likely occur during the period 2014-2019. They may be conducted up to 30 days annually during June-July. In addition to deployment of longline gear, protocols include the use of multi-frequency active acoustics (38, 70, 120, 200 and 333 kHz) (Table 1.1).

1.4.3 Surveys conducted in the Antarctic Marine Living Resources area (AMLR)

Antarctic Survey. These surveys are conducted annually during January through March or in August and include the extended area around the South Shetland and South Orkney archipelagos in the Scotia Sea, the eastern section of the Bellingshausen Sea, and the northwestern section of the Weddell Sea. They are usually conducted on a charter vessel and required about 70 survey days.

Shipboard surveys are designed to map the distribution of Antarctic krill relative to the distributions of krill predators (including penguins, pinnipeds, and flying birds) as well as estimate krill biomass within the survey area. The physical and biological environment is also characterized. Protocols include the use of 2.5 m^2 single-warp Isaacs Kidd Midwater Trawl (IKMT) with 505 micron mesh net, multi-frequency active acoustics (38, 70, 120 and 200 kHz), CTD with an array of vertically profiling instruments and water samples at discrete depths, marine mammal and bird observations, and meteorological observations using a wide-range of passive sensors.

The SWFSC is currently investigating use of 4 m^2 single-warp Tucker Midwater Trawl with two 505 micron mesh nets and one 5 mm mesh net for use on these surveys.

Every 2-3 years a bottom trawl is used to assess benthic invertebrates and fish on the continental shelf. Gear used is a towed camera array and a two-warp NET Systems Hard-Bottom Snapper Trawl.

Table 1.1. Summary description of surveys conducted on NOAA vessels and NOAA-chartered vessels for SWFSC.

Survey Name	Survey Description	General Area of Operation	Season, Frequency, Yearly Days at Sea (DAS)	Vessel Used	Gear Used	Gear Details	Number of Samples	Mitigation Measures
California Current Research Area								
Survey Using Trawl Gear								
Coastal Pelagic Species (CPS) Survey (aka Sardine Survey)	One or two ship survey. Results of survey inform the annual assessment of sardines and the corresponding harvest guideline. Consists of southern and northern portions conducted on two survey vessels. When possible, preference has been for a two-ship survey. The southern portion is done in conjunction with the spring or summer CalCOFI Survey. Protocols similar to CalCOFI with the addition of mid-water trawls conducted near the surface at night to sample adult sardines.	United States (U.S.) West Coast Exclusive Economic Zone (EEZ)	Annually or biennially, April-May or July-August 70 DAS (~35DAS/vessel)	NOAA ship, Charter vessel One or two ship survey	NETS Nordic 264 two-warp rope trawl	Towed near-surface, primarily at night Tow speed: 2-4 knots (kts) Duration: 30 min at intended depth	50 tows	Acoustic pingers, development of marine mammal excluder devices (MMEDs), visual monitoring (limited on night trawl), "move-on" rule.
					Various plankton nets (Bongo, Pairovet, Manta)	Tow speed: 1.5- 2.5 kts for Bongo and Manta; 0 for Pairovet Duration: 10-20 min	75 tows	
					Conductivity Temperature Depth (CTD) and rosette water sampler	Tow speed: 0 Duration: 20-120 min	75 casts	
					Continuous Underway Fish Egg Sampler (CUFES)		Continuous	
					Multi-frequency single-beam active acoustics	18, 38, 70, 120, 200 kilohertz (kHz)	Continuous	
					Multi-beam echosounder (Simrad ME70) and sonar (Simrad MS70)		Continuous	
Juvenile Rockfish Survey	Targets pelagic phase of juvenile rockfish with nighttime tows. Results of survey inform assessments of several rockfish populations and may soon be used in assessments of Central California salmon productivity.	West Coast EEZ	Annually, May-mid-June 45 DAS	NOAA ship, Charter vessel	Modified Cobb Midwater Trawl	Tow speed: 2 kts Duration: 15 min at intended depth	150 tows	Acoustic pingers, development of marine mammal excluder devices (MMEDs), visual monitoring, "move-on" rule.
					CTD profiler and rosette water sampler	Tow speed: 0 Duration: 5-120 min	250 casts	
					Various plankton nets (Bongo and Tucker)	Tow speed: 1.5- 2.5 kts Duration: 20-60 min	50 tows	

Survey Name	Survey Description	General Area of Operation	Season, Frequency, Yearly Days at Sea (DAS)	Vessel Used	Gear Used	Gear Details	Number of Samples	Mitigation Measures
					Multi-frequency single-beam active acoustics	18, 38, 70, 120, 200, 333 kHz	Continuous	
Juvenile Salmon Survey	Measures ocean survival of juvenile salmon and produces early estimate of adult returns. Protocols include surface-water trawls, active acoustics, oceanographic and meteorological measurements. Tissue samples are collected for genetic analysis.	Central CA to southern OR	Annually, June and September 30 DAS total for two surveys	Charter vessel	NETS Nordic 264 two-warp rope trawl	Towed at 15-30 meters (m) deep during daytime Tow speed: 2-4 kts Duration: 30 min at intended depth	50 tows	Acoustic pingers, development of marine mammal excluder devices (MMEDs), visual monitoring, “move-on” rule.
					CTD profiler and rosette water sampler	Tow speed: 0 Duration: 20-120 min	50 casts	
					Various plankton nets (Bongo and Tucker)	Tow speed: 1.5- 2.5 kts Duration: 20-60 min	50 tows	
					Multi-frequency single-beam active acoustics	18, 38, 70, 120, 200, 333 kHz	Continuous	
Surveys Using Longline Gear								
Highly Migratory Species (HMS) Survey	This survey targets blue sharks, shortfin mako sharks, and other HMS as a basis for stock assessments and support for HMS Fishery Management Plans. Information is also obtained about their biology, distribution, movements, stock structure and status, and potential vulnerability to fishing pressure. Surveys involve catching sharks on longline gear, measuring, attaching various tags, and releasing them alive.	Southern to central CA	Annually, June-July 30 DAS	NOAA ship, Charter vessel	Pelagic longline	Mainline length: 2-4 mile set 50 to 75 feet for mako and blue sharks; 300 to 600 feet for swordfish. Gangion length: 10-15 ft. ; 36 ft for swordfish Gangionspacing: 50-100 ft. apart. Hook size and type: 9/0 J hooks for blue and mako sharks; 16/0 and 18/0 offset, stainless circle hooks for swordfish. Soak time: 2-4 hr for most species, up to 8 hr for swordfish	60 sets	Visual monitoring, “move-on” rule, operational adjustments to avoid take.
					CTD profiler and rosette water sampler	Tow speed: 0 Duration: 30 min	60 casts	
					Bongo plankton tows	Tow speed: 1.5 kts Duration: 20 min	60 tows	
					Multi-frequency single-beam active acoustics	18, 38, 70, 120, 200, 333 kHz	Continuous	

Survey Name	Survey Description	General Area of Operation	Season, Frequency, Yearly Days at Sea (DAS)	Vessel Used	Gear Used	Gear Details	Number of Samples	Mitigation Measures
Reproductive Life History Analysis of Sablefish	This survey is conducted to collect adult sablefish for reproduction studies. Surveys involve catching sablefish on longline gear.	Central California (near Bodega Bay)	Monthly (One day per month), 30 DAS	Charter vessel	Small scale longline	75 hooks per line, baited with squid, set at or near the bottom, usually at depths of 360-450m	2-3 sets per trip	"move on" rule if a marine mammal is encountered
Thresher Shark Survey	This survey is conducted to support stock assessment and management of thresher sharks, which are subject to commercial and recreational fisheries. Surveys involve catching sharks on longline gear, measuring and taking tissue samples, attaching various tags, and releasing them alive.	Primarily Southern CA Bight, possibly as far north as Monterey, CA	Annually, September 20 DAS	Charter vessel	Anchored longline	Mainline length: 1-2 mile set at 12 ft. deep Gangion length: 10-15 ft. Gangionspacing: 50-100 ft. apart. Hook size and type:13/0 offset circle hooks for thresher sharks Soak time: 2-4 hr	40 sets	Visual monitoring, "move-on" rule, operational adjustments to avoid take. Use of circle hooks and finfish bait to minimize protected species bycatch and magnitude of injury associated with hooking events.
					CTD profiler and rosette water sampler	Tow speed: 0 Duration: 30 min	40 casts	
					Bongo plankton tows	Tow speed: 1.5 kts Duration: 20 min	60 tows	
					Multi-frequency single-beam active acoustics	18, 38, 70, 120, 200, 333 kHz	Continuous	

Survey Name	Survey Description	General Area of Operation	Season, Frequency, Yearly Days at Sea (DAS)	Vessel Used	Gear Used	Gear Details	Number of Samples	Mitigation Measures
Surveys Using Trawl and /or Longline Gear								
Habitat Surveys **(adult rockfish, swordfish)**	Surveys include adult rockfish, EFH, habitat use by swordfish	California Current LME	Opportunistically as funds and ship time are available 50 DAS	NOAA ship, Charter	NETS Nordic 264 two-warp rope trawl	Towed near-surface at night Tow speed: 2-3 kts Duration: 30 min at intended depth	10 tows	Visual monitoring, "move-on" rule, acoustic pingers, and MMEDs
					Pelagic longline	Mainline length: 2-12 mile set to 600 feet depending on target species. Gangion length: 36 ft. Gangionspacing: 50-100 ft. apart Hook size and type:16/0 and 18/0 offset, stainless circle hooks for swordfish Soak time: up to 8 hr	20 sets	Visual monitoring, operational adjustments to avoid take. Use of circle hooks and finfish bait to minimize protected species bycatch and magnitude of injury associated with hooking events.
					Bongo plankton tows	Tow speed: 1.5 kts Duration: 20 min	100 tows	
					CTD profiler and rosette water sampler	Tow speed: 0 Duration: 30 min	100 casts	
					Oozeki, IKMT, MOCNESS, Tucker nets	Tow speed: 2-3 kts Duration: 20-60 min	50 tows	
					Manned Submersible	1-3 hour dives	10 dives	

Survey Name	Survey Description	General Area of Operation	Season, Frequency, Yearly Days at Sea (DAS)	Vessel Used	Gear Used	Gear Details	Number of Samples	Mitigation Measures
Surveys Using Other Gear								
California Cooperative Oceanic Fisheries Investigation (CalCOFI) **Winter, Spring, Summer and Fall Surveys**	CalCOFI is a partnership of NMFS, California Department of Fish and Game, and Scripps Institution of Oceanography. The survey series was started in 1949 to describe the pelagic ecology of the California Current and its influence on the population dynamics of west coast sardine stocks. Several hundred taxa of marine fishes and zooplankton are monitored along with aspects of their physical and biological environment. Sampling protocols include transects to assess the distribution and abundance of marine mammals and seabirds	San Diego to San Francisco	Four surveys annually in January-February, April, July and October 90 DAS total for four surveys	NOAA ships and University-National Oceanographic Laboratory System fleet (Scripps Institution of Oceanography)	Various plankton nets (Bongo, Pairovet, Manta, PRPOOS)	Tow speed: 1.5- 2.5 knots (kts) for Bongo and Manta; 0 for Pairovet Duration: 10-20 minutes (min)	75-113 stations per survey; 340 samples total	Visual Monitoring
					CTD profiler and rosette water sampler	Tow speed: 0 Duration: 20-120 min	340 casts total	
					Various small, towed, fine-mesh nets designed to sample larval and juvenile fish and small pelagic invertebrates (Matsuda-Oozeki-Hu trawl net [MOHT], Isaacs-Kidd Mid-water Trawl[IKMT], MOCNESS, Tucker)	Tow speed: 2-3 kts Duration: 20-60 min	35-85 tows total	
					CUFES		Continuous	
					Multi-frequency single-beam active acoustics	18, 38, 70, 120, 200 kHz	Continuous	
					Multi-beam echosounder (Simrad ME70) and sonar (Simrad MS70)		Continuous	
Collaborative Optical Acoustical Survey Technology (COAST) Survey	ROV and acoustic surveys of offshore banks designed to monitor recovery of rockfish. Conducted in collaboration with the charter boat fishing industry.	Southern and Central California	Opportunistically as funds and ship time are available 40 DAS	NOAA ship, Charter vessel	Multi-frequency single-beam active acoustics	18, 38, 70, 120, 200, 333 kHz	Continuous	
					Still and video camera images taken from an ROV			

Survey Name	Survey Description	General Area of Operation	Season, Frequency, Yearly Days at Sea (DAS)	Vessel Used	Gear Used	Gear Details	Number of Samples	Mitigation Measures
Marine Mammal and Ecosystem Assessment Surveys	One or two ship surveys are conducted to assess all marine mammal species in west coast EEZ, or to focus on the distribution and ecology of a selected group of species. Protocols include sampling of various ecosystem components.	California Current Large Marine Ecosystem (LME)	Tri-annually (July - Dec) 60-120 DAS total for three surveys	NOAA ship One or two ship survey	Bongo plankton tows	Tow speed: 1.5 kts Duration: 20 min	60 tows	
					CTD profiler and rosette water sampler	Tow speed: 0 Duration: 30 min	40 casts	
					Oozeki, IKMT, MOCNESS, Tucker nets	Tow speed: 2-3 kts Duration: 20-60 min	60 tows	
					Expendable bathythermographs (XBTs)		80-240 units	
					Multi-frequency single-beam active acoustics	18, 38, 70, 120, 200, 333 kHz	Continuous	
Pacific Coast Ocean Observing System (PacOOS) Central CA	Extension of CalCOFI observation protocols to CalCOFI lines off Monterey Bay and San Francisco during summer and fall surveys when the CalCOFI sampling grid is confined to the Southern California Bight. Surveys conducted in conjunction with Monterey Bay Aquarium Research Institute, UC Santa Cruz, and Navy Post-Graduate School	Central CA, fixed survey lines off Monterey and San Francisco Bays	Annually, July and October 6 DAS total for two surveys	Research Vessel (R/V) Point Sur	Various plankton nets (Bongo, CalVET, Pairovet, Manta)	Tow speed: 1.5- 2.5 kts for Bongo and Manta; 0 for Californai Vertical Egg Tow (CalVET) and Pairovet Duration: 10-20 min	40 tows	
					CTD profiler and rosette water sampler	Tow speed: 0 Duration: 20-120 min	40 casts	
PacOOS North CA	Extension of CalCOFI observation protocols to a sampling line off Eureka CA. Surveys conducted in conjunction with Humboldt State University.	Northern CA, fixed survey lines off Eureka	Monthly 12 DAS total for 12 surveys	R/V Coral Sea	Various plankton nets (Bongo, CalVET, Pairovet, Manta)	Tow speed: 1.5- 2.5 kts for Bongo and Manta; 0 for CalVET and Pairovet Duration: 10-20 min	100 tows	
					CTD profiler and rosette water sampler	Tow speed: 0 Duration: 20-120 min	100 casts	
Swordfish Tagging using Deep-set Buoy Gear	Investigate the use of deep-set buoy gear to capture and tag swordfish without generating significant bycatch interactions	Southern California Bight	Annually, June-November	PIER research vessel *R/V Malolo*, cooperative commercial fishing vessels	Modified swordfish buoy gear to target pelagic swordfish at depths of 250-400 meters during daylight hours	250-400 m mainline monofilament with a buoy flotation system and a 1-2 kilogram (kg) drop sinker. Two monofilament gangions would branch from the mainline at 250-400	300 - 600 sets per year	Minimize slack in the fishing line to maintain a vertical profile and use a high speed electric reel to reduce the time that baits are within the upper water column and minimize potential for marine mammal interactions. Use circle hooks to increase

Survey Name	Survey Description	General Area of Operation	Season, Frequency, Yearly Days at Sea (DAS)	Vessel Used	Gear Used	Gear Details	Number of Samples	Mitigation Measures
						m and would contain a crimped 14/0 circle hook baited with either squid or mackerel. A single set of gear consists of two baited hooks soaked on average for a 4 hour period.		post-hooking survivorship of non-target species. Visually monitor all of the indicator buoys from the vessel. When an indicator flag rises, the buoy set would immediately be tended and the animal caught would either be released or tagged and released in order to increase post-hooking survivorship of all animals.
White Abalone Survey	Remotely Operated Vessel (ROV) surveys of endangered white abalone to monitor population recovery. Surveys confined to offshore banks, island and continental margins, 30-150 m. depth.	Southern CA Bight	Opportunistically as funds and ship time are available 25 DAS	Charter vessel	Still and video camera images taken from an ROV	Tether connecting ROV to the ship is 0.75 inches diameter Avg. speed: 0.49 kts Max. speed: 2.43 kts	100 transects/yr	Slow operating speed minimizes risk of striking a marine mammal. The tether is securely attached to a steel cable and down-weight to minimize slack and prevent loops that might lead to entanglement risk.
Eastern Tropical Pacific Research Area								
Surveys Using Longline Gear								
HMS Survey	New survey planned for the future to monitor HMS abundance and distribution. Conditional on funding.	Eastern Tropical Pacific Ocean	Annually, June-July 30 DAS	NOAA Ship, Charter vessel	Pelagic longline	Mainline length: 2-4 mile set 50 to 75 feet for mako and blue sharks; 300 to 600 feet for swordfish. Gangion length: 10-15 ft. ; 36 ft for swordfish Gangionspacing: 50-100 ft. apart. Hook size and type: 9/0 J hooks for blue and mako sharks; 16/0 and 18/0 offset, stainless circle hooks for swordfish. Soak time: 2-4 hr; up to 8 hr for swordfish	60 sets	Visual monitoring, “move-on” rule, operational adjustments to avoid take.
					Bongo plankton tows	Tow speed: 1.5 kts Duration: 20 min	60 tows	
					CTD profiler and rosette	Tow speed: 0 kts	60 casts	

Survey Name	Survey Description	General Area of Operation	Season, Frequency, Yearly Days at Sea (DAS)	Vessel Used	Gear Used	Gear Details	Number of Samples	Mitigation Measures
					water sampler	Duration: 20-120 min		
					Multi-frequency single-beam active acoustics	18, 38, 70, 120, 200, 333 kHz	Continuous	
Surveys Using Other Gear								
Marine Mammal and Ecosystem Assessment Surveys	Multi-year cetacean and ecosystem assessment study designed to monitor the recovery of several dolphin stocks that were depleted by the yellowfin tuna purse-seine fishery in the ETP Ocean. Protocols include sampling of various ecosystem components.	Eastern Tropical Pacific Ocean	Tri-annually (Jul – Dec) 240 DAS total for three surveys	NOAA ships Two ship survey	Bongo plankton tows	Tow speed: 1.5 kts Duration: 20 min	500 tows	
					CTD profiler and rosette water sampler	Tow speed: 0 Duration: 30 min	500 casts	
					Oozeki, IKMT, MOCNESS, Tucker nets	Tow speed: 2-3 kts Duration: 20-60 min	50-125 tows	
					Multi-frequency single-beam active acoustics	18, 38, 70, 120, 200, 333 kHz	Continuous	
					XBTs		720 units	
Antarctic Research Area								
Antarctic Survey	Shipboard surveys monitor the abundance and distribution of krill for stock assessments and studies of the foraging ecology of krill predators including penguins and pinnipeds. Protocols include marine mammal and seabird observations. Every 2-3 years these protocols are augmented with a bottom trawl and towed camera array used to sample benthic invertebrates and fish. Results of the survey inform fish stock assessments and benthic habitat descriptions.	Scotia Sea sector of the Southern Ocean, including the continental shelf adjacent to the Antarctic Peninsula, and the South Shetland, South Orkney, South Sandwich and South Georgia archipelagos	Annually, January-March or Annually, July-October Bottom trawl conducted every 2-3 years 70 DAS	Charter (RVIB Nathaniel B. Palmer)	Oozeki, IKMT, MOCNESS, Tucker nets	Tow speed: 2-3 kts Duration: 20-60 min	200 tows	
					Multi-frequency active acoustics	38, 70, 120 and 200 kHz	Continuous	
					CTD profiler and rosette water sampler	Tow speed: 0 Duration: 45 min	200 casts	
					Video camera tows	Tow speed: <3 kts Duration: <65 min	50 tows	
					Two-warp NET Hard-Bottom Snapper Trawl	Tow speed: 2-3 kts Duration: 30 min	100 tows	

2. THE DATE(S) AND DURATION OF SUCH ACTIVITY AND THE SPECIFIC GEOGRAPHICAL REGION WHERE IT WILL OCCUR

2.1 Dates and Duration of Activities

Table 1.1 is a summary of regularly occurring SWFSC surveys conducted on NOAA owned and chartered vessels. These surveys are likely to continue during the next five years, although not necessarily every year.

Some cooperative research projects last multiple years or may continue with modifications. Other projects only last one year and are not continued. Therefore, not all of the projects summarized in Table 1.1 are likely to continue in the future. Actual projects that will occur from 2014 through 2019 depend on competitive grant processes and congressional funding levels for the SWFSC, which are inherently uncertain.

- While some surveys are consistently conducted every year (Table 1.1), they are often based on randomized sampling designs so the exact location of survey effort varies year to year in the same general area.
- Some surveys are only conducted every two or three years or when funding is available. Timing of the surveys is a key element of their design but sea and atmospheric conditions as well as ship contingencies often dictate what can happen on any given day or whether scheduled surveys actually occur so there is variability inherent in even the most consistently conducted surveys.
- In addition, the cooperative research program is designed to provide flexibility on a yearly basis in order to address issues as they arise.

Most cooperative research projects go through an annual competitive selection process to determine which projects should be funded based on proposals developed by many independent researchers and fishing industry participants. Because the need for different kinds of fisheries information changes over time and overall funding levels vary with annual congressional appropriations, the priorities for funding different kinds of projects change regularly, which makes it difficult to know what will be funded in the next several years.

2.2 Geographic Region Where the Activity Will Occur

SWFSC research is conducted in three geographic areas that correspond to the California Current Ecosystem (CCE), Eastern Tropical Pacific (ETP), and Antarctic marine living resources (AMLR) ecosystem (Figures 2.1, 2.2, 2.3).

2.2.1 California Current Ecosystem

The SWFSC conducts research surveys in the CCE, both inside and outside of the Large Marine Ecosystem (LME) boundaries. The California Current LME has a surface area of about 2.2 million km^2 and is bordered by the U.S. and Mexico. The California Current moves south along the western coast of North America, beginning off southern British Columbia, flowing southward past Washington, Oregon and California, and ending off southern Baja California (Bograd et al. 2010). The California Current is part of the North Pacific Gyre and brings cool waters southward. Additionally, extensive upwelling of colder sub-surface waters supports large populations of whales, seabirds and important fisheries along the west coast of the U.S. (Sherman and Hempel 2009). The California Current LME includes coastal areas where SWFSC conducts research surveys for rockfish, coastal pelagics and numerous other species. However the SWFSC also conducts research that extends into deeper waters beyond the California Current LME boundary.

On the shoreward side of the California Current, the California Current Front (CCF) separates cold, low-salinity upwelled waters from the warmer saltier waters close to shore. Offshore frontal filaments transport the frontal water across the entire LME. In winter, the Davidson Current Front forms along the boundary between inshore subtropical waters and colder offshore temperate and subarctic waters (Sherman and Hempel 2009).

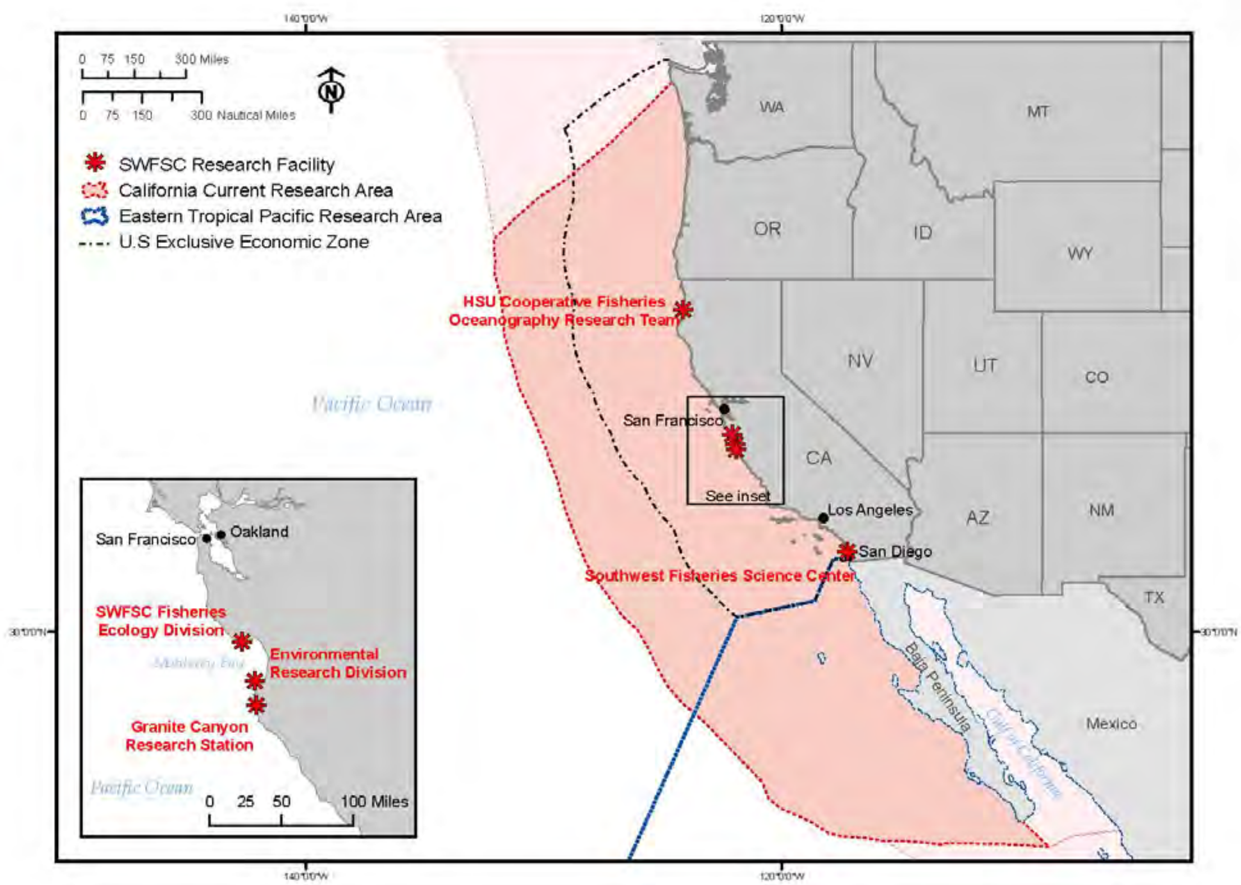

Figure 2.1 California Current Ecosystem (CCE) research area and facilities.

2.2.2 Eastern Tropical Pacific

The eastern tropical portion of the Pacific Ocean extends from San Diego west to Hawaii and south to Peru. Located between the subtropical gyres of the North and South Pacific, this area is one of the most productive tropical oceans in the world. Cool, low-salinity eastern boundary current waters flow into the ETP from the north and south, while warm, high-salinity subtropical surface waters flow into the ETP after being subducted into the thermocline primarily in the southern Subtropical Convergence. As a result of upwelling, the surface layer has relatively cool temperatures, high salinity, and high nutrient concentrations along the equator, coastal Peru and Baja California, and at the Costa Rica Dome. Nutrient-rich thermocline waters lie close to the surface along the countercurrent thermocline ridge between the North Equatorial Countercurrent and the North Equatorial Current. Deep and bottom waters formed in the Antarctic and North Atlantic are relatively homogeneous in the ETP (Fiedler and Lavın 2006).

The SWFSC's ETPRA spans the boundaries of several LMEs, including the California Current LME, the Gulf of California (Sea of Cortez) LME, the Pacific-Central American Coastal LME, and the Humboldt Current LME. The Research Area also includes a large portion of the offshore ETP Ocean outside of coastal LME boundaries (Sherman and Hempel 2009).

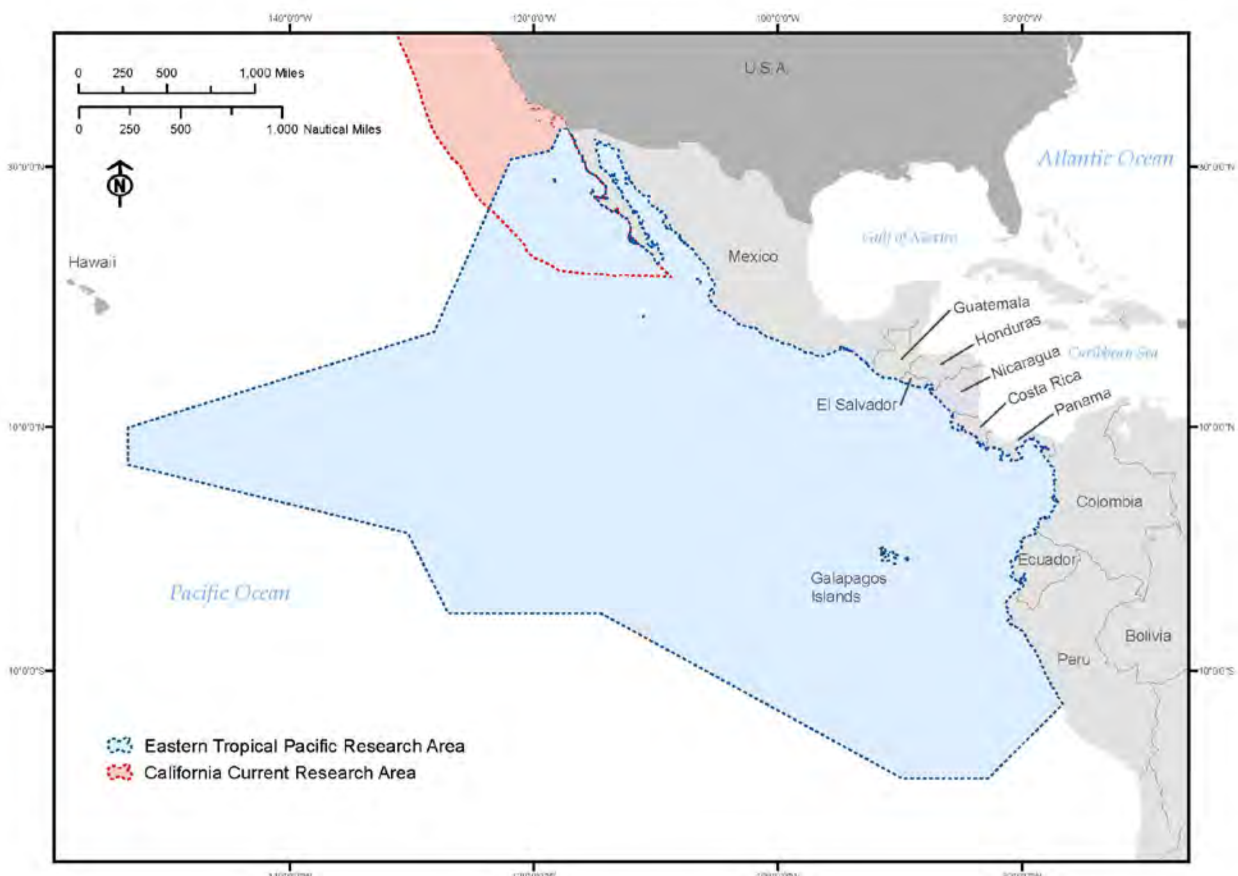

Figure 2.2 Eastern Tropical Pacific (ETP) research area.

2.2.3 AMLR

The AMLR region includes the waters encircling Antarctica south of 60°S latitude. Cold waters flowing north from Antarctica mix with warm sub-Antarctic waters in the Antarctic Ocean. There are only limited areas of shallow waters in the Southern Ocean, where the average depth is between 4,000 and 5,000 meters (13,000 to 16,000 ft) over most of its extent. The Antarctic Circumpolar Current moves eastward and comprises the world's longest ocean current. The keystone species of the Antarctic ecosystem is the Antarctic krill which provides an important food source for many species of marine mammals, seabirds, and fishes (SWFSC 2010).

The SWFSC's survey activities are usually conducted within the Antarctic large marine ecosystem (LME), the northern boundary of which is defined by the Antarctic Convergence. The location of the Antarctic Convergence oscillates between 48 and 60 degrees south and represents the boundary between cold Antarctic Surface water and warmer sub-Antarctic waters (Sherman and Hempel 2008)

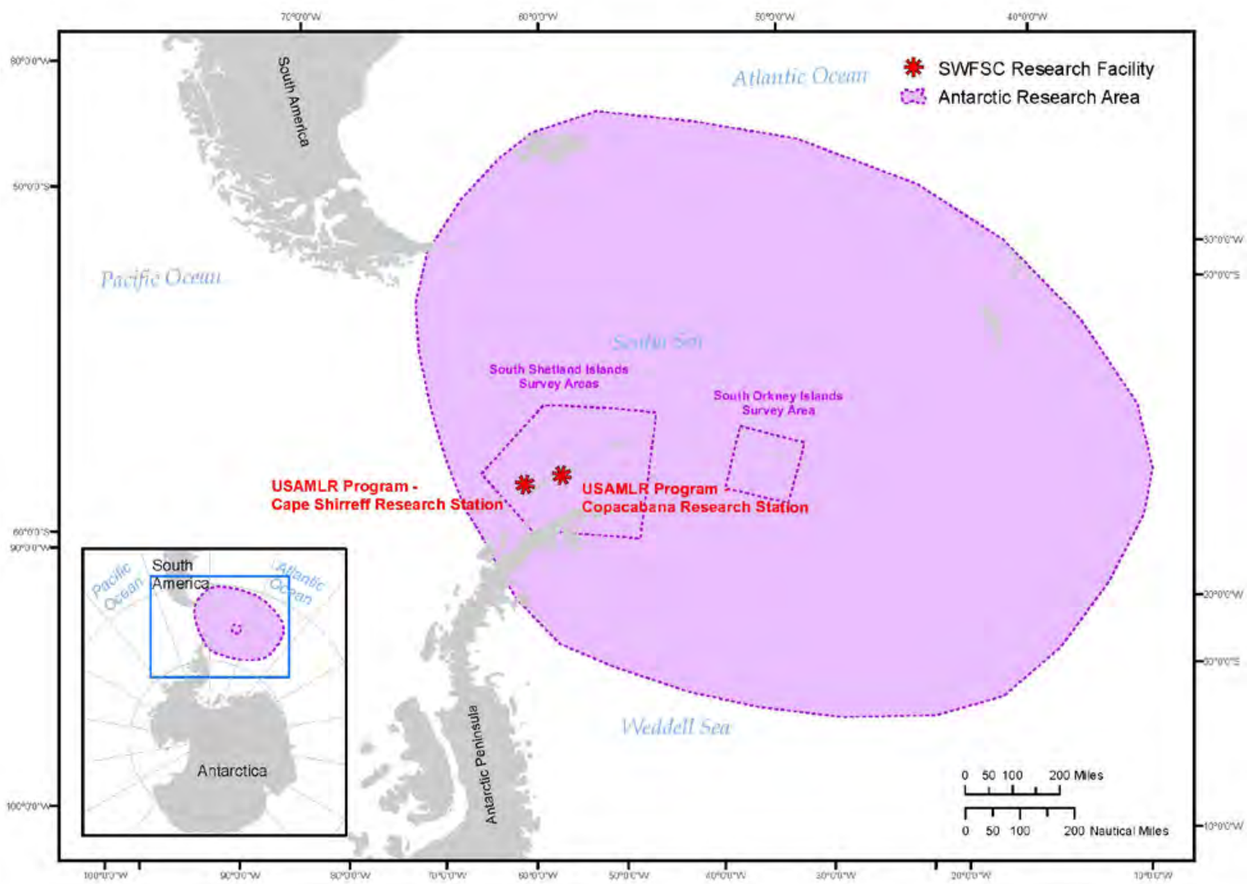

Figure 2.3 Antarctic research area and facilities.

3. SPECIES AND NUMBERS OF MARINE MAMMALS LIKELY TO BE FOUND WITHIN THE ACTIVITY AREA

Marine mammal abundance estimates in this application represent the total number of individuals that make up a given stock or the total number estimated within a particular study area. NMFS stock abundance estimates for most species represent the total estimate of individuals within the geographic area, if known, that comprises that stock. For some species, this geographic area may extend beyond U.S. waters. Survey abundance (as compared to stock or species abundance) is the total number of individuals estimated within the survey area, which may or may not align completely with a stock's geographic range as defined in the NMFS Stock Assessment Reports (SARs) (http://www.nmfs.noaa.gov/pr/sars/region.htm). These surveys may also extend beyond U.S. waters. Both stock abundance and survey abundance are used in this application when available to determine a density of marine mammal species within the survey area.

The species and approximate numbers of marine mammals likely to be found in the three SWFSC activity areas are shown in Tables 3.1 – 3.4. Extralimital species are not included. These are species that do not normally occur in the survey area for which there are one or more records that are considered beyond the normal range; these species that are not likely to be 'taken' pursuant to the MMPA during survey operations are not included in the take request. For the CCE extralimital species include Bryde's whale (*Balaenoptera edeni*) and the North Pacific right whale (*Eubalaena japonica).* For the Eastern Tropical Pacific (ETP) extralimital species include the pygmy sperm whale (*Kogia breviceps*), Burmeister's porpoise (*Phocoena spinipinnis*), long-finned pilot whales (*Globicephala melas*), southern bottlenose whale (*Hyperoodon planifrons*) and Dall's porpoise (*Phocoenoides dalli*); and for the AMLR extralimital species include the pygmy right whale (*Caperea marginata*), Shepherd's beaked whale (*Tasmacetus shepherdi*), strap-toothed beaked whale (*Mesoplodon layardii)*, Gray's beaked whale (*Mesoplodon grayi*), Cuvier's beaked whale (*Ziphius cavirostris)* and sei whale (*Balaenoptera borealis*), which have distributions that only border the northernmost edge of the AMLR study area. Ross seal (*Ommatophoca rossii*) is also considered extralimital to the AMLR study area due to its preference for dense pack ice, an area that is not part of the AMLR survey.

Table 3.1 lists the twenty-three cetacean species (of which *Mesoplodon* spp. includes six beaked whale species) and six pinniped species that occur in the waters of the CCE. The list includes six cetacean species that are also listed as endangered under the ESA (southern resident killer, sperm, blue, fin, sei, and humpback whales), two pinnipeds listed as threatened under the ESA (eastern subspecies of Steller sea lion and Guadalupe fur seal) and one pinniped designated as depleted under the MMPA (Pribilof Islands stock of northern fur seal). As seen in Table 1.1, SWFSC survey activity occurs during most months of the year; trawl surveys occur during May through June and September and longline surveys are during June/July and September. The CalCOFI surveys occur during January-February, April, July and October. Thus many of the marine mammal species that occur in the CCE may be present when surveys occur. However most survey activity occurs offshore and is unlikely to interact with coastal species such as harbor porpoise or gray whales migrating north. Although sea otters are found in the CCE, they are not included in Table 3.1. Sea otters are under the jurisdiction of the U.S. Fish and Wildlife Service (USFWS) and a separate MMPA permit application for sea otters will be sent to the USFWS. Sea otters will not be discussed further in this application.

Table 3.2 lists the thirty marine mammal species occurring within the ETP Research Program's study area. The list includes twenty-six cetaceans and four pinniped species. The list includes five cetacean species that are also listed as endangered under the ESA (sperm, blue, fin, sei, and humpback whales) and three stocks of dolphin designated as depleted under the MMPA (northeastern offshore pantropical spotted, eastern spinner and coastal pantropical spotted dolphins). The marine mammal surveys currently conducted by the SWFSC in the ETP occur triannually July- December (Table 1.1). Marine mammal species that occur in the ETP may interact with these surveys.

Table 3.3 lists the twelve cetacean species and five pinniped species that occur in the waters of the AMLR Survey area. The list includes four cetacean species that are also listed as endangered under the ESA (blue, fin, humpback, and southern right whales). The AMLR surveys occur annually during January-March or August-October (Table 1.1) and may interact with marine mammals that occur in the survey area.

Marine mammals are seen from vessels while in transit to the AMLR survey areas or to and from AMLR field camps, primarily within the Drake Passage, the Sub-Antarctic, and waters around South America. Sighted species include the sei, fin, southern right, and humpack whales, which are listed as endangered on the ESA, as well as the following that are not listed: Commerson's dolphin, black (Chilean) dolphin, southern right-whale dolphin, Peale's dolphin, dusky dolphin, Risso's dolphin, Gray's beaked whale, strap-toothed beaked whale, Cuvier's beaked whale, dwarf minke whale, sub-Antarctic fur seal, South American fur seal, leopard seal, Weddell seal and South American sea lion. These animals are seen from various vessels used to transport Center scientists to the Antarctic. The vessel operators may use passive and active acoustic gear while transiting to collect baseline environmental data. Center scientists have no control over the operation of this gear; and they are not conducting scientific research during this transit other than visual surveys. Therefore, the Center has concluded that marine mammal species in the transit area should be treated like species present during other vessel transits and will not be considered further in the take request by the Center.

For completeness and to avoid redundancy, the required information about all marine mammal species and numbers of species (insofar as it is known), are included in section 4.

Table 3.1. Marine mammals that occur in the California Current Ecosystem (CCE)[1], their status under the Endangered Species Act and Marine Mammal Protection Act, and estimated numbers and density in the CCE. Density estimates were calculated from line-transect surveys in waters from the California/Mexican border to northern Washington. The transect lines followed a grid that was established before each survey to uniformly cover waters between the coast and approximately 556 km (300 nmi) offshore (Barlow and Forney 2007).

Common Name	**Scientific Name**	**Federal ESA/MMPA Status[2]**	**Estimated Minimum Number in the CCE[3]**	**Best Estimate[3]**	**Density/1000 km[2] (footnote 3)**
Cetaceans					
Harbor porpoise	*Phocoena phocoena*	--	Morro Bay stock = 1,478 Monterey Bay stock = 1,079 San Fran. /Russian R. = 6,745 N. CA/S. OR = 28,233	Morro Bay stock = 2,044 Monterey Bay stock = 1,492 San Fran. /Russian R. = 9,189 N. CA/S. OR = 39,581	Not determined
Dall's porpoise	*Phocoenoides dalli*	--	32,106	42,000	75.53
Pacific white-sided dolphin	*Lagenorhynchus obliquidens*	--	21,406	26,930	20.93
Risso's dolphin	*Grampus griseus*	--	4,913	6,272	10.46
Bottlenose dolphin	*Tursiops truncatus*	--	California coastal = 290; offshore = 684	California coastal = 323; offshore = 1,006	1.78
Striped dolphin	*Stenella coeruleoalba*	--	8,231	10,908	16.67
Short-beaked common dolphin	*Delphinus delphis*	--	343,990	411,211	309.35
Long-beaked common dolphin	*Delphinus capensis*	--	17,127	27,046	19.24
Northern right-whale dolphin	*Lissodelphis borealis*	--	6,019	8,334	9.75
Killer whale[4]	*Orcinus orca*	endangered	S. resident = 86 Transient = 354 Offshore = 162	S. resident = 86 Transient = 354 Offshore = 240	0.71
Short-finned	*Globicephala*	--	465	760	0.31

pilot whale	*macrorhynchus*				
Baird's beaked whale	*Berardius bairdii*	--	615	907	0.88
Mesoplodont beaked whales[5]	*Mesoplodon* spp.	--	576	1,024	1.03
Cuvier's beaked whale	*Ziphius cavirostris*	--	1,298	2,143	3.82
Pygmy sperm whale	*Kogia breviceps*	--	271	579	1.09
Dwarf sperm whale	*Kogia sima*	--	No estimate	No estimate	1.09
Sperm whale	*Physeter macrocephalus*	endangered	751	971	1.70
Humpback whale	*Megaptera novaeangliae*	endangered	1,878	2,043	0.83
Blue whale	*Balaenoptera musculus*	endangered	2,046	2,497	1.36
Fin whale	*Balaenoptera physalus*	endangered	2,624	3,044	1.84
Sei whale	*Balaenoptera borealis*	endangered	83	126	0.09
Common Minke whale	*Balaenoptera acutorostrata scammoni*	--	202	478	0.72
Gray whale	*Eschrichtius robustus*	--	18,017	19,126	19.13
Pinnipeds		--			
California sea lion	*Zalophus californianus*	--	153,337	296,750	Not determined
Steller sea lion eastern subspecies[6]	*Eumetopias jubatus monteriensis*	threatened	52,847	58,334-72,223	Not determined
Guadalupe fur seal	*Arctocephalus townsendi*	threatened	3,028	7,408	Not determined
Northern fur seal	*Callorhinus ursinus*	depleted (Pribilof Islands stock only)	San Miguel Is. = 5,395; Pribilof Islands = 642,265	San Miguel = 9.968 P.I. = 653,171	Not determined
Harbor seal	*Phoca vitulina richardsi*	--	CA stock = 26,667 OR/WA = no estimate WA Inland = no estimate	CA stock =30,196 OR/WA unk; WA inland unk	Not determined
Northern elephant seal	*Mirounga angustirostris*	--	74,913	124,000	Not determined

[1] Does not include extralimital species or sea otters.
[2] Denotes ESA listing as either endangered or threatened, or MMPA listing as depleted.
[3] Allen and Angliss (2012), Barlow and Forney (2007), Carretta et al. (2011, 2012), Man-Tec 2007, and see Section 4 below.
[4] Southern Resident Killer Whales that occur in Puget Sound and other locals are listed as endangered under the ESA. All other forms of killer whale that occur in the CCE are not listed under the ESA.
[5] Six *Mesoplodon* spp. beaked whale species occur in the offshore waters of the California Current Ecosystem including Stejneger's, Hubb's, Blainville's, Perrin's, Lesser, and Gingko-toothed beaked whales.
[6] A recent paper has proposed that the two Steller sea lion stocks (eastern and western) be designated as two subspecies (Phillips et al. 2009). Presently the eastern subspecies, which includes those that breed in the California Current Ecosystem, is listed as threatened under the US Endangered Species Act; the western subspecies is listed as endangered.

Table 3.2. Marine mammal species occurring within the Eastern Tropical Pacific (ETP)[1] Research Program's study area, their status under the ESA and MMPA, and estimated numbers in the ETP, if available. The estimated number in the ETP presented in this table is the best estimate available for these marine mammal species.

Common Name	Scientific Name	Federal ESA/MMPA Status[2]	Estimated Number in the ETP[3]	Density/1000 km[2] (see footnote 4)
Cetaceans				
Risso's dolphin	*Grampus griseus*	--	110,457	5.173
Short-beaked common dolphin	*Delphinus delphis*	--	3,127,203	146.453
Long-beaked common dolphin[5]	*Delphinus capensis*	--	372,429	19.45
Rough toothed dolphin	*Steno bredanensis*	--	107,663	5.042
Striped dolphin	*Stenella coeruleoalba*	--	964,362	45.163
Spinner dolphin	*Stenella longirostris*	depleted (eastern stock)	White belly =734,837 East.=1,062,879 Centr. Amer.=no est.	White belly =34.414 Eastern =49.777 Central Amer.= Not determined
Pantropical Spotted dolphin	*Stenella attenuata*	depleted (coastal and northeastern offshore stocks)	NE offshore = 857,884 W/S offshore = 439,208 coastal = 278,155	NE offshore =122.625 W/S offshore =30.592 Coastal =43.435
Dusky dolphin[5]	*Lagenorhynchus obscurus*	--	40,211	2.10
Fraser's dolphin	*Lagenodelphis hosei*	--	289,300	13.548
Melon-headed whale	*Peponocephala electra*	--	45,400	2.126
Bottlenose dolphin	*Tursiops truncatus*	--	335,834	15.728
Killer whale	*Orcinus orca*	--	8,500	0.398
False killer whale	*Pseudorca crassidens*	--	39,800	1.864
Pygmy killer whale	*Feresa attenuata*	--	38,990	1.826
Short-finned pilot whale	*Globicephala macrorhynchus*	--	589,315	27.599
Cuvier's beaked whale	*Ziphius cavirostris*	--	20,000	0.937
Longman's beaked whale[5]	*Indopacetus pacificus*	--	1,007	0.037
Mesoplodont beaked whales	*Mesoplodon spp.*	--	25,300	1.185
Sperm whale	*Physeter macrocephalus*	endangered	4,145	0.194
Dwarf sperm whale	*Kogia sima*	--	11,200	0.525
Humpback whale[5]	*Megaptera novaeangliae*	endangered	2,566	0.134

Blue whale	*Balaenoptera musculus*	endangered	1,415	0.194
Fin whale[5]	*Balaenoptera physalus*	endangered	574	0.03
Sei whale[5]	*Balaenoptera borealis*	endangered	0	0
Common Minke whale[5]	*Balaenoptera acutorostrata scammoni*	--	115	0.006
Bryde's whale	*Balaenoptera edeni*	--	10,411	0.488
Pinnipeds				
California sea lion[6]	*Zalophus californianus*	--	105,000	Not determined
Guadalupe fur seal	*Arctocephalus townsendi*	--	No ETP est.	Not determined
South American sea lion[7]	*Otaria flavescens*	--	150,000	Not determined
Northern elephant seal	*Mirounga angustirostris*	--	No ETP est.	Not determined

[1] Does not include extralimital species.
[2] Denotes ESA listing as either endangered or threatened, or MMPA listing as depleted. All marine mammal stocks are considered protected under the MMPA.
[3] See Section 4.
[4] Densities calculated from Gerrodette et al. 2008. Abundance estimates divided by the whole ETP area, which is the sum of the stratum areas given in the first line of Table 1 of Gerrodette et al. 2008. The exception is the area for NE offshore spotted dolphins, which is the sum of Core, Core2 and N Coastal stratum areas; for the WS spotted dolphins area it is the sum of the Outer and S Coastal areas; and for coastal spotted dolphins the area is the sum of the N Coastal and Core areas.
[5] Densities calculated from abundance reported in Wade and Gerrodette (1993) or, for those not reported in that publication, density was calculated from sighting data collected on board SWFSC cetacean and ecosystem assessment surveys in the ETP during 1998-2000, 2003 and 2006 using number of sightings (n), mean group size (s), total distance on effort (L) and effective strip width (w) as $D = n*s/2/w/L$
[6] Lowry and Maravilla 2005, Szteren et al. 2006
[7] IUCN Red List of Threatened Species (*www.iucnredlist.org*)

Table 3.3. Marine mammal species occurring within the Antarctic Marine Living Resources (AMLR)[1] Program's study area, their status under the ESA and MMPA, and estimated numbers in the AMLR area, if available. The estimated number in the AMLR survey area presented in this table is the best estimate available for these marine mammal species.

Common Name	**Scientific Name**	**Federal ESA/MMPA Status[2]**	**Estimated Number in the AMLR**	**Estimated Density** (see footnote 3)
Cetaceans				
Spectacled porpoise[6]	*Phocoena dioptrica*	--	Not determined	0.0015/km^2
Hourglass dolphin	*Lagenorhynchus cruciger*	--	Not determined	0.0015/km
Killer whale	*Orcinus orca*	--	Not determined	0.0015/km
Sperm whale[5]	*Physeter macrocephalus*	endangered	Not determined	0.00065/km^2
Arnoux's beaked whale[6]	*Berardius arnuxii*	--	Not determined	0.0006/km^2
Southern bottlenose whale	*Hyperoodon planifrons*	--	Not determined	0.0006/km
Long-finned pilot whale	*Globicephala melas*	--	Not determined	0.0076/km
Antarctic Minke whale	*Balaenoptera bonaerensis*	--	18,125[4]	0.0018/km
Southern Right whale	*Eubalaena australis*	endangered	1,755[4]	0.00041/km^2
Fin whale	*Balaenoptera physalus*	endangered	4,672[4]	0.0839/km^2
Blue whale[7]	*Balaenoptera musculus*	endangered	Not determined	0.00012/km
Humpback whale	*Megaptera novaeangliae*	endangered	9,484[4]	0.0361/km
Pinnipeds			Not determined	
Antarctic fur seal	*Arctocephalus gazella*	--	Not determined	0.0999/km
Southern elephant seal	*Mirounga leonina*	--	Not determined	0.0003/km
Crabeater seal[6]	*Lobodon carcinophaga*	--	Not determined	0.649/km^2
Weddell seal[6]	*Leptonychotes weddelli*	--	Not determined	0.054/km^2

Leopard seal	*Hydruga leptonyx*	--	Not determined	0.0003/km

[1] Does not include extralimital species.
[2] Denotes ESA listing as either endangered or threatened, or MMPA listing as depleted. All marine mammal stocks are considered protected under the MMPA.
[3] See Section 4 below, and for some species density estimates are available based on marine mammal sightings during 2008/2009 SWFSC AMLR surveys. The following species densities were estimated using strip transect methods during AMLR surveys: hourglass dolphin, killer whale, southern bottlenose whale, long finned pilot whale, humpback whale, Antarctic fur seal, southern elephant seal, leopard seal. These densities are depicted as the number of animals for each km of trackline surveyed.
[4] Reilly et al. (2004)
[5] Whitehead (2002)
[6] IUCN Red List Assessment (iucnredlist.org)
[7] Branch et al. (2007)

4. A DESCRIPTION OF THE STATUS, DISTRIBUTION, AND SEASONAL DISTRIBUTION (WHERE APPLICABLE) OF THE AFFECTED SPECIES OR STOCKS OF MARINE MAMMALS LIKELY TO BE AFFECTED BY SUCH ACTIVITIES

The following information summarizes data on the affected species, status and trends, distribution and habitat preferences, behavior and life history, and auditory capabilities, as available in published literature and reports, including marine mammal stock assessment reports.

Additionally, Southall et al. (2007) provided a comprehensive review of marine mammal acoustics including designating functional hearing groups. Table 4.1 presents the functional hearing groups and representative species or taxonomic groups for each, although most species found in the project area are in the first two groups, low frequency cetaceans (baleen whales) and mid frequency cetaceans (odontocetes). General reviews of cetacean and pinniped sound production and hearing may be found in Richardson et al. (1995), Edds-Walton (1997), Wartzok and Ketten (1999), and Au (2000).

Table 4.1. Summary of the five functional hearing groups of marine mammals (based on Southall et al. 2007 and modified from DON 2008b).

Functional Hearing Group	Estimated Auditory Bandwidth	Species or Taxonomic Groups
Low frequency cetaceans (Mysticetes–Baleen whales)	7 Hz to 22 kHz (best hearing is generally below 1000 Hz, higher frequencies result from humpback whales)	All baleen whales
Middle frequency Cetaceans (Odontocetes)	150 Hz to 160 kHz (best hearing is from approximately 10-120 kHz)	Most delphinid species including rough-toothed, bottlenose, spinner, common, white-sided, Risso's and right whale dolphins; medium and large odontocete whales including melon-headed pygmy killer, false killer, killer whale, pilot sperm whale, and beaked whales
High frequency cetaceans (Odontocetes)	200 Hz to 180 kHz (best hearing is from approximately 10-150 kHz)	Porpoise species including the harbor, finless, and Dall's porpoise; the dwarf and pygmy sperm whales).
Pinnipeds in water	75 Hz to 75 kHz (best hearing is from approximately 1-30 kHz)	All seals, fur seals, sea lions
Pinnipeds in air	75 Hz to 30 kHz (best hearing is from approximately 1-16 kHz)	All seals, fur seals, sea lions

4.1 California Current Ecosystem (CCE)

As mentioned above, sea otters and extralimital species are not included. For the CCE, extralimital species include Bryde's whale (*Balaenoptera edeni*) and the North Pacific right whale (*Balaena japonica*).

Cetaceans

4.1.1 Harbor Porpoise (*Phocoena phocoena*) Morro Bay, Monterey Bay, San Francisco-Russian River, and Northern California-Southern Oregon Stocks

Description: Harbor porpoise are one of the smaller porpoises and have a short, stocky body. On average females reach 1.6 m in length and 60 kg while males reach 1.4 m and 50 kg (Bjørge and Tolley 2009). The body is dark gray dorsally with the chin and ventral surfaces a contrasting white that sweeps up the mid flanks (ibid). They have a small triangular dorsal fin that facilitates recognition when swimming but are also known to lie on the surface (ibid). Harbor porpoise tend to avoid ships and rarely bow ride.

Status and trends: Harbor porpoise belong to the Order Cetacea, Suborder Odontoceti, and Family Phocoenidae. Within the CCE geographic area four stocks are recognized: Morro Bay, Monterey Bay, San Francisco-Russian River, and Northern California-Southern Oregon. Two additional harbor porpoise stocks are recognized within Washington inland waters and coastal Oregon/Washington but are not discussed in this review.

Morro Bay stock: Based on 2002-2007 aerial surveys conducted under good survey conditions the estimate of abundance for this stock is 2,044 animals (Carretta et al. 2012). The minimum population estimate is 1,478 animals with a Potential Biological Removal (PBR)[1] of 15 animals. There has been an increasing trend in porpoise abundance in the Morro Bay stock since 1988, perhaps partly due to emigration of animals from the Monterey Bay stock.

Monterey Bay: Based on 2002-2007 aerial surveys under good survey conditions the estimate of abundance for this stock is 1,492 animals (Carretta et al. 2012). The minimum population estimate is 1,079 animals with a PBR of 10 animals. Abundance estimates from aerial surveys conducted between 1988 and 2007 show evidence of a declining trend, though this decline is not statistically significant.

San Francisco-Russian River: Based on 2002-2007 aerial surveys under good survey conditions the estimate of abundance for this stock is 9,189 animals (Carretta et al. 2012). The minimum population estimate is 6,745 animals with a PBR of 67 animals. Abundance of the San Francisco-Russian River harbor porpoise stock appeared to be stable or declining between 1988 and 1991 and has steadily increased since 1993.

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[1] Potential Biological Removal (PBR) Level is defined by the MMPA as the maximum number of animals, not including natural mortalities, which may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population. The PBR level is the product of the minimum population estimate of the stock; one-half the maximum theoretical or estimated net productivity rate of the stock at a small population size; and a recovery factor of between 0.1 and 1.0.

Northern California-Southern Oregon: Based on pooled 2002-2007 aerial survey data including data from both inshore and offshore areas, an updated estimate of abundance for the northern California-southern Oregon harbor porpoise stock is 39,581 harbor porpoise. This estimate represents a combined estimate of aerial surveys completed between 2002-2007 by SWFSC (Carretta et al. 2012) and unpublished data from the National Marine Mammal Laboratory. The minimum population estimate for harbor porpoise in northern California-southern Oregon is 28,833 animals with a PBR of 577 animals. Because the northern boundary of this stock has changed two times in recent years, trends in abundance have been examined only for the northern California portion of this stock. A possible increasing trend in abundance is apparent from surveys conducted between 1989 and 2007, but the trend is not statistically significant (Carretta et al. 2012). ManTech (2007) estimated a density of 1.12 harbor porpoise/km^2 in the coastal and inland waters of Washington but there are no density estimates for coastal waters of the CCE in the SWFSC survey areas.

Harbor porpoise are not listed as "threatened" or "endangered" under the ESA or as "depleted" under the MMPA. The average annual human-caused mortality for all but the Monterey Bay stock is estimated to be less than the PBR, and therefore they are not classified as a "strategic" stock under the MMPA. However, fishery-related mortality of harbor porpoise still occurs in the Monterey Bay stock's range, though the bycatch levels and responsible fisheries are unknown. Because the overall level of fishery mortality is unknown relative to the PBR it cannot be considered to be insignificant and approaching zero mortality and serious injury rate. Although there is uncertainty regarding the observed levels of fishery-related mortality for the Monterey Bay stock, documented human caused mortality is less than the PBR, thus this stock is not considered "strategic" under the MMPA (Carretta et al. 2012).

Distribution and habitat preferences: Harbor porpoises are distributed throughout the coastal waters of the North Pacific, North Atlantic, and Black Sea. In the eastern North Pacific they occur from Point Conception, California to Alaska and across to Russia (Carretta et al. 2012). Harbor porpoise along the west coast of North America are not panmictic or migratory, and movement is sufficiently restricted that genetic differences have evolved. Recent preliminary genetic analyses of samples ranging from Monterey Bay, California to Vancouver Island, British Columbia indicate that there is small-scale subdivision within the U.S. portion of this range. They are typically found in small groups of 1-3 individuals often consisting of a female-calf pair, but larger groups are not uncommon (Bjørge and Tolley 2009). The species frequents inshore areas, shallow bays, estuaries, and harbors. Harbor porpoises are found almost exclusively shoreward of the 200 m contour line, with the vast majority found inside the 50 m curve (Gearin and Scordino 1995; Osmek et al. 1996). A radio-tagged animal remained over deep water of the southern Strait of Georgia (200 m) and movements were confined to a 65 square kilometer area of the capture site off Orcas Island, Washington (Hanson et al. 1999).

Behavior and life history: Harbor porpoises calve and breed throughout the range, and they generally give birth in summer from May through July. Calves remain dependent for at least six months (Leatherwood et al. 1982). Harbor porpoise are usually shy and avoid vessels; thus, they are difficult to approach. Harbor porpoise often feed near bottom in waters less than 200 m deep on bottom-dwelling fishes and small pelagic schooling fishes with high lipid content; herring and anchovy are common prey (Bjørge and Tolley 2009; Leatherwood and Reeves 1986).

Acoustics and hearing: The harbor porpoise has the highest upper-frequency limit of all odontocetes investigated. Kastelein et al. (2002) found that the range of best hearing was from 16 to 140 kHz, with a reduced sensitivity around 64 kHz. Maximum sensitivity (about 33 dB re 1 µPa) occurred between 100 and 140 kHz. This maximum sensitivity range corresponds with the peak frequency of echolocation pulses produced by harbor porpoises (120–130 kHz). Harbor porpoise are in the high-frequency functional hearing group, whose estimated auditory bandwidth is 200 Hz to 180 kHz (Southall et al. 2007). Their vocalizations range from 110 to 150 kHz (DON 2008a) (Table 4.1).

4.1.2 Dall's Porpoise (*Phocoenoides dalli*) California, Oregon, Washington Stock

Description: Dall's porpoises are a stocky, medium sized porpoise with a wide-based dorsal fin that is topped with white pigment. The tail stock is deepened and there is a noticeable beak; the flippers and fluke are small (Jefferson 2009a). Males are somewhat larger than females but both may reach a length of about 2.2 m and weigh about 150 kg or more. The body is black with a large white flank patch that extends to the level of the dorsal fin. They are extremely fast in the water and are often misidentified as 'baby killer whales' (Osborne et al. 1988).

Status and trends: Dall's porpoise belong to the Order Cetacea, Suborder Odontoceti, and Family Phocoenidae. Up to ten populations or stocks are recognized, one of which is the California/Oregon/Washington stock. An estimated 42,000 Dall's porpoises were estimated in the California, Oregon, and Washington population (Carretta et al. 2012). The minimum population estimate is 32,106 Dall's porpoise with a PBR of 257 animals. They were the most common small cetacean observed in ship surveys off the Washington coast from 1995 to 2002 with 115 sightings of 406 animals and mean group size of 3.6 animals (Barlow and Forney 2007). Additional numbers of Dall's porpoise occur in the inland waters of Washington state, but the most recent abundance estimate obtained in 1996 (900 animals, CV = 0.40) is over 8 years old and is not included in the overall estimate of abundance for this stock. Barlow and Forney (2007) estimated the density of Dall's porpoise at 75.53 porpoise/1000 km^2.

As summarized in Carretta et al. (2011, and citations therein) the status of Dall's porpoise in California, Oregon and Washington relative to the Optimal Sustainable Population (OSP) is not known, and there are insufficient data to evaluate potential trends in abundance. No habitat issues are known to be of concern for this species. They are not listed as threatened or endangered under the ESA nor as "depleted" under the MMPA. The average annual human-caused mortality in 2002-2006 (1.6 animals) is estimated to be less than the PBR (318), and therefore they are not classified as a "strategic" stock under the MMPA. The total fishery mortality and serious injury for this stock is less than 10% of the calculated PBR and, therefore, can be considered to be insignificant and approaching zero mortality and serious injury rate.

Distribution and habitat preferences: The species is found only in temperate waters of the North Pacific and adjacent seas (Jefferson 2009a). The southern end of this population's range is not well-documented, but they are commonly seen off Southern California in winter, and during cold-water periods they probably range into Mexican waters off northern Baja California. Dall's porpoises occur in small groups, although aggregations of at least 200 individuals have been reported. Dall's porpoise occur only rarely in groups of mixed species, although they are sometimes seen in the company of harbor porpoises and gray whales (Jefferson 2009a). It is probably the most widely distributed cetacean in temperate and subarctic regions of the North Pacific and Bering Sea. This is an oceanic species found along the continental shelf and in inland and coastal waters. There are seasonal inshore-offshore and north-south movements, but these movements are poorly understood (Jefferson 2009a). Hanson (2007) described movements of radio-tagged Dall's porpoise from the San Juan Islands to the outer coast coincident with the timing of development of the Juan de Fuca eddy in two consecutive years. Their departure is consistent with the breakdown of this feature.

Behavior and life history: Calves are born in summer, and gestation is thought to be about one year (Osborne et al. 1988; Jefferson 2009a). Dall's porpoises apparently feed at night. Prey species in the inland waters of British Columbia and Puget Sound include squid and schooling fishes (Walker et al. 1998). Dall's porpoise equipped with dive recorders dove to about 94 m in water that exceeded 200 m while feeding in Puget Sound inland waters. Dive duration was about 1.3 minutes (Baird and Hanson 1996).

Acoustics and hearing: Only short duration pulsed sounds have been recorded for Dall's porpoise; this species apparently does not whistle often (Richardson et al. 1995). Dall's porpoises produce short-duration (50 to 1,500 μs), high-frequency, narrow band clicks, with peak energies between 120 and 160 kHz. There are no published data on hearing ability of this species (DON 2008b).

4.1.3 Pacific White-sided Dolphin (*Lagenorhynchus obliquidens*) California, Oregon, Washington Northern and Southern Stocks

Description: Pacific white-sided dolphins are a medium sized dolphin with adults ranging from 1.7 m to 2.5 m in length and weighing 75-198 kg; males are slightly larger than females (Black 2009). They are boldly marked with a dark gray or black dorsal surface, light gray sides and light gray 'suspender stripes' anterior. The dorsal fin is falcate to lobate with a rounded tip; it has a darker leading edge with light gray color covering two thirds of the posterior portion; the flukes are all dark (Black 2009). A few predominately white individuals with small patches of black pigmentation on the sides, heads, and fins have been identified in Monterey Bay.

Status and trends: Pacific white-sided dolphins belong to the Order Cetacea, Suborder Odontoceti, and Family Delphinidae. Although there is clear evidence that two forms of Pacific white-sided dolphins occur along the U.S. west coast, there are no known differences in color pattern, and it is not currently possible to distinguish animals without genetic or morphometric analyses. Geographic stock boundaries appear dynamic and are poorly understood, and therefore cannot be used to differentiate the two forms.

Pacific white-sided dolphins may spend time outside the U.S. Exclusive Economic Zone (EEZ), and therefore a multi-year average abundance estimate including California, Oregon and Washington is the most appropriate for management within U.S. waters. The 2005-2008 geometric mean abundance estimates for California, Oregon and Washington waters based on the two most recent ship surveys is 26,930 with a minimal population estimate of 21,406 dolphins. Barlow and Forney (2007) estimated the density of Pacific white-sided dolphins at 20.93 dolphins/1000 km^2. The PBR is 193 animals. No long-term trends in the abundance of Pacific white-sided dolphins in California, Oregon and Washington are suggested based on historical and recent surveys (Carretta et al. 2012).

As summarized in Carretta et al. (2011, and citations therein), the status of Pacific white-sided dolphins in California, Oregon and Washington relative to OSP is not known, and there is no indication of a trend in abundance for this stock. No habitat issues are known to be of concern for this species. They are not listed as threatened or endangered under the ESA nor as "depleted" under the MMPA. The average annual human-caused mortality in 2000-2006 (1.4 animals) is estimated to be less than the PBR (193), and therefore they are not classified as a "strategic" stock under the MMPA. The total fishery mortality and serious injury for this stock is less than 10% of the calculated PBR and, therefore, can be considered to be insignificant and approaching zero mortality and serious injury rate.

Distribution and habitat preferences: This dolphin is one of the most abundant pelagic species of dolphin found in cold-temperate North Pacific waters. In the eastern Pacific it occurs as far west as Amchitka Island in the central Aleutian Islands through the Gulf of Alaska and down to 20^o N, just south of Baja California (Black 2009). They do not migrate but exhibit seasonal shifts in distribution related to oceanographic variability. As summarized in Carretta et al. (2011, and citations therein), Pacific white-sided dolphins are endemic to temperate waters of the North Pacific Ocean, and are common both on the high seas and along the continental margins. Off the U.S. west coast, Pacific white-sided dolphins have been seen primarily in shelf and slope waters. Sighting patterns from recent aerial and shipboard surveys conducted in California, Oregon and Washington suggest seasonal north-south movements, with animals found primarily off California during the colder water months and shifting northward into Oregon and Washington as water temperatures increase in late spring and summer. They typically inhabit productive continental shelf and slope waters generally within 185 km of shore (Black 2009). They frequent some areas with complex bathymetry such as Monterey Bay, CA, an area where deep submarine canyons approach shore (ibid).

Behavior and life history: As summarized from Black (2009, and citations therein) calving occurs from May to September. Age and length of maturation varies by area with females becoming sexually mature at 8-11 years with a 4 to 5-year calving interval. These are highly social dolphins and are avid bow riders that commonly occur in groups of less than a hundred but can form herds of over a thousand animals. They often associate with other dolphins typically Risso's, commons, and northern right-whale dolphins and porpoises and occasionally feed near humpback whales. Killer whales (*Orcinus orca*) appear to be a significant predator. Prey species include cephalopods (30 species known to be consumed) and schooling fishes (at least 60 species) (Black 2009). Pacific white-sided dolphins equipped with radio transmitters had mean dive duration of 24 seconds and a maximum dive time of 6.2 minutes (ibid).

Acoustics and hearing: As summarized in DON (2008b, and citations therein), vocalizations produced by Pacific white-sided dolphins include whistles and clicks. Whistles are in the frequency range of 2 to 20 Hz. Peak frequencies of the pulse trains for echolocation fall between 50 and 80 kHz; the peak amplitude is 170 dB re 1μPa-m. Underwater hearing sensitivity of the Pacific white-sided dolphin is from 75 Hz through 150 kHz. The greatest sensitivities were from 4 to 128 kHz. Below 8 Hz and above 100 kHz, this dolphin's hearing was similar to that of other toothed whales.

4.1.4 Risso's Dolphin (*Grampus griseus*) California, Oregon, Washington Stock

Description: Risso's dolphins are large dolphins with adults of both sexes reaching up to 4 m in length; there is no evidence of sexual dimorphism (Baird 2009). The anterior body is robust tapering to a relatively narrow tail stock with a relatively small dorsal fin. The bulbous head has a distinct vertical crease along the anterior surface of the melon (Baird 2009). Color patterns change with age; older animals are covered with linear scars and may appear whitish on the dorsal and lateral surfaces. The dorsal fin is falcate and black in color (Baird 2009). They are often confused with killer whales due to the large size of their dorsal fin.

Status and trends: Risso's dolphins belong to the Order Cetacea, Suborder Odontoceti, and are the fifth largest member of the Family Delphinidae. As oceanographic conditions vary, Risso's dolphins may spend time outside the U.S. EEZ, and therefore a multi-year average abundance estimate is the most appropriate for management within U.S. waters. The 2005-2008 geometric mean abundance estimate for California, Oregon and Washington waters based on the two most recent ship surveys is 6,272 animals with a minimum population estimate of 4,913; the PBR for Risso's dolphins is 39 animals. Barlow and Forney (2007) estimated the density of Risso's dolphins at 10.46 dolphins/1000 km^2. There is no apparent trend in abundance between the most recent survey years 1991 and 2008 (Carretta et al. 2012).

As summarized in Carretta et al. (2011, and citations therein) the status of Risso's dolphins off California, Oregon and Washington relative to OSP is not known, and there are insufficient data to evaluate potential trends in abundance. No habitat issues are known to be of concern for this species. They are not listed as "threatened" or "endangered" under the ESA nor as "depleted" under the MMPA. Over the last 5-year period (2002-2006), the average annual human-caused mortality (4.9 animals) is estimated to be less than the PBR (97), and therefore they are not classified as a "strategic" stock under the MMPA. The total fishery mortality and serious injury for this stock is less than 10% of the calculated PBR and, therefore, can be considered to be insignificant and approaching zero mortality and serious injury rate.

Distribution and habitat preferences: Risso's dolphins are distributed world-wide in tropical and warm-temperate waters. Off the U.S. west coast, Risso's dolphins are commonly seen on the shelf in the Southern California Bight and in slope and offshore waters of California, Oregon and Washington (Carretta et al. 2012). Animals found off California during the colder water months are thought to shift northward into Oregon and Washington as water temperatures increase in late spring and summer. The southern end of this population's range is not well-documented, but previous surveys have shown a conspicuous 500 nmi distributional gap between these animals and Risso's dolphins sighted south of Baja California and in the Gulf of California. Thus this population appears distinct from animals found in the eastern tropical Pacific and the Gulf of California (Carretta et al. 2012). They seem to prefer temperate and tropical waters in steep edged habitat between 400- and 1000-m deep. In the Pacific they can be found as far north as the Gulf of Alaska and the Kamchatka Peninsula and south to Tierra del Fuego and New Zealand (Baird 2009).

Behavior and life history: As summarized in Baird (2009, and citations therein), Risso's dolphins are relatively gregarious, typically travelling in groups of 10-50 individuals; the largest group reported had over 4,000 individuals. They have been observed bow riding in front of gray whales and are often seen surfing in swells. Gestation is 13-14 months and calving intervals are about

2.4 years with peak calving during winter in the eastern North Pacific. Sexual maturity for females is thought to be 8-10 years of age and males 10-12 years of age. They feed almost exclusively on squid, likely at night (Baird 2009).

Acoustics and hearing: Risso's dolphins are in the mid-frequency functional hearing group, with an estimated auditory bandwidth of 150 Hz to 160 kHz (Southall et al. 2007). Vocalizations of Risso's dolphin range from 400 Hz to 65 Hz (DON 2008a) (Table 4.1).

4.1.5 Bottlenose Dolphin (*Tursiops truncatus*) California Coastal Stock and Offshore Stock

Description: Bottlenose dolphins are large and robust, varying in color from light gray to charcoal. The common bottlenose dolphin is characterized by a medium-length stocky beak that is clearly distinct from the melon (Jefferson et al. 2008). The dorsal fin is tall and falcate. There are striking regional variations in body size, with adult lengths from 1.9 to 3.8 m (Wells and Scott 2009).

Status and trends: Bottlenose dolphins belong to the Order Cetacea, Suborder Odontoceti, and Family Delphinidae. Two forms of common bottlenose dolphins are recognized in the western North Pacific Ocean: California coastal stock (coastal) and California/Oregon/Washington offshore (offshore) stock. As summarized in Carretta et al. (2011, and citations therein) the population of the coastal stock has been estimated based on photographic mark-recapture surveys conducted along the San Diego coast in 2004 and 2005. The most recent estimate of population size is 323 dolphins but may be closer to 450-500 animals, with a minimum population estimate of 290 animals and a PBR of 2.4 dolphins per year. The population has remained stable for about 20 years.

Because the distribution of the offshore stock of bottlenose dolphins appears to vary inter-annually and they may spend time outside the U.S. EEZ, a multi-year average abundance estimate is the most appropriate for management within U.S. waters. The most comprehensive multi-year average abundance is the geometric mean abundance estimate for California, Oregon and Washington waters based on the 2005 and 2008 ship surveys, or 1,006 offshore bottlenose dolphins with a minimum population estimate of 684; the PBR is 5.5 animals per year (Carretta et al. 2012). No information on trends in abundance of offshore bottlenose dolphins is available. Barlow and Forney (2007) estimated the density of bottlenose dolphins at 1.78 dolphins/1000 km^2.

The status of coastal and offshore bottlenose dolphins relative to OSP is not known, and there is no evidence of a trend in abundance. They are not listed as "threatened" or "endangered" under the ESA nor as "depleted" under the MMPA. Coastal bottlenose dolphins are not classified as a "strategic" stock under the MMPA because total annual fishery mortality and serious injury for this stock ($\geq$ 0.2 per year) is less than the PBR (2.4 and 5.5, respectively). The total human-caused mortality and serious injury for this stock is less than 10% of the calculated PBR and, therefore, can be considered to be insignificant and approaching zero mortality and serious injury rate.

Distribution and habitat preferences: In general, bottlenose dolphins are distributed world-wide; in the North Pacific they are commonly found as far north as the southern Okhotsk Sea, Kuril Islands, and central California. Bottlenose dolphins are distributed in tropical and warm-temperate waters that range from about 10 to 32^o C. They inhabit temperate and tropical shorelines, adapting to a variety of marine and estuarine habitats, even ranging into rivers (Wells and Scott 2009). They are primarily coastal but do occur in pelagic waters, near oceanic islands and over the continental shelf. In many regions, including California, separate coastal and offshore populations exist. As summarized in Carretta et al. (2011, and citations therein), California coastal bottlenose dolphins are found within about one kilometer of shore primarily from Point Conception (but as far north as San Francisco) south into Mexican waters, at least as far south as San Quintin, Mexico. In southern California, animals are found within 500 m of the shoreline 99% of the time and within 250 m 90% of the time. Oceanographic events appear to influence the distribution of animals along the coasts of California and Baja California as indicated by a change in residency patterns along Southern California and a northward range extension into central California after the 1982-83 El Niño is known.

Offshore bottlenose dolphins have been found at distances greater than a few kilometers from the mainland and throughout the Southern California Bight. They have also been documented in offshore waters as far north as about 41^o N, and they may range into Oregon and Washington waters during warm water periods. Sighting records off California and Baja California suggest that offshore bottlenose dolphins have a continuous distribution in these two regions. Based on aerial surveys and shipboard surveys no seasonality in distribution is apparent. Offshore bottlenose dolphins are not restricted to U.S. waters, but cooperative management agreements with Mexico exist only for the tuna purse seine fishery and not for other fisheries that may take this species (e.g., gillnet fisheries).

Behavior and life history: Births have been reported from all seasons with peaks during spring-summer months. Females may give birth as late as their 48th year. A large variety of fish and squid forms most of the diet and varies by region, although they do seem to prefer sciaenids (drums and croakers), scombrids (mackerels and tunas), and mugilids (mullets) (Wells and Scott 2009). Most consumed fish are bottom dwellers. Sharks are probably the most important predators on bottlenose dolphins. As summarized in DON (2008a, and citations therein), dive durations as long as 15 min are recorded for trained individuals but typical dives are more shallow and of a much shorter duration. Mean dive durations of Atlantic bottlenose dolphins typically range from 20 to 40 seconds at shallow depths and can last longer than 5 minutes during deep offshore dives. Offshore bottlenose dolphins regularly dive to 450 m and possibly as deep as 700 m.

Acoustics and hearing: Coastal and offshore stocks of bottlenose dolphins are in the mid-frequency functional hearing group, with an estimated auditory bandwidth of 150 Hz to 160 kHz (Southall et al. 2007). Bottlenose dolphin vocalization frequencies range from 3.4 to 130 kHz (DON 2008a) (Table 4.1).

4.1.6 Striped Dolphin *(Stenella coeruleoalba)* California, Oregon, Washington Stock

Description: The striped dolphin is uniquely marked with black lateral stripes from eye to flipper and eye to anus. There is also a white V-shaped "spinal blaze" originating above and behind the eye and narrowing to a point below and behind the dorsal fin (Archer 2009). There is a dark cape and white belly; the lateral field is usually darker than the ventral. This is a relatively robust dolphin with a long, slender beak and prominent dorsal fin. The longest specimen was 2.56 m and the heaviest was 156 kg but mean maximum body length in the western pacific is 2.4 m for males and 2.2 m for females (Archer 2009).

Status and trends: Striped dolphins belong to the Order Cetacea, Suborder Odontoceti, and Family Delphinidae. The abundance of striped dolphins in this region appears to be variable between years and may be affected by oceanographic conditions. Because animals may spend time outside the U.S. EEZ as oceanographic conditions change, a multi-year average abundance estimate is the most appropriate for management within U.S. waters. The 2005-2008 geometric mean abundance estimate for California, Oregon and Washington waters based on the 2005 and 2008 ship surveys is 10,908 striped dolphins; the minimum population estimate is 8,231 striped dolphins with a PBR of 82 striped dolphins per year (Carretta et al. 2012). Barlow and Forney (2007) estimated the density of striped dolphins at 16.67 dolphins/1000 km^2.

The status of striped dolphins in California relative to OSP is not known, and there are insufficient data to evaluate potential trends in abundance. No habitat issues are known to be of concern for this species. They are not listed as threatened or endangered under the ESA nor as "depleted" under the MMPA. Because recent fishery and human-caused mortality is less than 10% of the PBR (82), striped dolphins are not classified as a "strategic" stock under the MMPA, and the total fishery mortality and serious injury for this stock can be considered to be insignificant and approaching zero.

Distribution and habitat preferences: Striped dolphins are distributed worldwide in cool-temperate to tropical zones. On recent surveys extending about 300 nmi offshore of California, they were sighted within about 100-300 nmi from the coast. No sightings have been reported for Oregon and Washington waters, but striped dolphins have stranded in both states. Striped dolphins are also commonly found in the central North Pacific, but sampling between this region and California has been insufficient to determine whether the distribution is continuous. Based on sighting records off California and Mexico, striped dolphins appear to have a continuous distribution in offshore waters of these two regions (Carretta et al. 2012). Striped dolphins are usually found beyond the continental shelf, typically over the continental slope out to oceanic waters and are often associated with convergence zones and waters influenced by upwelling. The species feeds on a variety of pelagic and benthopelagic fish and squid.

Behavior and life history: As summarized from Archer (2009, and references therein), mating is seasonal and gestation lasts 12-13 months. Females become sexually mature between 5 and 13 years of age and between 7 and 15 years of age for males. Striped dolphins are acrobatic and perform a variety of aerial behaviors but they do not commonly bow ride. They often feed in pelagic or benthopelagic zones along the continental slope or just beyond it in oceanic waters. A majority of their prey possesses luminescent organs, suggesting that striped dolphins may be feeding at great depths, possibly diving to 200 to 700 m to reach potential prey. Striped dolphins may feed at night in order to take advantage of the deep scattering layer's diurnal vertical movements (Archer 2009).

Acoustics and hearing: Striped dolphins are in the mid-frequency functional hearing group, with an estimated auditory bandwidth of 150 Hz to 160 kHz (Southall et al. 2007). Their vocalizations range from 6 to > 24 kHz (DON 2008a) (Table 4.1).

4.1.7 Short-Beaked Common Dolphin (*Delphinus delphis*) California, Oregon, Washington Stock

Description: As summarized in DON (2008a, and citations therein) and Perrin (2009), short-beaked common dolphins are slender, moderately robust dolphins, with a moderate length beak, and a tall, slightly falcate dorsal fin. The beak is shorter than in long-beaked common dolphins, and the melon rises from the beak at a steeper angle. Short-beaked common dolphins are distinctively marked with a V-shaped saddle caused by a dip in the cape below the dorsal fin, yielding an hourglass pattern on the side of the body. The back is dark brownish-gray, the belly is white, and the anterior flank patch is tan to cream in color. The lips are dark, and there is a dark stripe from the eye to the apex of the melon and another one from the chin to the flipper (the latter is diagnostic to the genus). There are often variable light patches on the flippers and dorsal fin. Length ranges up to about 2.3 m (females) and 2.6 m (males).

Status and trends: Short-beaked common dolphins belong to the Order Cetacea, Suborder Odontoceti, and Family Delphinidae. As summarized in Carretta et al. (2012, and citations therein), the most recent estimates of abundance estimates are based on two summer/fall shipboard surveys that were conducted within 300 nmi of the coasts of California, Oregon and Washington in 2005 and 2008. The distribution of short-beaked common dolphins throughout this region is highly variable, apparently in response to oceanographic changes on both seasonal and inter-annual time scales. As oceanographic conditions vary, short-beaked common dolphins may spend time outside the U.S. EEZ, and therefore a multi-year average abundance estimate is the most appropriate for management within U.S. waters. The 2005-2008 geometric mean abundance estimates for California, Oregon and Washington waters based on the two ship surveys is 411,211 short-beaked common dolphins; the minimum population estimate is 343,990 short-beaked common dolphins with a PBR of 3,440 short-beaked common dolphins per year (Carretta et al. 2012). Barlow and Forney (2007) estimated the density of short-beaked common dolphins at 309.35 dolphins/1000 km^2.

The status of short-beaked common dolphins in Californian waters relative to OSP is not known (Carretta et al. 2012). The observed increase in abundance of this species off California probably reflects a distributional shift, rather than an overall population increase due to growth. No habitat issues are known to be of concern for this species. They are not listed as threatened or endangered under the ESA nor as "depleted" under the MMPA. The average annual human-caused mortality in 2002-2006 is estimated to be less than the PBR (3,440), and therefore they are not classified as a "strategic" stock under the MMPA. The total estimated fishery mortality and injury for short-beaked common dolphins is less than 10% of the calculated PBR and, therefore, can be considered to be insignificant and approaching zero mortality and serious injury rate.

Distribution and habitat preferences: Short-beaked common dolphins are the most abundant dolphin in offshore warm-temperate waters in the Atlantic and Pacific (Perrin 2009). They occur worldwide from about 40-60^o N to about 50^o S (Perrin 2009). They are the most abundant cetacean off California, and are widely distributed between the coast and at least 300 nmi distance from shore (Carretta et al. 2012). The abundance of this species off California has been shown to change on both seasonal and inter-annual time scales. Historically, they were reported primarily south of Pt. Conception, but have been commonly recorded as far north as 42^o N

(Carretta et al. 2012). The short-beaked common dolphin is found in coastal and offshore waters along the eastern Pacific coast from Peru to Vancouver Island. They are widely distributed to 556 km offshore (Carretta et al. 2012). They tend to prefer cooler water farther offshore than the sympatric long-beaked common dolphin; they occupy upwelling-modified habitats with less tropical characteristics than surrounding water masses (Perrin 2009). During summer and fall, short-beaked common dolphins primarily occur along the outer coast in waters deeper than 200 m, south of 42^o N and to a lesser extent in water depths between 100 m and 200 m south of 42^o N, and seaward of the 100 m water depth north of 42^o N. In winter and spring, animals typically stay south of the 13^o C isotherm. There is a rare occurrence for this species in waters cooler than 12^o C and within the Puget Sound (DON 2008b). Separate northern, central, and southern stocks associated with different upwelling areas are recognized in the management of incidental mortality in tuna fisheries (Perrin 2009).

Behavior and life history: Short-beaked common dolphins are usually found in large groups of hundreds to thousands of individuals and are often associated with other marine mammal species. Gestation is 10-11.7 months with a calving interval of 1-3 years, depending on location (Perrin 2009). Age at sexual maturity varies by region from 3 years to 7-12 years for males and 2-4 and 6-8 years for females. Cooler water populations exhibit more seasonality in reproduction (Perrin 2009). There are limited direct measurements of dive behavior but dives to > 656 ft (200 m) are possible, but most occur in the range of 9-50 m based on a study on one tagged individual tracked off San Diego (DON 2008b). Diel fluctuations in vocal activity of this species (more vocal activity during late evening and early morning) appear to be linked to feeding on the deep scattering layer as it rises. Foraging dives up to 200 m in depth have been recorded off southern California (DON 2008b).

Acoustics and hearing: As summarized in DON (2008a, and citations therein), recorded vocalizations include whistles, chirps, barks, and clicks. Clicks range from 0.2 to 150 kHz with dominant frequencies between 23 and 67 kHz and estimated source levels of 170 dB re 1 µPa. Chirps and barks typically have a frequency range from less than 0.5 to 14 kHz, and whistles range in frequency from 2 to 18 kHz. Maximum source levels are approximately 180 dB 1 µPa-m.

4.1.8 Long-Beaked Common Dolphin (*Delphinus capensis*) California Stock

Description: As summarized in Perrin (2009), all common dolphins are slender and have a moderate length beak, and a tall, slightly falcate dorsal fin that may tend toward triangular. The beak is longer than in short-beaked common dolphins, and the melon rises from the beak at a steeper angle. Long-beaked common dolphins in California tend to be longer and heavier than the short-beaked common dolphin. Both species are distinctively marked with a V-shaped saddle caused by a dip in the cape below the dorsal fin, yielding an hourglass pattern on the side of the body. The back is dark brownish-gray, the belly is white, and the anterior flank patch is tan to cream in color. The lips are dark, and there is a dark stripe from the eye to the apex of the melon and another one from the chin to the flipper (the latter is diagnostic to the genus). There are often variable light patches on the flippers and dorsal fin. Length ranges up to about 2.3 m (females) and 2.6 m (males).

Status and trends: Long-beaked common dolphins belong to the Order Cetacea, Suborder Odontoceti, and Family Delphinidae. Long-beaked common dolphins have only recently been recognized as a distinct species. Along the U.S. west coast, their distribution overlaps with that of the short-beaked common dolphin, and much historical information has not distinguished between these two species. The most recent abundance estimate is 27,046 long-beaked common dolphin based on 2005 and 2008 ship line transect surveys of California, Oregon, and Washington waters with a minimum population estimate of 17,127; the PBR is 164 long-beaked common dolphins for the California stock (Carretta et al. 2012). Barlow and Forney (2007) estimated the density of long-beaked common dolphins at 19.24 dolphins/1000 km^2.

The status of long-beaked common dolphins in California waters relative to OSP is not known, and there are insufficient data to evaluate potential trends in abundance. No habitat issues are known to be of concern for this species. They are not listed as threatened or endangered under the ESA or as “depleted” under the MMPA. The average annual human-caused mortality from 2002-2006 does not exceed the PBR (164), and therefore they are not classified as a "strategic" stock under the MMPA. The average total fishery mortality and injury for long-beaked common dolphins (13) is less than 10% of the PBR and, therefore, is considered to be insignificant and approaching zero mortality and serious injury rate (Carretta et al. 2012).

Distribution and habitat preferences: Long-beaked common dolphins are commonly found within about 50 nmi of the coast, from Baja California (including the Gulf of California) northward to about central California. California waters represent the northern limit for this stock and they likely move between U.S. and Mexican waters. No information on trends in abundance is available for this stock because of high interannual variability in line-transect abundance estimates. Heyning and Perrin (1994) detected changes in the proportion of short-beaked to long-beaked common dolphins stranding along the California coast, with the short-beaked common dolphin stranding more frequently prior to the 1982-83 El Niño (which increased water temperatures off California), and the long-beaked common dolphin more commonly observed for several years afterwards. Thus, it appears that both relative and absolute abundance of these species off California may change with varying oceanographic conditions (Carretta et al. 2012). The long-beaked species seems to prefer shallower and warmer water and generally occurs closer to shore than the short-beaked form (Perrin 2009).

Behavior and life history: Long-beaked common dolphins, as with the short-beaked, are usually found in large groups of hundreds to thousands of individuals and are often associated with other marine mammal species. Other traits are as described above for the short-beaked common dolphin.

Acoustics and hearing: Long-beaked common dolphins likely have similar acoustics and hearing to the short-beaked common dolphin. As above for the short-beaked common dolphin, DON (2008a) state that recorded vocalizations include whistles, chirps, barks, and clicks. Clicks range from 0.2 to 150 kHz with dominant frequencies between 23 and 67 kHz and estimated source levels of 170 dB re 1 μPa. Chirps and barks typically have a frequency range from less than 0.5 to 14 kHz, and whistles range in frequency from 2 to 18 kHz. Maximum source levels are approximately 180 dB 1 μPa-m.

4.1.9 Northern Right-Whale Dolphin (*Lissodelphis borealis*) California, Oregon, Washington Stock

Description: Right-whale dolphins, of which there are two recognized species, are slender, sleek dolphins known for their distinctive black and white color patterns and lack of a dorsal fin. The northern right-whale dolphin is mainly black with a white ventral patch that runs from the fluke notch to the throat region; there is another white patch on the ventral tip of the rostrum and the underside of the flipper (Lipsky 2009). They can grow to 3 m in length and 116 kg; and males tend to be larger than females.

Status and trends: Northern right-whale dolphins belong to the Order Cetacea, Suborder Odontoceti, and Family Delphinidae. A multi-year average abundance estimate is the most appropriate for management within U.S. waters; the 2005-2008 geometric mean abundance estimate for California, Oregon and Washington waters based on the two ship surveys is 8,334 (CV= 0.40) northern right-whale dolphins with a minimum population estimate for 2005-2008 of 6,019 dolphins; the PBR is 48 dolphins per year (Carretta et al. 2012). Barlow and Forney (2007) estimated the density of northern right-whale dolphins at 9.75 dolphins/1000 km^2.

The status of northern right-whale dolphins in California, Oregon and Washington relative to OSP is not known, and there are insufficient data to evaluate trends in abundance. No habitat issues are known to be of concern for this species. They are not listed as threatened or endangered under the ESA nor as "depleted" under the MMPA. The average annual human-caused mortality in 2002-2006 (4.8 animals) is estimated to be less than the PBR (48), and therefore they are not classified as a "strategic" stock under the MMPA. The total fishery mortality and serious injury for northern right-whale dolphins is less than 10% of the calculated PBR and, therefore, can be considered to be insignificant and approaching zero mortality and serious injury rate (Carretta et al. 2012).

Distribution and habitat preferences: This species is endemic to the North Pacific Ocean, and is found primarily in cool-temperate (8–19^o C) continental shelf and slope waters. They range from the Kuril Islands south to Sanriko, Japan extending eastward to the Gulf of Alaska and south to Southern California (Lipsky 2009). Northern right-whale dolphins occur in the survey area year-round, but their abundance and distribution vary seasonally. This species is most abundant off central and northern California in nearshore waters in winter. They occur off Oregon and Washington except in winter; peak abundance occurs along the continental slope in fall (Carretta et al. 2012; DON 2008b). Right-whale dolphins prefer cool-temperate and subarctic waters in the North Pacific. They tend to be offshore oceanic cetaceans with rare inshore sightings (Lipsky 2009).

Behavior and life history: Sexual maturity occurs at about 10 years of age. Although calving seasonality is unknown, small calves are seen in winter and early spring. They tend to be gregarious and travel in groups of up to 2,000-3,000 in the North Pacific. Males may attain sexual maturity between 212 and 220 cm in length and females at about 200 cm but few data are available on age, growth, and reproduction. The diet primarily includes squid and mesopelagic fish. No dive data are available.

Acoustics and hearing: As summarized in DON (2008b), clicks with high repetition rates and whistles have been recorded from animals at sea. Maximum source levels were approximately

170 dB 1 μPa-m. Mean frequency of individual echolocation clicks was 31.3 kHz (range of 23 – 41 kHz; SD = 3.7 kHz). There is no published data on the hearing abilities of this species.

4.1.10a Killer Whale (*Orcinus orca*) – Resident Ecotype

Description: Killer whales are the largest member of the dolphin family attaining maximum body lengths of 9 m for males and 7.7 m for females (Ford 2009). Maximum measured weights for males is 5,568 kg and for females 3,810 kg (Ford 2009). Males develop larger appendages than females including the pectoral fins, tail flukes, and dorsal fin, which is erect in shape and may be as high as 1.8 m in males. Directly behind the dorsal fin is a gray area of variable shape called the saddle patch. Killer whales are generally black dorsally and white ventrally with a conspicuous elliptically shaped white patch behind the eye (post-ocular patch). Considerable variation exists in the shape and color of the post-ocular patch, saddle patch, and the size and shape of the dorsal fin such that they are used to identify individuals.

Status and trends: Killer whales belong to the Order Cetacea, Suborder Odontoceti, and Family Delphinidae. There are three recognized ecotypes in the North Pacific Ocean: residents, transients, and offshores (Krahn et al. 2004). Resident killer whales forage primarily for fish in relatively large groups in coastal areas. Transient killer whales, whose range extends over a broader area, primarily hunt marine mammals (Krahn et al. 2004; Baird et al. 1992). Transient pods are usually fewer in number than resident pods, and they typically have different dorsal fin shapes and saddle patch pigmentation than resident pods. Little is known about offshore killer whales, but their groupings are large, they range from Mexico to Alaska, and their prey includes fish (Ford et al. 2000; Krahn et al. 2004).

In 2005, NMFS listed the Puget Sound southern resident killer whale (SRKW) distinct population segment (DPS) as an endangered species under the ESA. Listing factors included reduced quantity and quality of prey, persistent pollutants that could cause immune or reproductive system dysfunction (see Krahn et al. 2009), oil spills, and noise and disturbance from vessel traffic. Additionally, the small size of this stock made it potentially vulnerable to inbreeding that could cause a major population decline. In June 2006, NMFS designated critical habitat for the southern resident killer whales. The designation included approximately 2,500 square miles of Puget Sound, including the entire Strait of Juan de Fuca. Areas with water less than 20 feet deep were not proposed. Also excluded was the Admiralty Inlet naval restricted area.

Resident killer whales of British Columbia and Washington occur as two communities, a northern resident community and a southern resident community. The northern resident community is composed of three clans, A, G, and R with a total of 16 pods. The southern resident community is comprised of a single clan, J-clan made of three pods J1, K1, and L1 (Ford et al. 2000). Population estimates are direct counts of known individuals. The southern resident killer whale population increased to 99 whales in 1995, then declined to 79 whales in 2001 before increasing slightly to 84 whales in 2004 (Ford et al. 2000; Center for Whale Research, unpublished data). About 84 total animals were documented in the J, K, and L pods in 2008; however the minimum population estimate as reported in Carretta et al. (2012) is 86 whales. One birth was recorded in 2008 and seven animals were lost as of October 2008 (Center for Whale Research 2008, NMFS 2008b). Two of these deaths were calves which would not have been counted as part of the population until they were older; females K7 and L21 were 98 and 56 years of age respectively and their deaths were not surprising; the deaths of reproductively active females J11 (35 years old) and L67 (32 years old) were unexpected; and subadult male L101 (5 years old) was attributed to L67 being ill (NMFS 2008b). Two births were reported in February 2009, one in January 2010, and another in February 2010. The unofficial count of the SRKW clan in February 2010 was 89 whales. The PBR level for this stock is calculated as the minimum population size (85) times one-half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.1 (for an endangered stock), resulting in a PBR of 0.17 whales per year

Distribution and habitat preferences: Killer whales are found in all oceans and are second only to humans as the most widely spread of all mammals (Ford 2009). They are most commonly found in coastal and temperate waters of high productivity. The range of southern resident killer whales during the spring, summer, and fall includes the inland waters of Puget Sound, Strait of Juan de Fuca, and Southern Georgia Strait. The southern residents also occur in the coastal waters off the coast of Oregon, Washington, and Vancouver Island and in recent years off the central California coast and the Queen Charlotte Islands. Winter movements and range are poorly known for this stock; however, the J pod is more commonly sighted in inland waters in winter, while pods K and L spend more time offshore during winter (Ford et al. 2000). As summarized by Carretta et al. (2011), most sightings of the SRKW stock have occurred in the summer in inland waters of Washington and southern British Columbia. The complete winter range of this stock is uncertain.

Heimlich-Boran (1988) found that resident killer whales in the inland waters of the Pacific Northwest fed more in areas of high substrate topography along salmon migratory routes while transient whales fed in shallow protected areas around concentrations of their prey. The location of food resources and habitats suitable for prey capture appeared to be the prime determining factor in the behavioral ecology of killer whales.

Behavior and life history: Killer whales are very social and the basic social unit is based on matriline relationship and linked by maternal decent. A typical matriline is composed of a female, her sons and daughters, and the offspring of her daughters (Ford 2009). Females may live to 80-90 years so a female’s line may contain four generations. The pod is the next level of organization that is a group of related matrilines that shared a common maternal ancestor. The next level of social structure is the clan, followed by a resident society.

Births may occur in any month but most are in October-March. Females give birth when between 11 and 16 years of age with a 5-year interval between births. Gestation is 15-18 months and weaning is about 1-2 years after birth. Males attain sexual maturity at about 15 years of age. Life expectancy for females is about 50 years with a maximum of 80-90; males typically live to about 29 years of age (Ford 2009).

The southern residents primarily feed on salmon, especially Chinook salmon, returning to rivers in Washington and southern British Columbia. Resident killer whale pods in Puget Sound exhibit cooperative food searching but perhaps not food capture (Hoelzel 1993). Transient killer whales feed on seals, sea lions, and young or smaller cetaceans (Ford 2009) with an optimal group size of at least three whales needed to efficiently chase and capture marine mammal prey (Baird and

Dill 1996). Although killer whales regularly dive to greater than 150 m, there appears to be a trend toward a greater frequency of shallower dives and that males dive deeper than females (Krahn et al. 2004). Seven resident killer whales followed in 2002 were found to have dives that exceeded 228 m with an average maximum depth of 141 m (Baird et al. 2003). Dive rates (number of dives/hour) are similar for males and females and by age and among pods, but dive rates and swim speeds were greater during the day than at night (Baird et al. 2005). Killer whales have no natural predators other than humans but neonatal mortality is high with nearly 46% dying in the first 6 months (Ford 2009).

Acoustics and hearing: Killer whales, like most cetaceans, are highly vocal and use sound for social communication and to find and capture prey. The sounds include a variety of clicks, whistles, and pulsed calls (Ford 2009). As summarized in DON (2008b, and citations therein), the peak to peak source levels of echolocation signals range between 195 and 224 dB re 1 μPa-m. The source level of social vocalizations ranges between 137 to 157 dB re 1 μPa-m. Acoustic studies of resident killer whales in British Columbia have found that there are dialects, in their highly stereotyped, repetitive discrete calls, which are group-specific and shared by all group members (Ford 2009). These dialects likely are used to maintain group identity and cohesion, and may serve as indicators of relatedness that help in the avoidance of inbreeding between closely related whales (Ford 2009). The killer whale has the lowest frequency of maximum sensitivity and one of the lowest high frequency hearing limits known among toothed whales. The upper limit of hearing is 100 kHz for this species.

4.1.10b Killer Whale (*Orcinus orca*) – Transient Ecotype

Please refer to the descriptions above for transient ecotype killer whales regarding description and taxonomy. Transient killer whales, whose range extends over a broader area, primarily hunt marine mammals. Transient pods are usually fewer in number than resident pods, and they typically have different dorsal fin shapes and saddle patch pigmentation than resident pods. As summarized in Allen and Angliss (2011, and references therein) the transient ecotype contains three communities of transient whales within three discrete populations: 1) Gulf of Alaska, Aleutian Islands, and Bering Sea transients, 2) AT1 transients, and 3) West Coast transients. The West Coast Transient Stock includes animals that occur in California, Oregon, Washington, British Columbia and southeastern Alaska. On many occasions, transient whales from the inland waters of southeastern Alaska have been seen in association with British Columbia/Washington State transients. On other occasions, some of those same British Columbia whales have been sighted with whales more frequently seen off California thus linking these whales by association. Combining the counts of cataloged ‘transient’ whales gives a minimum number of 354 killer whales belonging to the West Coast Transient stock with a PBR of 3.5 animals per year.

Barlow and Forney (2007) estimated the density of killer whales, regardless of ecotype, at 0.71 killer whales/1000 km^2.

In contrast to resident whales, transient killer whales appear to use passive listening as a primary means of locating prey, call less often, and use high-amplitude vocalizations only when socializing, communicating over long distances, or after a successful attack (Deecke et al. 2002). This probably results from the increased cost to killer whales of warning wary marine mammal prey and reducing the chance of a successful attack (Deecke et al. 2002; DON 2008b).

4.1.10c Killer Whale (*Orcinus orca*) – Offshore Ecotype
As summarized in Carretta et al. (2011), the total number of known offshore killer whales along the U.S. West coast, Canada and Alaska is 211 animals, but it is not known what proportion of time this transboundary stock spends in U.S. waters, and therefore this number is difficult to work with for PBR calculations. A minimum abundance estimate for all killer whales along the coasts of California, Oregon and Washington can be estimated from the 2005-2008 line-transect surveys as the 20th percentile of the geometric mean 2005-2008 abundance estimate, or 466 killer whales. Using a prorating of known ecotypes, a minimum of 162 offshore killer whales are estimated to be in U.S. waters off California, Oregon and Washington. No information is available regarding trends in abundance of Eastern North Pacific offshore killer whales.
The PBR level is 1.6 offshore killer whales per year.

4.1.11 Short-Finned Pilot Whale (*Globicephala macrorhynchus*) California, Oregon, Washington Stock
Description: Pilot whales appear black or dark gray; the body is robust with a thick tailstock. The melon is exaggerated and bulbous and there is either no beak or a barely discernable one (Olson 2009). They exhibit striking sexual dimorphism with adult males reaching an average length of 6 m and they are larger than females; the broad-based dorsal fin of a male is larger than that of a female (Olson 2009).

Status and trends: Short-finned pilot whales belong to the Order Cetacea, Suborder Odontoceti, and Family Delphinidae. The abundance of short-finned pilot whales in this region appears to be variable and influenced by prevailing oceanographic conditions. Because animals may spend time outside the U.S. EEZ as oceanographic conditions change, a multi-year average abundance estimate is the most appropriate for management within U.S. waters. The 2005-2008 unweighted average abundance estimate for California, Oregon and Washington waters based on two ship surveys is 760 (CV=0.64) short-finned pilot whales with a minimum population estimate of 465; the PBR is 4.6 short-finned pilot whales per year. Barlow and Forney (2007) estimated the density of short-finned pilot whales at 0.31 whales/1000 km^2.

The status of short-finned pilot whales off California, Oregon and Washington in relation to OSP is unknown. They have declined in abundance in the Southern California Bight, likely a result of a change in their distribution since the 1982-83 El Niño, but the nature of these changes and potential habitat issues are not adequately understood. Short-finned pilot whales are not listed as threatened or endangered under the ESA or as depleted under the MMPA. The average annual human-caused mortality from 2004-2008 is zero animals, less than the PBR of 4.6, and therefore they are not classified as a "strategic" stock under the MMPA. Total annual human-caused mortality and serious injury for this stock is estimated at zero animals, therefore, mortality is considered to be approaching a zero mortality and serious injury rate (Carretta et al. 2012).

Distribution and habitat preferences: The short-finned pilot whale is found in tropical to warm-temperate seas. It usually does not range north of 50^o N or south of 40^o S. Along the west coast of North America, sightings of short-finned pilot whales north of Point Conception are uncommon but there are infrequent sightings off Oregon and Washington. Worldwide, pilot whales usually are found over the continental shelf break, in slope waters, and in areas of high topographic relief, but movements over the continental shelf and close to shore at oceanic islands can occur.

Behavior and life history: Pilot whales are very social and may travel in groups of several to hundreds of animals, often with other cetaceans. They appear to live in relatively stable, female-based groups (DON 2008b). Sexual maturity occurs at 9 years for females and 17 years for males. The mean calving interval is 4 to 6 years. Pilot whales are deep divers; the maximum dive depth measured is about 971 m (Baird et al. 2002). Short-finned pilot whales feed on squid and fish. Stomach content analysis of pilot whales in the Southern California Bight consisted entirely of cephalopod remains. The most common prey item identified was *Loligo opalescens*, which has been documented in spawning concentrations at depths of 20-55 m.

Acoustics and hearing: Short-finned pilot whale whistles and clicks have a dominant frequency range of 2 to14 kHz and a source level of 180 dB re 1 µPa-m for whistles (DON 2008b). *Globicephala* spp. are in the mid-frequency functional hearing group, with an estimated auditory bandwidth of 150 Hz to 160 kHz (Southall et al. 2007) (Table 4.1).

4.1.12 Baird's Beaked Whale (*Berardius bairdii*) California, Oregon, Washington Stock
Description: Baird's beaked whales are one of the largest members of the family Ziphiidae. The entire body is dark brown with the ventral side paler with irregular white patches; tooth marks of conspecifics are numerous on the back, particularly on adult males (Kasuya 2009). The body is slender with a small head, low falcate dorsal fin and small flippers that fit into depressions on the body. The melon is small and its front surface is almost vertical with a slender projecting rostrum (ibid). Mean body length of whales 15 years or older are 10.5 m in females and 10.1 m in males.

Status and trends: Baird's beaked whales belong to the Order Cetacea, Suborder Odontoceti, and Family Ziphiidae. Because the distribution of Baird's beaked whale varies and animals probably spend time outside the U.S. EEZ, a multi-year average abundance estimate is the most appropriate for management within U.S. waters (Carretta et al. 2012). The 2005-2008 geometric mean abundance estimate for California, Oregon and Washington waters based on the above two ship surveys is 907 (CV=0.49) Baird's beaked whales (Barlow and Forney 2007; Forney 2007), with a minimum population estimate of 615 Baird's beaked whales; the PBR is 6.2 Baird's beaked whales per year (Carretta et al. 2012). Barlow and Forney (2007) estimated the density of Baird's beaked whale at 0.88 whales/1000 km^2.

The status of Baird's beaked whales in California, Oregon and Washington waters relative to OSP is not known, and there are insufficient data to evaluate trends in abundance (Carretta et al. 2012). No habitat issues are known to be of concern for this species, but in recent years questions have been raised regarding potential effects of human-made sounds on deep-diving cetacean species, such as Baird's beaked whales. In particular, active sonar has been implicated in the mass stranding of beaked whales in the Mediterranean Sea and in the Caribbean. They are not listed as threatened or endangered under the ESA nor as "depleted" under the MMPA. Including the one animal that died as the result of a ship strike in 2003, the average annual human-caused mortality in 2004-2008 is zero animals/year. Because recent fishery and human-caused mortality is less than the PBR (6.2), Baird's beaked whales are not classified as a "strategic" stock under the MMPA. The total fishery mortality and serious injury for this stock is zero and can be considered to be insignificant and approaching zero.

Distribution and habitat preferences: Baird's beaked whale is distributed throughout deep waters and along the continental slopes of the North Pacific Ocean (Kasuya 2009). In the eastern North Pacific the northern limits are Cape Navarin (62^o N) in the Bering Sea south to just north of northern Baja California. They have been harvested and studied in Japanese waters, but little is known about this species elsewhere. Along the U.S. west coast, Baird's beaked whales have been seen primarily along the continental slope from late spring to early fall. They have been seen less frequently and are presumed to be farther offshore during the colder water months of November through April (Carretta et al. 2012). Baird's beaked whale probably is a slope-associated species. As a result, the area of highest utilization for this whale in the eastern North Pacific is in waters deeper than 500 m. The area of lower utilization is between 200 m to 500 m water depth. There is a rare occurrence in waters shallower than 200 m.

Behavior and life history: Baird's beaked whales occur in relatively large groups of 6 to 30, and groups of 50 or more sometimes are seen (Kasuya 2009). Sexual maturity occurs at about 8 to 10 years, and the calving peak is in March and April (Kasuya 2009). Mating generally occurs in October and November but little else is known of their reproductive behavior (Kasuya 2009). They feed mainly on benthic fish and cephalopods, but prey also includes pelagic fish such as mackerel, sardine, and saury (Walker et al. 2002). Baird's beaked whales in Japan prey primarily on deepwater gadiform fishes and cephalopods, indicating that they feed primarily at depths ranging from 800 to 1,200 m (Walker et al. 2002). Baird et al. (2006) reported on the diving behavior of four Blainville's beaked whales (a similar species) off the west coast of Hawaii. The four beaked whales foraged in deep ocean areas with a maximum dive to 1,407 m. Dives ranged from at least 13 min to a maximum of 68 min (Baird et al. 2006).

Acoustics and hearing: DON (2008b) reviewed the literature on beaked whale acoustics and reported that beaked whales use frequencies of between 300 Hz and 129 kHz for echolocation, and between 2 and 10 kHz, and possibly up to 16 kHz, for social communication. Both whistles and clicks have been recorded from Baird's beaked whales in the eastern North Pacific Ocean. Whistles had fundamental frequencies between 4 and 8 kHz, with 2 to 3 strong harmonics within the recording bandwidth. Pulsed sounds (clicks) had a dominant frequency around 23 kHz, with a second frequency peak around 42 kHz. Baird's beaked whales are in the mid-frequency functional hearing group, with an estimated auditory bandwidth of 150 Hz to 160 kHz (Southall et al. 2007). There is no information on the hearing abilities of Baird's beaked whale.

4.1.13 Mesoplodont Beaked Whales (*Mesoplodon* spp.) California, Oregon, Washington Stocks
Description: At least six species in this genus have been recorded off the U.S. west coast, but due to the rarity of records and the difficulty in identifying these animals in the field, virtually no species-specific information is available (Carretta et al. 2012). The six species known to occur in this region are: Blainville's beaked whale (*M. densirostris*), Perrin's beaked whale (*M. perrini*), Lesser beaked whale (*M. peruvianus*), Stejneger's beaked whale (*M. stejnegeri*), Gingko-toothed beaked whale (*M. gingkodens*), and Hubbs' beaked whale (*M. carlhubbsi*). Insufficient sighting records exist off the U.S. west coast to determine any possible spatial or seasonal patterns in the distribution of mesoplodont beaked whales. Although they are fairly common in some parts of the ocean, because of their shyness around vessels and unobtrusive behavior, they are rarely observed (Pitman 2009). All have a single tooth in the front to the middle of the jaw. They are relatively small whales ranging in length from about 4 m to 6.2 m, depending on species (Pitman 2009). The body is spindle shaped with a small, usually triangular dorsal fin located

approximately two-thirds of the way back on the body. The flippers are small and narrow and fit into pigmented depressions in the body.

Status and trends: Mesoplodont beaked whales belong to the Order Cetacea, Suborder Odontoceti, and Family Ziphiidae. Although mesoplodont beaked whales have been sighted along the U.S. west coast on several line transect surveys utilizing both aerial and shipboard platforms, sightings have generally been too rare to produce reliable population estimates, and species identification has been problematic (Barlow 2010; Barlow and Forney 2007; Forney 2007). Previous abundance estimates have been imprecise and biased downward by an unknown amount because of the large proportion of time mesoplodont beaked whales spend submerged, and because the surveys on which they were based covered only California waters, and thus could not include animals off Oregon/Washington. The abundance of Blainville's beaked whales for California, Oregon, and Washington, based on the geometric mean of 2005-2008 surveys is 603 animals. The abundance estimate for mesoplodont beaked whales of unknown species, based on the same 2005-2008 surveys is 421 (CV=0.88). The combined estimate of abundance for all species of *Mesoplodon* beaked whales in California, Oregon, and Washington waters out to 300 nmi is 1,024 (CV=0.77) animals with a minimum population estimate of 576 animals. This estimate does not include sightings of 'unidentified beaked whales' made during 2005, some of which may have been *Mesoplodon* beaked whales. The PBR for this group is 5.8 beaked whales per year (Carretta et al. 2012). Barlow and Forney (2007) estimated the density of Mesoplodont beaked whales at 1.03 whales/1000 km^2.

The status of mesoplodont beaked whales in California, Oregon and Washington waters relative to OSP is not known, and there are insufficient data to evaluate trends in abundance. No habitat issues are known to be of concern for these species, but in recent years questions have been raised regarding potential effects of human-made sounds on deep-diving cetacean species, such as mesoplodont beaked whales. None of the six species are listed as threatened or endangered under the ESA nor considered "depleted" under the MMPA. Including driftnet mortality only for years after implementation of the Take Reduction Plan (1997-98), the average annual human-caused mortality in 2002-2006 is zero. Because recent mortality is zero, mesoplodont beaked whales are not classified as a "strategic" stock under the MMPA, and the total fishery mortality and serious injury for this stock can be considered to be insignificant and approaching zero. It is likely that the difficulty in identifying these animals in the field will remain a critical obstacle to obtaining species-specific abundance estimates and stock assessments in the future.

Distribution and habitat preferences: Mesoplodon beaked whales are distributed throughout deep waters and along the continental slopes of the North Pacific Ocean. World-wide, beaked whales normally inhabit continental slope and oceanic waters that are deeper than 200 m (Pitman 2009). Occurrence often has been linked to the continental slope, canyons, escarpments, and oceanic islands (MacLeod and D'Amico 2006). They may associate with strong turbulence caused by rough topography along the slope near Heceta Bank off the Oregon coast but beaked whales are only occasionally reported in waters over the continental shelf (Pitman 2009).

Behavior and life history: They occur alone or in groups of up to 15, and probably calve in the summer. They may be both a mid-water and bottom feeder on squid and fish (Pitman 2009). Analysis of stomach contents from captured and stranded individuals suggests that beaked whales are deep-diving animals, feeding by suction (Heyning and Mead 1996). Baird et al. (2006) reported on the diving behavior of four Blainville's beaked whales (*M. densirostris*) off the west coast of Hawaii. The four beaked whales foraged in deep ocean areas (690-3,000 m) with a maximum dive to 1,408 m. Dives ranged from at least 13 min to a maximum of 68 min (Baird et al. 2006).

Acoustics and hearing: Mesoplodon spp. beaked whales are in the mid-frequency functional hearing group, with an estimated auditory bandwidth of 150 Hz to 160 kHz (Southall et al. 2007). Vocalization ranges are similar at 300 Hz to 135 kHz (DON 2008a) (Table 4.1).

4.1.14 Cuvier's Beaked Whale (*Ziphius cavirostris)* California, Oregon, Washington Stock
Description: Cuvier's beak whale resembles other beaked whales in that it has a robust, cigar-shaped body with a smallish falcate dorsal fin set about two thirds back; the small flippers fit into a slight depression as with other beaked whales (Heyning and Mead 2009). The head is blunt with a small poorly defined rostrum that grades into a generally sloping melon region (Heyning and Mead 2009). Minimum length at sexual maturity is 5.3 m for females and 5.3 m for males.

Status and trends: Cuvier's beaked whales belong to the Order Cetacea, Suborder Odontoceti, and Family Ziphiidae. Previous abundance estimates for this species of beaked whale have been imprecise and biased downward by an unknown amount because of the large proportion of time this species spends submerged, and because the ship surveys on which they were based covered only California waters, and thus could not observe animals off Oregon/Washington. Furthermore, there were a large number of unidentified beaked whale sightings, which were probably either *Mesoplodon* spp. or Cuvier's beaked whales (*Ziphius cavirostris*). Updated analyses are based on 1) combining data from two surveys conducted within 300 nmi of the coasts of California, Oregon and Washington in 2005 (Forney 2007) and 2008 (Barlow 2010), 2) whenever possible, assigning unidentified beaked whale sightings to *Mesoplodon* spp. or *Ziphius cavirostris* based on written descriptions, size estimates, and 'most probable identifications' made by the observers at the time of the sightings, and 3) estimating a correction factor for animals missed, based on a model of their diving behavior, detection distances, and the searching behavior of observers. An estimated 23% of track line groups are estimated to be seen. Because animals probably spend time outside the U.S. EEZ, a multi-year average abundance estimate is the most appropriate for management within U.S. waters. The 2005-2008 geometric mean abundance estimate for California, Oregon and Washington waters based on the above analyses is 2,143 (CV=0.65) Cuvier's beaked whales. The minimum population estimate for Cuvier's beaked whale is 1,298 animals with a PBR of 13 whales per year (Carretta et al. 2012). Barlow and Forney (2007) estimated the density of Cuvier's beaked whale at 3.82 whales/1000 km^2.

The status of Cuvier's beaked whales in California, Oregon and Washington waters relative to OSP is not known, and there are insufficient data to evaluate trends in abundance. No habitat issues are known to be of concern for this species, but in recent years questions have been raised regarding potential effects of human-made sounds on deep-diving cetacean species, such as Cuvier's beaked whales. They are not listed as threatened or endangered under the ESA nor as "depleted" under the MMPA. The average annual human-caused mortality in 2002-2006 is zero. Because recent human-caused mortality is less than the PBR, Cuvier's beaked whales are not classified as a "strategic" stock under the MMPA. The total fishery mortality and serious injury for this stock is less than 10% of the PBR and thus can be considered to be insignificant and approaching zero.

Distribution and habitat preferences: Cuvier's beaked whale is distributed in all oceans and seas except the high polar regions. Cuvier's beaked whale generally is sighted in waters >200 m deep, and is frequently recorded at depths >1,000 m. They are commonly sighted around seamounts, escarpments, and canyons (Heyning and Mead 2009). In Hawaii, Cuvier's beaked whales showed a high degree of site fidelity in a study spanning 21 years and showed that there was an offshore population and an island associated population (McSweeney et al. 2007). The site fidelity in the island associated population was hypothesized to take advantage of the influence of islands on oceanographic conditions that may increase productivity (McSweeney et al. 2007). Waters deeper than 1,000 m are the area of highest utilization for the Cuvier's beaked whale in the Northeast Pacific while water depths between 500 m and 1,000 m are less utilized. Occurrence in waters shallower than 500 m is rare (DON 2008b).

Behavior and life history: Little is known of the feeding preferences of Cuvier's beaked whale. They may be mid-water and bottom feeders on cephalopods and, rarely, fish. There is little information on beaked whale reproductive behavior. Recent studies by Baird et al. (2006) show that Cuvier's beaked whales dive deeply (maximum of 1,450 m) and for long periods (maximum dive duration of 68.7 min) but also spent time at shallow depths. Tyack et al. (2006) has also reported deep diving for Cuvier's beaked whales with mean depth of 1,070 m and mean duration of 58 min.

Acoustics and hearing: DON (2008b) reviewed the literature on beaked whale acoustics and reported that beaked whales use frequencies of between 300 Hz and 129 kHz for echolocation, and between 2 and 10 kHz, and possibly up to 16 kHz, for social communication. Cuvier's beaked whales echolocation clicks were recorded at frequencies from 20 to 70 kHz. There is no information on the hearing abilities of Cuvier's beaked whale. Cuvier's beaked whales are in the mid-frequency functional hearing group, with an estimated auditory bandwidth of 150 Hz to 160 kHz (Southall et al. 2007). Vocalizations ranges are similar at 300 Hz to 135 kHz (DON 2008a) (Table 4.1).

4.1.15 Pygmy Sperm Whale (*Kogia breviceps*) and Dwarf Sperm Whale (*K. sima*) California, Oregon, Washington Stock

Description: Kogia spp. are porpoise-like and robust with a distinctive under-slung lower jaw. Pygmy sperm whales reach a maximum size of about 3.8 m and weight of 450 kg; dwarf sperm whales are smaller at 2.7 m and 272 kg (McAlpine 2009). Adults of both species are bluish-gray to blackish-brown dorsally and light below (ibid). On the side of the head between the eye and the flipper there is a crescent shaped light colored mark referred to as a "false gill." Both species have the shortest rostrum of any cetacean, and the skull is markedly asymmetrical (ibid).

Status and trends: Pygmy and dwarf sperm whales belong to the Order Cetacea, Suborder Odontoceti, and Family Kogiidae. As summarized in Carretta et al. (2011, and citations therein), the most recent abundance estimate for pygmy sperm whales is 579 (CV=1.02) animals and is based on one sighting of an unidentified *Kogia* during a 2008 ship survey of California, Oregon, and Washington waters (Barlow 2010). Based on previous sighting surveys and historical stranding data, it is likely that these sightings were of pygmy sperm whales. The estimate incorporates a correction factor for animals missed, based on a model of their diving behavior, detection distances, and the searching behavior of observers. Based on this sighting and population estimate the current estimate of minimum population is 271 pygmy sperm whales with a calculated PBR of 2.7 whales. The lack of recent sightings likely reflects the cryptic nature of this species (they are detected almost exclusively in extremely calm sea conditions), rather than an absence of animals in the region.

There is no information on population size for the dwarf sperm whale in the California Current Ecosystem and thus no minimum population estimate or PBR can be calculated.

Barlow and Forney (2007) estimated the density of *Kogia* spp. at 1.09 animals/1000 km^2.

The status of pygmy and dwarf sperm whales in California, Oregon and Washington waters relative to OSP is not known, and there are insufficient data to evaluate potential trends in abundance. No habitat issues are known to be of concern for these species. They are not listed as threatened or endangered under the ESA nor as "depleted" under the MMPA. Given the rarity of sightings and fishery interactions in U.S. west coast waters, pygmy and dwarf sperm whales are not classified as a “strategic” stock under the MMPA.

Distribution and habitat preferences: Pygmy and dwarf sperm whales have a worldwide distribution in tropical and temperate waters of the Atlantic, Pacific, and Indian Oceans (McAlpine 2009). Pygmy sperm whales are sighted primarily along the continental shelf edge and over deeper waters off the shelf. However, along the U.S. west coast, sightings of the whales have been rare, although that is likely a reflection of their pelagic distribution and small size rather than their true abundance (Carretta et al. 2012). Several studies have suggested that pygmy sperm whales live mostly beyond the continental shelf edge. There are eight confirmed stranding records of *Kogia* from Oregon and Washington (Carretta et al. 2012).

Behavior and life history: As summarized in DON (2008b, and citations therein) pygmy and dwarf sperm whales probably feed on fish and invertebrates that feed on the zooplankton in tropical and temperate waters. There is no information on the breeding behavior of either species. *Kogia* feed on cephalopods and, less often, on deep-sea fishes and shrimps. *Kogia* make dives of up to 25 min. Median dive times of around 11 minutes have been documented. A satellite-tagged pygmy sperm whale released off Florida was found to make long nighttime dives, presumably indicating foraging on squid in the deep scattering layer (Scott et al. 2001). Most sightings are brief; these whales are often difficult to approach and they actively avoid aircraft and vessels.

Acoustics and hearing: Kogia species are in the high-frequency functional hearing group, with an estimated auditory bandwidth of 200 Hz to 180 kHz (Southall et al. 2007). Vocalizations frequencies range from 13 to 200 kHz (Table 4.1). Recordings of clicks emitted by free-ranging *K. sima* (dwarf sperm whales) in the Lesser Antilles were in the lower end of the range (13-30 kHz). Recordings of stranded pygmy sperm whales were in the 60 to 200 kHz range (DON 2008a).

4.1.16 Sperm Whale (*Physeter macrocephalus)* California, Oregon, Washington Stock

Description: The sperm whale is the largest toothed whale species and the most sexually dimorphic cetacean in body length and weight (Whitehead 2009). Adult females can reach 12 m in length, while adult males measure as much as 18 m in length (Jefferson et al. 1993). The head is large (comprising about one-third of the body length) and squarish. The lower jaw is narrow and under slung. The blowhole is located at the front of the head and is offset to the left. Sperm whales are brownish gray to black in color with white areas around the mouth and often on the belly. The flippers are relatively short, wide, and paddle-shaped. There is a low rounded dorsal hump and a series of bumps on the dorsal ridge of the tailstock and the surface of the body behind the head tends to be wrinkled (Whitehead 2009).

Status and trends: Sperm whales belong to the Order Cetacea, Suborder Odontoceti, and Family Physeteridae. As summarized in Carretta et al. (2011, and citations therein), large populations of sperm whales exist in waters of the California Current Ecosystem that are within several thousand miles west and south of the California, Oregon, and Washington region; however, there is no evidence of sperm whale movements into this region from either the west or south and genetic data suggest that mixing to the west is extremely unlikely. There is limited evidence of sperm whale movement from California to northern areas off British Columbia, but there are no abundance estimates for this area. The most precise and recent estimate of sperm whale abundance for this stock is 971 (CV=0.33) animals from the ship surveys conducted in 2005 (Forney2007) and 2008 (Barlow 2010). The minimum population estimate for sperm whales in this region is 751 whales with a calculated PBR of 1.5 sperm whales per year. Barlow and Forney (2007) estimated the density of sperm whales at 1.70 whales/1000 km^2.

Whaling removed at least 436,000 sperm whales from the North Pacific between 1800 and the end of commercial whaling (summarized in Carretta et al. 2012 and references therein). Of this total, an estimated 33,842 were taken by Soviet and Japanese pelagic whaling operations in the eastern North Pacific from the longitude of Hawaii to the U.S. West coast, between 1961 and 1976, and approximately 1,000 were reported taken in land-based U.S. West coast whaling operations. There has been a prohibition on taking sperm whales in the North Pacific since 1988, but large-scale pelagic whaling stopped earlier, in 1980. As a result of this whaling, sperm whales are formally listed as "endangered" under the ESA, and consequently the California to Washington stock is automatically considered as a "depleted" and "strategic" stock under the MMPA. The annual rate of kill and serious injury (0.4 per year) is less than the calculated PBR for this stock (1.5). Total human-caused mortality is greater than 10% of the calculated PBR and, therefore, cannot be considered to be insignificant and approaching zero mortality and serious injury rate.

Distribution and habitat preferences: With the exception of humans and killer whales, few animals on earth are as widely distributed as the sperm whale (Whitehead 2009). As summarized in Carretta et al. (2011, and citations therein), sperm whales are widely distributed across the entire North Pacific and into the southern Bering Sea in summer but the majority are thought to be south of 40^o N in winter. Sperm whales are found year round in California waters, but they reach peak abundance from April through mid-June and from the end of August through mid-November. They were seen in every season except winter (Dec.-Feb.) in Washington and Oregon. Of 176 sperm whales that were marked with Discovery tags off southern California in winter 1962-70, only three were recovered by whalers: one off northern California in June, one off Washington in June, and another far off British Columbia in April. Recent summer/fall surveys in the eastern tropical Pacific show that although sperm whales are widely distributed in the tropics, their relative abundance tapers off markedly westward towards the middle of the tropical Pacific (near the IWC stock boundary at 150^o W) and tapers off northward towards the tip of Baja California.

Behavior and life history: Females reach sexual maturity at about age 9 when roughly 9 m long and they give birth about every 5 years; gestation is 14-16 months (Whitehead 2009). Males are larger during the first 10 years and continue to grow well into their 30s, finally reaching physical maturity at about 16 m (ibid). The sperm whale consumes numerous varieties of deep water fish and cephalopods. Sperm whales forage during deep dives that routinely exceed a depth of 400 m and duration of 30 min (Watkins et al. 2002). They are capable of diving to depths of over 2,000 m with durations of over 60 min. Sperm whales spend up to 83 percent of daylight hours underwater. Males do not spend extensive periods of time at the surface. In contrast, females spend prolonged periods of time at the surface (1 to 5 hrs daily) without foraging (Whitehead 2009). An average dive cycle consists of about a 45 min dive with a 9 min surface interval. The average swimming speed is estimated to be 2.5 km/hr.

Acoustics and hearing: As summarized in DON (2008a, and citations therein), sperm whales typically produce short-duration (less than 30 ms), repetitive broadband clicks used for communication and echolocation. These clicks range in frequency from 0.1 to 30 kHz, with dominant frequencies between the 2 to 4 kHz and 10 to 16 kHz ranges. When sperm whales are socializing, they tend to repeat series of group-distinctive clicks (codas), which follow a precise rhythm and may last for hours (Whitehead 2009). Codas are shared between individuals of a social unit and are considered to be primarily for intra-group communication. Neonatal clicks are of low directionality, long duration (2 to 12 ms), low frequency (dominant frequencies around 0.5 kHz) with estimated source levels between 140 and 162 dB re 1 μPa-m rms. Source levels from adult sperm whales' highly directional (possible echolocation), short (100 μs) clicks have been estimated up to 236 dB re 1 μPa-m rms. Creaks (rapid sets of clicks) are heard most frequently when sperm whales are engaged in foraging behavior in the deepest portion of their dives with intervals between clicks and source levels being altered during these behaviors. In summary, sperm whales are in the mid-frequency functional hearing group, with an estimated auditory range of 150 Hz to 160 kHz (Southall et al. 2007). Vocalizations, including echolocation clicks, range from 100 Hz to 30 kHz (DON 2008a) (Table 4.1).

4.1.17 Humpback Whale (*Megaptera novaeangliae*) California, Oregon, Washington Stock

Description: As summarized by Clapham (2009, and citations therein), humpback whales are large baleen whales with females slightly larger than males. Adult lengths are 16-17 m and calves are about 4 m. Humpback whales are easily recognized at close range by their extremely long flippers, which may be one-third the length of the body. The flippers are white on the bottom and may be white or black on top, depending on the population. The body is black on top with variable coloration ventrally and on the sides. The head and jaws have numerous knobs that are diagnostic for the species. The dorsal fin is small and variable in shape. The underside of the tail exhibits a pattern of white to black that is individually identifiable. The baleen is primarily black and occurs in 270-400 plates on each side of the mouth.

Status and trends: The humpback whale belongs to the Order Cetacea, Suborder Mysticeti, and Family Balaenopteridae. No subspecies are recognized. The species is listed as endangered throughout its range. Three relatively distinct stocks migrate between their summer/fall feeding areas and winter/spring calving and mating areas: eastern, central, and western North Pacific stocks. The eastern North Pacific stock spends the winter/spring in Central America and Mexico and migrates along the west coast from California to British Columbia during summer and fall. Some individuals from the central North Pacific stock, which winters in Hawaii and summers in Alaska, overlap with the summer/fall distribution of the eastern North Pacific stock off the coast of Washington and British Columbia (Clapham 2009). The eastern North Pacific stock contains several distinct populations including the California/Oregon/Washington population. Waters off northern Washington may be an area of mixing between the California/Oregon/Washington population and a southern British Columbia population (Carretta et al. 2012).

Forney (2007) estimated 1,769 (CV=0.16) humpbacks in the California/Oregon/Washington region based on a 2005 summer/fall ship line-transect survey, which included additional fine-scale coastal strata not included in a 2001 survey. Barlow (2010) estimated 1,090 (CV=0.41) humpback whales from a 2008 summer/fall ship line-transect survey of the same region. The combined 2005 and 2008 line-transect estimate of abundance is the geometric mean of the two annual estimates, or 1,389 (CV=0.21). The minimum population estimate for humpback whales in the California/Oregon/Washington population is based on abundance estimated from line-transect and mark-recapture methods and is approximately 1,878 whales and the best estimate is 2,043 humpback whales (Carretta et al. 2012). The population is growing at about 6-7% per year. The PBR level for this stock is calculated as the minimum population size (1,878) times one half the estimated population growth rate for this stock times a recovery factor of 0.1, resulting in a PBR of 22.5. Because this stock spends approximately half its time outside the U.S. EEZ, the PBR allocation for U.S. waters is 11.3 whales per year. Barlow and Forney (2007) estimated the density of humpback whales at 0.83 whales/1000 km^2.

The species is listed as endangered under the ESA, and consequently the California/Mexico stock is automatically considered as a "depleted" and "strategic" stock under the MMPA. The estimated annual mortality and serious injury due to entanglement (3.2/yr), other anthropogenic sources (zero), plus ship strikes (0.4/yr) in California is less than the PBR allocation of 11.3 for U.S. waters. Based on strandings and at sea observations, annual humpback whale mortality and serious injury in commercial fisheries is greater than 10% of the PBR; therefore, total fishery mortality and serious injury is not approaching zero mortality and serious injury rate. The eastern North Pacific stock appears to be increasing in abundance (Carretta et al. 2012).

Distribution and habitat preferences: Surveys conducted by Brueggeman et al. (1992) recorded 36 groups of 68 humpbacks off the Oregon and Washington coasts between May and November. Humpbacks were most abundant between May and September, and no whales were observed during winter. No calves were observed during the surveys. Green et al. (1993) reported 50 groups of 77 humpback whales off the Oregon and Washington coasts between March and April, but did not give their locations relative to the continental shelf. Humpback whales are found in all oceans of the world and are highly migratory from high latitude feeding grounds to low latitude calving areas. They are typically found in coastal or shelf waters in summer and close to islands and reef systems in winter (Clapham 2009). Humpbacks primarily occur near the edge of the continental slope and deep submarine canyons, where upwelling concentrates zooplankton near the surface for feeding. They often feed in shipping lanes, which makes them susceptible to mortality or injury from large ship strikes (Douglas et al. 2008). About 10% of the whales that were identified off Oregon were also photographed off northern Washington. The results from these surveys showed that humpback whales fed off the Washington coast near the edges of the continental slope or deep canyons from May through September, with the highest numbers in June and July (Calambokidis et al. 2004).

Behavior and life history: Humpback whales are known for their spectacular aerial behaviors and complex songs of males. They breed in warm tropical waters after an 11 month gestation period; calves likely feed independently after 6 months. Humpback whales feed on euphausiids and various schooling fishes, including herring, capelin, sand lance, and mackerel (Clapham 2009). As summarized in Clapham (2009, and citations therein) and DON (2008b, and citations therein), humpback whale dives in summer last less than 5 min; those exceeding 10 min are atypical. In winter (December through March), dives average 10 to 15 min. Although humpback whales have been recorded to dive as deep as about 500 m, on the feeding grounds they spend the majority of their time in the upper 122 m of the water column. On the wintering grounds they dive deeper to 176 m or greater. Like other large mysticetes, they are a "lunge feeder" taking advantage of dense prey patches and engulfing as much food as possible in a single gulp. They also blow nets, or curtains, of bubbles around or below prey patches to concentrate the prey in one area, then lunge with mouths open through the middle.

Acoustics and hearing: Humpback whales are known to produce three classes of vocalizations: (1) "songs" in the late fall, winter, and spring by solitary males; (2) sounds made within groups on the wintering (calving) grounds; and (3) social sounds made on the feeding grounds (Richardson et al. 1995). The main energy of humpback whale songs lies between 0.2 and 3.0 kHz, with frequency peaks at 4.7 kHz. Feeding calls, unlike song and social sounds, are highly stereotyped series of narrow-band trumpeting calls. They are 20 Hz to 2 kHz, less than 1 second in duration, and have source levels of 175 to 192 dB re 1 μPa-m. The fundamental frequency of feeding calls is approximately 500 Hz (summarized in DON 2008b, and citations therein). Thus, humpback whales are in the low-frequency functional hearing group, with an estimated auditory bandwidth of 7 Hz to 22 kHz (Southall et al. 2007). Their vocal repertoire ranges from 20 Hz to greater than 10 kHz (DON 2008a) (Table 4.1).

4.1.18 Blue Whale (*Balaenoptera musculus*) Eastern North Pacific Stock

Description: The blue whale is the largest animal to have ever existed on earth and is found world-wide ranging into all oceans. The largest recorded blue whale from the northern hemisphere was a 28.1 m female; females tend to be larger than males, and southern hemisphere blue whales are larger than those in the north (Sears and Perrin 2009). They have a tapered, elongated shape with a huge broad, relatively flat, U-shaped head. The baleen is black (ibid). The dorsal fin is proportionately smaller than in other baleen whales and varied in shape, ranging from a small nubbin to triangular and falcate positioned far back on the body (Ibid). Underwater they are slate blue; above water they appear mottled light and dark shades of gray.

Status and trends: The blue whale belongs to the Order Cetacea, Suborder Mysticeti, and Family Balaenopteridae. The U.S. west Coast feeding stock of blue whales was estimated recently by both line transect and mark-recapture methods (Carretta et al. 2012). Because some fraction of the population is always outside the survey area, the line-transect and mark recapture estimation methods provide different measures of abundance for this stock. Line transect estimates reflect the average density and abundance of blue whales in the study area during summer and autumn surveys, while mark recapture estimates provide an estimate of total population size. Therefore, the best estimate of blue whale abundance is the average of mark-recapture estimates, or 2,497 (CV= 0.24). The minimum population is approximately 2,046 blue whales with a calculated PBR of 12.2. Because whales in this stock spend approximately three quarters of their time outside the U.S. EEZ, the PBR allocation for U.S. waters is one-quarter of this total, or 3.1 whales per year. Barlow and Forney (2007) estimated the density of blue whales at 1.36 whales/1000 km^2.

As summarized in Carretta et al. (2011, and references therein), the reported take of North Pacific blue whales by commercial whalers totaled 9,500 between 1910 and 1965. Approximately 3,000 of these were taken from the west coast of North America from Baja California, Mexico to British Columbia, Canada. Blue whales in the North Pacific were given protected status by the IWC in 1966. As a result of commercial whaling, blue whales were listed as "endangered" under the Endangered Species Conservation Act of 1969. This protection was transferred to the ESA in 1973. They are still listed as “endangered”, and consequently the Eastern North Pacific stock is automatically considered as a "depleted" and "strategic" stock under the MMPA. The annual incidental mortality and injury rate (1.0/year) from ship strikes is less than the calculated PBR for this stock, but this rate does not include unidentified large whales struck by vessels, some of which may have been blue whales. To date, no blue whale mortality has been associated with California gillnet fisheries; therefore total fishery mortality is approaching zero mortality and serious injury rate.

Distribution and habitat preferences: The blue whale has a worldwide distribution in circumpolar and temperate waters. They undertake seasonal migrations and were historically hunted on their summer, feeding areas. It is assumed that blue whale distribution is governed largely by food requirements and that populations are seasonally migratory. Pole-ward movements in spring allow the whales to take advantage of high zooplankton production in summer. Movement toward the subtropics in the fall allows blue whales to reduce their energy expenditure while fasting and to avoid ice entrapment. For the California Current Ecosystem as defined in Carretta et al. (2011), the Eastern North Pacific Stock of blue whales includes animals found in the eastern North Pacific from the northern Gulf of Alaska to the eastern tropical Pacific. This definition is consistent with both the distribution of the northeastern call type and with the known range of photographically identified individuals. Based on locations where the northeastern call type has been recorded, some individuals in this stock may range as far west as Wake Island and as far south as the Equator. The U.S. west coast is certainly one of the most important feeding areas in summer and fall, but, increasingly, blue whales from this stock have been found feeding to the north and south of this area during summer and fall. Six blue whales were sighted 25 miles off the Washington coast during October and November 2011. Most of this stock is believed to migrate south to spend the winter and spring in high productivity areas off Baja California, in the Gulf of California, and on the Costa Rica Dome (a large, 300-500 km^2, relatively stationary eddy centered near 9° N and 89° W).

Behavior and life history: Blue whales reach sexual maturity at 5-15 years of age; length at sexual maturity in the Northern Hemisphere for females is 21-23 m and for males it is 20-21 m (Sears and Perrin 2009). Females give birth about every 2-3 years in winter after a 10-12 month gestation; longevity is thought to be at least 80-90 years (ibid). Blue whales occur primarily in offshore deep waters (but sometimes near shore, e.g., the deep waters in Monterey Canyon, CA) and feed almost exclusively on euphausiids. Croll et al. (2001) determined that blue whales dived to an average of 141 m and for 7.8 min when foraging and to 68 m and for 4.9 min when not foraging. Data from southern California and Mexico showed that whales dove to > 100 m for foraging. Calambokidis et al. (2003) deployed tags on blue whales and collected data on dives as deep as about 300 m.

Acoustics and hearing: Blue whales, along with other mysticetes, are in the low-frequency functional hearing group, with an estimated auditory range of 7 Hz to 22 kHz (Southall et al. 2007). Their vocalizations range from 12 Hz to 400 Hz, with a dominant range of 12-25 Hz (DON 2008a) (Table 4.1).

4.1.19 Fin Whale (*Balaenoptera physalus*) California, Oregon, Washington Stock
Description: Fin whales are sexually dimorphic with females about 10-15% longer than males; in the Northern Hemisphere female length is about 22.5 m and for males 21 m (Aguillar 2009). Fin whales are slender with a narrow rostrum, a falcate fin located at 75% of total length; it is higher than the blue whale but lower than the sei whale (ibid). The ventral grooves are numerous and extend from the chin to the umbilicus. The pigmentation of the head region is strikingly asymmetrical whereas the left side, dorsal and ventral, is dark slate and the right side dorsal is light gray and the right ventral is white (ibid). The pigmentation also is shown in the baleen plates, which are gray and yellowish.

Status and trends: The fin whale belongs to the Order Cetacea, Suborder Mysticeti, and Family Balaenopteridae. As summarized in Carretta et al. (2011, and references therein), a 2005 ship survey of the California/Oregon/Washington stock resulted in an abundance estimate of 3,281 (CV=0.25) fin whales (Forney 2007). The best estimate of fin whale abundance in California, Oregon, and Washington waters out to 300 nmi is the geometric mean of line transect estimates from summer/autumn ship surveys conducted in 2005 (Forney 2007) and 2008 (Barlow 2010), or 3,044 (CV = 0.18) whales. This is probably an underestimate because it almost certainly excludes some fin whales which could not be identified in the field and which were recorded as “unidentified rorqual” or “unidentified large whale”. The minimum population estimate is 2,624 fin whales with a calculated PBR of 16 whales per year. Barlow and Forney (2007) estimated the density of fin whales at 1.84 whales/1000 km^2.

Fin whales in the entire North Pacific were estimated to be at less than 38% (16,625 out of 43,500) of historic carrying capacity (Mizroch et al. 1984). The initial abundance has never been estimated separately for the "west coast" stock, but this stock was also probably depleted by whaling. Approximately 46,000 fin whales were taken from the North Pacific by commercial whalers between 1947 and 1987. Approximately 5,000 fin whales were taken from the west coast of North America from 1919 to 1965. Fin whales in the North Pacific were given protected status by the IWC in 1976. Fin whales are formally listed as "endangered" under the ESA, and consequently the California to Washington stock is automatically considered as a "depleted" and "strategic" stock under the MMPA. The total incidental mortality due to fisheries (zero) and ship strikes (1.0/yr) is less than the calculated PBR (16). Total fishery mortality is less than 10% of PBR and, therefore, may be approaching zero mortality and serious injury rate. There is some indication that the population may be growing.

Distribution and habitat preferences: As summarized in DON (2008b, and references therein), fin whales occur in oceans of both Northern and Southern Hemispheres between 20–75^{o} N and S latitudes. Fin whales are distributed widely in the world's oceans. In the northern hemisphere, most migrate seasonally from high Arctic feeding areas in summer to low latitude breeding and calving areas in winter. During the summer in the North Pacific Ocean, fin whales are distributed in the Chukchi Sea, around the Aleutian Islands, the Gulf of Alaska, and along the coast of North America to California. The fin whale is found in continental shelf and oceanic waters. Globally, it tends to be aggregated in locations where populations of prey are most plentiful, irrespective of water depth, although those locations may shift seasonally or annually. Fin whales in the North Pacific spend the summer feeding along the cold eastern boundary currents. The North Pacific population summers from the Chukchi Sea to California, and winters from California southward.

Behavior and life history: Fin whales become sexually mature between six to ten years of age, depending on density-dependent factors. Reproduction occurs primarily in the winter. Gestation lasts about 11 months and nursing occurs for 6 to 11 months (Aguillar 2009). Fin whales typically dive for 5 to 15 min, separated by sequences of 4 to 5 blows at 10 to 20 second intervals. Goldbogen et al. (2006) reported that fin whales in California made foraging dives to a maximum of 228-271 m and dive durations of 6.2-7.0 min. Fin whale dives likely coincide with the diel migration of krill. Fin whales feed on planktonic crustaceans, including *Thysanoessa* sp. and *Calanus* sp., as well as schooling fish including herring, capelin and mackerel (Aguilar 2009).

Acoustics and hearing: Fin whales are in the low-frequency functional hearing group, with an estimated auditory range of 7 Hz to 22 kHz (Southall et al. 2007). They also vocalize at low frequencies of 15-30 Hz (DON 2008a) (Table 4.1).

4.1.20 Sei Whale (*Balaenoptera borealis)* Eastern North Pacific Stock

Description: The sei whale is a typical sleek rorqual and is the third largest whale (behind blue and fin) reaching a maximum length of about 20 m and weighing 20 tons; the dorsal fin is larger than that of the blue and fin but all three species may be confused at sea (Horwood 2009). There is a single prominent ridge on the rostrum and a slightly arched rostrum with a downturned tip. They are dark gray dorsally and on the ventral surfaces of the flukes and flippers (ibid). There is no whitening of the lower lip as in fin whales and the baleen is dark gray, often with a yellowish-blue hue; but some white baleen may occur in some individuals (ibid).

Status and trends: The sei whale belongs to the Order Cetacea, Suborder Mysticeti, and Family Balaenopteridae. As summarized in Carretta et al. (2011, and references therein) only five confirmed sightings of sei whales were made in California, Oregon, and Washington waters during extensive ship and aerial surveys between 1991-2005. Green et al. (1992) did not report any sightings of sei whales in aerial surveys of Oregon and Washington. Abundance estimates for the two most recent line transect surveys of California, Oregon, and Washington waters out to 300 nmi are 74 (CV=0.88) and 215 (CV=0.71) sei whales, respectively (Forney 2007, Barlow 2010). The best estimate of abundance for California, Oregon, and Washington waters out to 300 nmi is the unweighted geometric mean of the 2005 and 2008 estimates, or 126 (CV=0.53) sei whales (Barlow and Forney 2007 ; Forney 2007; Barlow 2010).with a minimum population estimate of 83; the calculated PBR is 0.17 sei whales per year. Barlow and Forney (2007) estimated the density of sei whales at 0.09 whales/1000 km^2.

Previously, sei whales were estimated to have been reduced to 20% (8,600 out of 42,000) of their pre-whaling abundance in the North Pacific. The initial abundance has never been reported separately for the eastern North Pacific stock, but this stock was also probably depleted by whaling. The reported take of North Pacific sei whales by commercial whalers totaled 61,500 between 1947 and 1987. Of these, at least 410 were taken by-shore-based whaling stations in central California between 1919 and 1965. There has been an IWC prohibition on taking sei whales since 1976, and commercial whaling in the U.S. has been prohibited since 1972. Sei whales are formally listed as "endangered" under the ESA, and consequently the eastern North Pacific stock is automatically considered as a "depleted" and "strategic" stock under the MMPA. Total estimated fishery mortality is zero and therefore is approaching zero mortality and serious injury rate. The total incidental mortality due to ship strikes is greater than the calculated PBR (0.17).

Distribution and habitat preferences: As summarized in Horwood (2009) and DON (2008a,b), sei whales have a worldwide distribution but are found primarily in cold temperate to subpolar latitudes rather than in the tropics or near the poles (Horwood 2009). Sei whales spend the summer months feeding in subpolar higher latitudes and return to lower latitudes to calve in the winter. There is some evidence from whaling catch data of differential migration patterns by reproductive class, with females arriving at and departing from feeding areas earlier than males. For the most part, the location of winter breeding areas is unknown.

Behavior and life history: Sei whales mature at about 10 years for both sexes. They are most often found in deep, oceanic waters of the cool temperate zone. They appear to prefer regions of steep bathymetric relief, such as the continental shelf break, canyons, or basins situated between banks and ledges. On feeding grounds, the distribution is largely associated with oceanic frontal systems (Horwood 2009). In the North Pacific, sei whales feed along the cold eastern currents (Perry et al. 1999). Prey includes calanoid copepods, krill, fish, and squid. The dominant food for sei whales off California during June through August is the northern anchovy, while in September and October they eat mainly krill. There are no reported diving depths or durations for Sei whales.

Acoustics and hearing: Sei whales are in the low-frequency hearing group, along with other baleen whales, with an estimated auditory bandwidth of 7 Hz to 22 kHz (Southall et al. 2007). There are few recordings of sei whale vocalizations in the North Pacific, where the sweep frequency ranged from 1.5 to 3.5 kHz (DON 2008a) (Table 4.1).

4.1.21 Common Minke Whale (*Balaenoptera acutorostrata scammoni*) California, Oregon, Washington Stock

Description: As summarized by Perrin and Brownell (2009, and citations therein), the North Pacific minke whale is the second smallest baleen whale with females somewhat larger than males. Females have been measured at 8.5 m and males at 7.9 m and weigh about 10 tons. The body is dark gray to brownish dorsally and white to cream ventrally; the flipper has a white chevron that is diagnostic. The baleen is white and short and numbers between 230-360 plates; the dorsal fin is relatively tall and falcate and located forward on the posterior one-third of the body. The rostrum is very narrow and pointed (thus the species name acutorostrata).

Status and trends: The common minke whale belongs to the Order Cetacea, Suborder Mysticeti, and Family Balaenopteridae. They are widely distributed in all oceans with three recognized subspecies, one in the North Atlantic (*B. a. acutorostrata*), one in the North Pacific (*B. a. scammoni*), and one around the Antarctic Peninsula (*B. acutorostrata)* where it is known as the dwarf minke whale (Acevedo et al. 2011; section 4.4.10). A second minke whale species is recognized in the southern hemisphere as the Antarctic minke whale (*B. bonaerensis*, section 4.3.8). Because 'resident' minke whales from California to Washington appear behaviorally distinct from migratory whales further north, minke whales in coastal waters of California, Oregon, and Washington are considered a separate stock (Carretta et al. 2012).

The number of minke whales in this stock has been estimated to be 478 whales with a minimum population estimate of 202 whales; the calculated PBR for this stock is 2 whales (Carretta et al. 2012). They typically occur as single animals, rather than in groups. Barlow and Forney (2007) estimated the density of minke whales at 0.72 whales/1000 km^2.

The annual mortality due to fisheries (0.0/yr) and ship strikes (0.0/yr) is less than the calculated PBR for this stock (2.0), so they are not considered a "strategic" stock under the MMPA. Fishery mortality is less than 10% of the PBR; therefore, total fishery mortality is approaching zero mortality and serious injury rate (Carretta et al. 2012).

Distribution and habitat preferences: Minke whales are common and the most numerous baleen whales found throughout the world. In the Northeast Pacific Ocean, minke whales range from the Chukchi Sea south to Baja California (Perrin and Brownell 2009). They occur year-round off California. The minke whales found in waters off California, Oregon, and Washington appear to be resident in that area, and to have home ranges, whereas those farther north are migratory. The minke whale generally occupies waters over the continental shelf, including inshore bays and estuaries (ibid). However, based on whaling catches and surveys worldwide, there is also a deep-ocean component to the minke whale's distribution. Minke whales appear to establish home ranges in the inland waters of Washington and along central California, and exhibit site fidelity to these areas. In Puget Sound they may be seen during all months but are most often seen during March through November (Calambokidis and Baird 1994). Little is known of specific habitat preferences for minke whales but they are seen in coastal, continental shelf, and deep pelagic waters. They are common but not numerous visitors to Puget Sound with 'resident' identifiable minke whales commonly observed in the San Juan Islands.

Behavior and life history: Little is known of the natural history of minke whales. They are assumed to breed in winter in warm waters of low latitudes, give birth to a single calf every other year, and reach sexual maturity when 7-9 m long (Osborne et al. 1988, Perrin and Brownell 2009). Minke whales in the North Pacific typically prey on euphausiids, Japanese anchovy, Pacific saury, walleye pollock, small fish, and squid (Perrin and Brownell 2009). There are no data on dive depth for minke whales. Minke whales are predated upon by killer whales.

Acoustics and hearing: Minke whales are in the low-frequency functional hearing group with an estimated auditory bandwidth of 7 Hz to 22 kHz (Southall et al. 2007). Vocalizations range from 60 Hz to 20 kHz (DON 2008a) (Table 4.1).

4.1.22 Gray Whale (*Eschrichtius robustus*) Eastern North Pacific Stock

Description: The gray whale is a robust, slow-moving whale recognized by a mottled gray color with numerous light patches scattered along the body and lack of a dorsal fin (Jones and Swartz 2009). They have more external parasites and epizoites than any other cetacean (Jones and Swartz 2009). Instead of a dorsal fin, they have a low hump, followed by a series of 10 or 12 knobs along the dorsal ridge of the tail, which are easily seen when the animal arches to dive. The baleen is short (5-40 cm), thick, and coarse and is cream-white to yellow. The upper jaw has 130-180 baleen plates (Jones and Swartz 2009). Adults are 10-15 m long and weigh between 16 and 45 tons. At birth, the calves are 5 m long and weigh close to 450 kg. Both male and female gray whales reach sexual maturity when they are between five and 11 years old, with the average being eight years (Rice 1986).

Status and trends: Gray whales belong to the Order Cetacea, Suborder Mysticeti, and Family Eschrichtiidae. There are two populations, the western North Pacific population that migrates along Asia and into the Okhotsk Sea, and the eastern North Pacific population that migrates along the coasts of eastern Siberia, North America, and Mexico. Over 20,000 gray whales swim through the California Current Ecosystem each year during their annual migration from feeding grounds in the Bering Sea to calving bays in Baja California. Of these a small number remain along the Canadian/Washington/Oregon coast to feed and explore, of which an even smaller number swim into Puget Sound and into and through Admiralty Inlet. On June 16, 1994, the eastern North Pacific gray whale population was formally removed from the list of endangered and threatened wildlife under the ESA. The stock is stable or increasing. The most recent abundance estimates are based on counts made during the 1997/98, 2000/01, 2001/02, and 2006/07 southbound migrations. Analyses of these data resulted in abundance estimates 16,369 (CV=6.1%) in 2000/01, 16,033 (CV=6.9%) in 2001/02, and 19,126 (CV=7.1%) in 2006/07.with a minimum population estimate of 18,017; the calculated PBR for this stock is 360 gray whales (Allen and Angliss 2011).

Distribution and habitat preferences: The gray whale migration covers 8,000-10,000 km each way (Rugh et al. 1999), perhaps the longest migration of any mammalian species. Most eastern North Pacific gray whales spend the summer in the shallow waters of the northern and western Bering Sea and in the adjacent waters of the Arctic Ocean; however, as mentioned above, some remain throughout the summer and fall along the Pacific coast as far south as southern California. These whales are designated as the Pacific Coast Feeding Aggregation and have been shown by photo-identification studies to 1) move widely within and between areas on the Pacific coast to feed in the summer and fall, 2) are not always observed in the same area each year, and 3) may have several year gaps between resightings in studied areas (Quan 2000). Gray whales are by far the most coastal of all the great whales, and inhabit primarily inshore or shallow, offshore continental shelf waters of the North Pacific. They tend to be nomadic, highly migratory, and tolerant of climate extremes (Jones and Swartz 2009).

Behavior and life history: Female gray whales usually breed once every two years. The breeding season is limited primarily to a three-week period in late November and early December near the start of the southward migrations. However, if no conception occurs at that time, a second estrus cycle can occur within 40 days (Rice and Wolman 1971), such that a few females may breed as late as the end of January on the winter grounds (Jones and Swartz 2009). Gray whale calves are born in the winter after a gestation period of about 13.5 months. Killer whale predation may be the most significant cause of mortality (ibid). The gray whales that feed within Puget Sound typically use shallow areas close to shore for feeding on herring eggs and larvae, crab larvae, ghost shrimp, amphipods and crustaceans.

Acoustics and hearing: As summarized in Jones and Swartz (2009) and DON (2008b, and references therein), gray whales produce broadband signals ranging from 100 Hz to 4 kHz (and up to 12 kHz). The most common sounds on the breeding and feeding grounds are knocks which are broadband pulses from about 100 Hz to 2 kHz and most energy at 327 to 825 Hz (Richardson et al. 1995). The source level for knocks is approximately 142 dB re 1 µPa-m. During migration, individuals most often produce low-frequency moans. The structure of the gray whale ear is evolved for low-frequency hearing. Gray whale responses to noise include changes in swimming speed and direction to move away from the sound source; abrupt behavioral changes from feeding to avoidance, with a resumption of feeding after exposure; changes in calling rates and call structure; and changes in surface behavior, usually from traveling to milling.

PINNIPEDS

4.1.23 California Sea Lion (*Zalophus californianus*) U.S. Stock

Description: California sea lions are highly sexually dimorphic; the weight and length of males is about 350 kg and 2.4 m compared to females at 100 kg and 1.8 m, respectively (Heath and Perrin 2009). Male and female pups weigh 6-9 kg. Adult males usually are a dark brown, but can range from light brown to black; females are dark brown to black (Heath and Perrin 2009). Males typically have a distinguishing sagittal crest on top of the head often topped with white fur.

Status and trends: The California sea lion belongs to the Order Carnivora, Suborder Pinnipedia, Family Otariidae and includes three subspecies of which *Z. c. californianus* (found from southern Mexico to southwestern Canada) occurs in the California Current Ecosystem. California sea lions breed on islands in three geographic regions which are used to separate this subspecies into three stocks: (1) the United States stock begins at the United States/Mexico border and extends northward into Canada; (2) the Western Baja California stock which extends from the United States/Mexico border to the southern tip of the Baja California Peninsula; and (3) the Gulf of California stock which includes the Gulf of California from the southern tip of the Baja California peninsula (Carretta et al. 2012). Based on extrapolations from pup counts, the population is estimated at 296,750 sea lions, and it is growing at 5.6 percent per year (Carretta et al. 2012). The minimum population estimate for the U.S. stock is 153,337 sea lions. The calculated PBR for this stock is 9,200 animals (Carretta et al. 2012).

As summarized in Carretta et al. (2011), a generalized logistic growth model of pup counts obtained during 1975-2005 (excluding El Niño years) indicated that the population reached its Maximum Net Productivity Level (MNPL) of 39,800 pups in 1997 and has reached carrying capacity (K) at 46,800 pups per year. This determination should be taken with caution until more years of data have been collected to verify whether the flattening of the generalized logistic curve persists in future years. California sea lions in the U.S. are not listed as "endangered" or "threatened" under the ESA or as "depleted" under the MMPA. California sea lions are not considered a "strategic" stock under the MMPA because (based on historical takes in the set gillnet fishery and current levels of fishing effort) total human-caused mortality is still likely to be less than the PBR (9,200). The total fishery mortality and serious injury rate (337 animals/year) for this stock is less than 10% of the calculated PBR and, therefore, is considered to be insignificant and approaching a zero mortality and serious injury rate.

Distribution and habitat preferences: The primary rookeries are located on the California Channel Islands of San Miguel, San Nicolas, Santa Barbara, and San Clemente. As summarized in Carretta et al. (2011) and DON (2008b, and references therein), their distribution shifts to the northwest in fall and to the southeast during winter and spring, probably in response to changes in prey availability. In the non-breeding season, adult and subadult males migrate northward along the coast to central and northern California, Oregon, Washington, and Vancouver Island and return south the following spring; they are occasionally sighted hundreds of kilometers offshore. Females and juveniles tend to stay closer to the rookeries. They also enter bays, harbors, and river mouths and often haul out on man-made structures such as piers, jetties, offshore buoys, and oil platforms (Riedman 1990). California sea lions in the Puget Sound haul out on log booms and U.S. Navy submarines, and are often seen rafted off river mouths (Jeffries et al. 2000). They are occasionally sighted up to several hundred kilometers offshore. California sea lions frequently travel up river systems in search of prey and are common at Bonneville Dam, 230 miles upriver from the mouth of the Columbia River, consuming migrating salmonids during winter and spring (NMFS 2008b).

Behavior and life history: California sea lion numbers ashore increase rapidly in May when males establish breeding territories. Birth to a single pup occurs from May through June and pups are weaned in about 10-12 months (Heath and Perrin 2009). While near rookeries in California, females typically feed over the continental shelf and travel within 54 km from the islands but are known to travel as far north as Monterey Bay to feed during the breeding season (Antonelis et al. 1990; Melin and DeLong 2000). California sea lions feed primarily on Pacific whiting, Pacific herring, salmonids, dogfish sharks, and squid. Dives off rookeries in California typically last about 2 minutes but can be as long as 10 minutes; dive depths average about 26-98 m, but can be well over 200 m (Heath and Perrin 2009). Females are known to dive to a maximum depth of 482 m for up to 16 minutes while foraging during the non-breeding period (Melin et al. 2008).

Acoustics and hearing: California sea lions are assigned to functional hearing groups based on the medium (air or water) through which they are detecting the sounds, for an estimated auditory bandwidth of 75 Hz to 75 kHz (Southall et al. 2007). Vocalizations range from <4 to 120 kHz (DON 2008a) (Table 4.1).

4.1.24 Steller Sea Lion (Loughlin's Northern Sea Lion; *Eumetopias jubatus monteriensis*) Eastern Subspecies

Description: Steller sea lions exhibit significant sexual dimorphism with males larger. Average length of males is 2.8 m and females 2.4 m (maximum of about 3.3 m and 2.9 m, respectively). Estimated average weight of males is 566 kg and of females 263 kg (maximum of about 1,120 kg and 350 kg, respectively). Pup weight at birth is 16-23 kg and may be slightly larger in the western part of their range. Pups are born with a wavy, chocolate brown fur that molts after 3-6 months of age. Adult fur color varies between a light buff to reddish brown with most of the under parts and flippers a dark brown to black; naked parts of the skin are black. Both sexes become blonder with age. Adult males have long, coarse hair on the chest, neck, and shoulders that are massive and muscular (Loughlin 2009).

Status and trends: Steller sea lions belong to the Order Carnivora, Suborder Pinnipedia, Family Otariidae. A recent paper has proposed that the two recognized Steller sea lion stocks (eastern and western) be formally designated as two subspecies (Phillips et al. 2009). Presently the eastern subspecies (*Eumetopias jubatus monteriensis*), which includes those that occur from California to Prince William Sound, Alaska, is listed as threatened under the ESA; the western subspecies (*E. j. jubatus*) is listed as endangered. NMFS is presently reviewing a petition to remove the eastern subspecies (aka stock) from the Endangered Species list. The vernacular name for the eastern subspecies has been proposed as Loughlin's northern sea lion; the western subspecies is to remain as Steller sea lion. The geographic separation for the subspecies designation is at 144^{o} W, near Cape Suckling, AK (Loughlin 1997). However since the vernacular designation of the eastern subspecies as Loughlin's northern sea lion is new, the vernacular Steller sea lion will be used in this document.

Based on extrapolations from non-pup and pup surveys, the total population of the eastern stock of Steller sea lions is estimated to be within the range of 58,334-72,223 with a minimum population estimate of 52,847 and a PBR of 2,378 (Allen and Angliss 2011). This stock is listed as threatened under ESA. Overall the stock has been increasing at about 3.1 percent per year since the 1970s with the population more than doubling in size by 2004, principally in Southeast Alaska (Pitcher et al. 2007).

Critical habitat in California and Oregon is defined as an area 3,000 feet from important rookeries and haulout sites and 3,000 above these sites; in Alaska it is defined as a 20 nm buffer around all major haul-out sites and rookeries, as well as associated terrestrial, air, and aquatic zones, plus three large offshore foraging zones.

Distribution and habitat preferences: Steller sea lions occur throughout the North Pacific Ocean rim from Japan to southern California. They abound on numerous breeding sites (rookeries) in the Russian Far East, Alaska, and British Columbia with fewer numbers in Oregon and California. Seal Rocks in Prince William Sound, Alaska is the northernmost (60^{o} 09 'N) rookery and Año Nuevo Island, California, the southernmost (37^{0} 06'N) (Loughlin et al. 1987, Loughlin 2009). The eastern subspecies occurs year round in the CCE, with peak numbers in late summer, fall, and winter (Carretta et al. 2012). The species does not breed in Washington although pups have been observed at one haulout site in 1997 and 1998; rookeries are in northern British Columbia, central Oregon, and central and northern California where pupping occurs from late May through early July.

Unlike their more gregarious cousin the California sea lion, Steller sea lions tend to avoid people and prefer isolated offshore rocks and islands to breed and rest. Although rookeries and rest sites occur in many areas, principally on exposed rocky shorelines and wave-cut platforms, the locations used are specific and change little from year to year. Steller sea lions tend to return to their birth island as adults to breed, but they range widely (some yearlings have been seen > 1,000 km from their birth rookery) during their first few years and during the non-breeding season (Loughlin 2009).

Steller sea lions exhibit two general types of distribution at sea: 1) less than 20 km from rookeries and haulout sites for adult females with pups, pups, and juveniles, and 2) larger areas (greater than 20 km) where these and other animals may range to find optimal foraging conditions once they are no longer tied to rookeries and haulout sites for nursing and reproduction (Call and Loughlin 2004). Telemetry studies show that in winter, adult females may travel far out to sea into water greater than 1,000 m deep (Merrick and Loughlin 1997), and juveniles less than 3 years of age travel nearly as far (Loughlin et al. 2003). Sea lions commonly occur near and beyond the 200 m depth contour. Some individuals may enter rivers in pursuit of prey.

Critical habitat: Critical habitat is defined as a 20 nm buffer around all major haul-out sites and rookeries, as well as associated terrestrial, air, and aquatic zones, plus three large offshore foraging zones (58 FR 45269). Critical habitat for the Steller sea lion does not include Puget Sound or the Strait of Juan de Fuca.

Behavior and life history: Steller sea lions breed from late May to early July throughout the range at rookeries located on remote islands and rocks. One pup is born annually after a 9 month gestation period. As with most pinnipeds, embryo implantation typically is delayed 3 months. Pups are weaned prior to the breeding season but some may remain with their mothers for 2-3 years (Loughlin 2009). They are opportunistic predators, feeding primarily on a wide variety of fishes and cephalopods. Some of the more important prey species include Pacific whiting, walleye pollock, Atka mackerel, Pacific herring, capelin, Pacific sand lance, Pacific cod, and salmon (ibid). Steller sea lions have been known to prey infrequently on harbor seal, fur seal, ringed seal, and possibly sea otter pups.

Compared to other pinnipeds, Steller sea lions tend to make relatively shallow dives, with few dives recorded to depths greater than 250 m. Maximum depths recorded for individual adult females in summer are in the range from 100 to 250 m; maximum depth in winter is greater than 250 m. The maximum depth measured for yearlings in winter was 72 m and average depths are near 18 m and in shallow near-shore waters (Loughlin et al. 2003).

Acoustics and hearing: Steller sea lions have similar hearing thresholds in-air and underwater to other otariids. Hearing in air ranges from 0.250–30 kHz, with a region of best hearing sensitivity from 5–14.1 kHz (Muslow and Reichmuth 2010). The underwater audiogram shows the typical mammalian U-shape. The range of best hearing was from 1 to 16 kHz. Higher hearing thresholds, indicating poorer sensitivity, were observed for signals below 16 kHz and above 25 kHz (Kastelein et al. 2005). Like other pinnipeds, sea lions are assigned to functional hearing groups based on the medium (air or water) through which they are detecting the sounds, for an estimated auditory bandwidth of 75 Hz to 75 kHz (Southall et al. 2007). Vocalizations range from <4 to 120 kHz (DON 2008a) (Table 4.1).

4.1.25 Guadalupe Fur Seal (*Arctocephalus townsendi*)

Description: Adult female Guadalupe fur seals weigh about 49 kg and males 124 kg (Arnould 2009). Fur seals in general can be distinguished from sea lions by the presence of a dense under fur and their smaller size. Pelage color is generally uniform dark brown to dark gray on the dorsal surface with a grizzled appearance caused by the tips of guard hairs being pale or white (ibid).

Status and trends: Guadalupe fur seals belong to the Order Carnivora, Suborder Pinnipedia, Family Otariidae. These fur seals were harvested for their pelts in the 19th century but size of the population prior to the commercial harvests is unknown; estimates range from 20,000 to 100,000 animals (Carretta et al. 2012, and citations therein). The population was estimated by Gallo (1994) to be about 7,408 animals in 1993. The population estimate was derived by multiplying the number of pups (counted and estimated) by a factor of 4.0. The minimum size of the population in Mexico can be estimated as the actual count of 3,028 hauled out seals with a PBR of 91 Guadalupe fur seals. The Guadalupe fur seal occurs in low numbers seasonally in California waters.

The state of California lists the Guadalupe fur seal as a fully protected mammal and it is listed also as a threatened species in the Fish and Game Commission California Code of Regulations. It is listed as a threatened species under the ESA, which automatically qualifies this as a "depleted" and "strategic" stock under the Marine Mammal Protection Act. There is insufficient information to determine whether the fishery mortality in Mexico exceeds the PBR for this stock. The total U.S. fishery mortality and serious injury for this stock is less than 10% of the calculated PBR and, therefore, can be considered to be insignificant and approaching zero mortality and serious injury rate. The population is growing at approximately 13.7% per year.

Distribution and habitat preferences: Guadalupe fur seals pup and breed mainly at Isla Guadalupe, Mexico (Arnould 2009; Carretta et al. 2012 and citations therein). In 1997, a second rookery was discovered at Isla Benito del Este, Baja California and a pup was born at San Miguel Island, California. Individuals have stranded or been sighted as far north as central California, inside the Gulf of California, and as far south as Zihuatanejo, Mexico. The population is considered to be a single stock because all are recent descendants from one breeding colony at Isla Guadalupe, Mexico.

Behavior and life history: Definitive data are lacking on life history of Guadalupe fur seals but most species in the genus reach sexual maturity at 3-5 years of age; males also mature at about the same age but are unable to attain reproductive status (obtain a reproductive territory) until 7-10 years of age. Timing of pupping is variable for the genus but for Guadalupe fur seals it is June-July. Southern fur seals, including the Guadalupe fur seal, feed on a variety of prey including fish, cephalopods and crustaceans, depending on prey abundance and location. Most southern fur seals forage in upwelling zones, oceanic fronts, or continental shelf-edge regions (Arnould 2009). Specific foraging and dive information is not known for the Guadalupe fur seal, but other species in this genus forage mainly in the surface mixed layer (<50-60 m) at night (Arnould 2009).

Acoustics and hearing: Like other pinnipeds, these fur seals are assigned to functional hearing groups based on the medium (air or water) through which they are detecting the sounds, for an estimated auditory bandwidth of 75 Hz to 75 kHz (Southall et al. 2007). Vocalizations range from <4 to 120 kHz (DON 2008a) (Table 4.1).

4.1.26 Northern Fur Seal (*Callorhinus ursinus*) San Miguel Island and Pribilof Islands Stocks

Description: The northern fur seal is a moderate sized pinniped and shows a marked difference in size with males two to three times larger than females. Northern fur seal males weigh 200-250 kg and are up to 1.9 m long; females weigh up to 45 kg and are 1.3 m long. Pups are black, weigh about 10 kg and are about 0.6 m long at birth (Gentry 2009). The under-fur is brown, very dense, and covered by coarser guard hair that in males varies from black to reddish, with a mane over the shoulders that is often a different color; females are typically brown to gray and lack the mane.

Status and trends: Fur seals belong to the Order Carnivora, Suborder Pinnipedia, Family Otariidae. The genus *Callorhinus* contains one species, the northern fur seal, *C. ursinus*. Northern fur seals are divided into two stocks in U.S. waters: eastern Pacific stock (Pribilof Islands and Bogoslof Island) and San Miguel Island stock. The Pribilof Islands northern fur seal population was designated as depleted pursuant to the Marine Mammal Protection Act on 17 June 1988 because it declined to less than 50 percent of levels observed in the late 1950s and there was no compelling evidence that the northern fur seal carrying capacity of the Bering Sea had changed substantially since the late 1950s (NMFS 2007). The San Miguel Island stock is not designated as depleted.

The Eastern Pacific stock has declined by about 60% in recent decades from a historical high of over 2 million in the 1970s to an estimated 687,902 in 2009 (Allen and Angliss 2011). The San Miguel Island population originated from colonization by individuals from the Pribilof Islands population during the 1950s or early 1960s (DeLong 1982). The colony has increased steadily, since its discovery in 1968, except for severe declines in 1983 and 1998 associated with El Niño Southern Oscillation events in 1982-1983 and 1997-1998 (DeLong and Antonelis 1991). The San Miguel Island stock reached a high in 1997 when pup production was estimated at just over 3,000, with a 2007 total population estimate of 9,968 (Carretta et al. 2012). The minimum population estimate for the Pribilof Islands stock is 642,265 fur seals and for the San Miguel Island stock it is 5,395 fur seals. The calculated PBR for the San Miguel Island stock is 324 fur seals per year; the calculated PBR for the Pribilof Islands stock is 13,809 fur seals per year (Carretta et al. 2012; Allen and Angliss 2012).

Distribution and habitat preferences: NMFS (2007) summarized northern fur seal distribution. They are endemic to the North Pacific Ocean. During the winter the southern limit of their range extends across the Pacific Ocean from southern California to the Okhotsk Sea and Honshu Island, Japan. In the spring most northern fur seals migrate north to breeding colonies in the Bering Sea. The largest breeding colonies are located on St. Paul and St. George islands in the Pribilof Islands and compose approximately 74 percent of the worldwide fur seal population. Other breeding colonies are located in the Commander Islands (Russia) in the western Bering Sea and on Robben Island (Russia) in the Okhotsk Sea that compose approximately 15 and 9 percent of the population, respectively. Small breeding colonies are also located on the Kuril Islands in the western North Pacific, Bogoslof Island in the central Aleutian Islands, and on San Miguel Island off the southern California coast. The subpolar continental shelf and shelf break from the Bering Sea to California are feeding grounds while fur seals are at sea. Highest fur seal densities in the open ocean occur in association with major oceanographic frontal features such as sea mounts, valleys, canyons and along the continental shelf break (NMFS 2007). Fur seals from San Miguel Island may also spend their winter months feeding at sea in the eastern North

Pacific Ocean. Northern fur seals are primarily pelagic in the winter months, but occasionally haul-out onto land for brief periods.

Behavior and life history: Northern fur seals are the most pelagic of pinnipeds with females spending all but 35 days per year at sea and males 45 days (Gentry 2009). From November to March they remain north of about 35^{o} N latitude without coming ashore. In March and April they gather along continental shelf breaks and begin to migrate to their respective breeding islands (Gentry 2009). Males come ashore and acquire breeding territories in late May and June and most pups are born in July, nursed for about 4 months and weaned in October or November. They are a highly migratory species and typically return to their natal sites to breed.

Northern fur seals prey primarily on schooling fish and gonatid squid, although the species consumed vary with location and season (Sinclair et al. 1996). Northern fur seals collected in continental shelf waters off the California and Washington coast between 1958 and 1972 fed primarily on fishes, while those collected beyond the shelf fed primarily on squids (Kajimura 1984). Adult female northern fur seals breeding on San Miguel Island fed on Pacific whiting, northern anchovy, juvenile rockfish, and several squid species in the oceanic zone northwest of the island. Pacific herring was consumed by fur seals in neritic areas off the coast of Washington during December-January and May-June. Rockfishes, northern anchovy, and squid were more prominent in fur seal stomachs off Washington during February and March (NMFS 2007). Dive behavior of northern fur seals is well studied and shows that females from the Pribilof Islands often dive to 200 m or more for at least 5-6 minutes with some to 11 minutes. Similar foraging behavior has been documented for fur seals foraging from San Miguel Island, CA (Gentry 2009).

Acoustics and hearing: Fur seals are assigned to functional hearing groups based on the medium (air or water) through which they are detecting the sounds, for an estimated auditory bandwidth of 75 Hz to 75 kHz (Southall et al. 2007). Vocalizations range from <4 to 120 kHz (DON 2008a) (Table 4.1).

4.1.27 Harbor Seal (*Phoca vitulina richardsi*) California, Oregon and Washington Coastal, and Inland Washington Waters Stocks

Description: Harbor seals are relatively small pinnipeds compared to sea lions and elephant seals. Males tend to be slightly larger than females. Both sexes weigh about 90-120 kg but can be as large as 180 kg and can be 1.2-1.8 m long (Burns 2009). They are covered with short, stiff hair with variable color pattern and two basic color phases. Background color ranges from yellowish (light phase) to black (dark phase), which is then covered with dark spots, and light rings (Burns 2009).

Status and trends: Harbor seals belong to the Order Carnivora, Suborder Pinnipedia, Family Phocidae. There are five presently recognized subspecies of harbor seal; *P.v. richardsi* occurs along the west coast of North America (Burns 2009). Three harbor seal stocks are recognized within the *P. v. richardsi* subspecies designation, including the California stock, outer coast of Oregon and Washington coastal stock, and Washington inland waters stock (Carretta et al. 2012, Lamont et al. 1996). The California stock is estimated to number 30,196 seals with a minimum population estimate of 26,667 seals, the calculated PBR is 1,600 California harbor seals per year. The Oregon/Washington coastal stock was estimated to number 24,732 harbor seals over ten years ago but because the most recent abundance estimate is >8 years old, there is no current estimate of abundance and consequently no estimate of PBR. Similarly, the number of seals in the Washington inland waters stock was estimated to be 14,612 but because the population estimates are over 8 years old there is currently no estimate for the minimum population size and consequently no estimate of PBR (Carretta et al. 2012).

Harbor seals are not considered to be “depleted” under the MMPA or listed as “threatened” or “endangered” under the ESA. Based on currently available data, the level of human-caused mortality and serious injury is not known to exceed the PBR for any of the three stocks. Therefore, none of the three stocks of harbor seals are classified as a “strategic” stock. At present, the minimum estimated fishery mortality and serious injury appears to be less than 10% of the calculated PBR and, therefore, appears to be insignificant and approaching zero mortality and serious injury rate.

Distribution and habitat preferences: The species is widespread in temperate and arctic waters of the northern hemisphere of both the Atlantic and Pacific Oceans; it is the most widespread of any pinniped. It occurs year-round in Washington. They occur principally in the near shore zone. Harbor seals use hundreds of sites to rest or haulout along the coast and inland waters, including intertidal sand bars and mudflats in estuaries, intertidal rocks and reefs, sandy, cobble, and rocky beaches, islands, log-booms, docks, and floats in all marine areas of the state. Group sizes typically range from small numbers of animals on some intertidal rocks to several thousand animals found seasonally in coastal estuaries (Burns 2009).

Behavior and life history: Harbor seals are considered a non-migratory species, breeding and feeding in the same area throughout the year. They give birth on shore and nurse their single pup for 4 to 5 weeks. After the pups are weaned, they disperse widely in search of food. Pupping seasons vary by geographic region, with pups born in coastal estuaries from mid-April through June; Olympic Peninsula coast from May through July; San Juan Islands and eastern bays of Puget Sound from June through August; southern Puget Sound from mid-July through September; and Hood Canal from August through January (Jeffries et al. 2000). Breeding occurs in the water shortly after the pups are weaned. Common prey include sole, flounder, sculpins, hake, cod, herring, squid, octopus, and, to a lesser degree, salmon (Orr et al. 2004). Harbor seals can dive to over 400 m and stay submerged over 20 minutes, but the average depth is less than 100 m and about 2 minutes in duration (Eguchi and Harvey 2005).

Acoustics and hearing: Harbor seals are assigned to functional hearing groups based on the medium (air or water) through which they are detecting the sounds, for an estimated auditory bandwidth of 75 Hz to 75 kHz (Southall et al. 2007). Vocalizations range from 25 Hz to 4 kHz (DON 2008a) (Table 4.1).

4.1.28 Northern Elephant Seal (*Mirounga angustirostris*) California Breeding Stock

Description: Northern elephant seals are the largest pinniped in the California Current Ecosystem. The species is sexually dimorphic with males weighing about 1,800 kg with a length of 4.8 m; females weigh about 900 kg and are about 2.5 m in length (Hindell and Perrin 2009). Males have a large inflatable proboscis and a pronounced chest shield associated with fighting with other males on land to acquire females. Females lack the proboscis and chest shield (ibid). Both males and females are gray to brown in color.

Status and trends: Northern elephant seals belong to the Order Carnivora, Suborder Pinnipedia, Family Phocidae. Elephant seal population size is typically estimated by counting the number of pups produced and multiplying by the inverse of the expected ratio of pups to total animals. Based on the estimated 35,549 pups born in California in 2005 and a 3.5 multiplier, the California stock was approximately 124,000 in 2005, with a minimum population estimate of 74,913 elephant seals (Carretta et al. 2012). The California population is slowly increasing. Elephant seals are not listed as either threatened or endangered under the ESA or by WA State nor designated as depleted under the MMPA. The calculated PBR for this stock is 4,382 (Carretta et al. 2012).

Distribution and habitat preferences: After the breeding season, immature and adult male northern elephant seals move northward to feed from Baja California to northern Vancouver Island and far offshore of the Gulf of Alaska and Aleutian Islands; adult females typically feed in the western North Pacific (Carretta et al. 2012). Northern elephant seals breed at about 15 colonies on the mainland and on islands off the California coast from the Farallon Islands, CA, south to islands off Mexico during winter. When not on the islands to breed or molt they tend to occur in deep offshore waters from central California north to the Aleutian Islands and west to Japan. Females tend to go farther northwest and males farther north (Hindell and Perrin 2009). However it is not uncommon to see male and female northern elephant seals hauled out on land alongside harbor seals, California and Steller sea lions, and northern fur seals throughout the North Pacific.

Behavior and life history: Adult males haulout onto deserted beaches in November/December; adult females arrive soon thereafter and a single pup is born about 2-5 days later. Elephant seals are highly polygynous with large dominant males presiding over large aggregations of females, known as harems consisting of up to 100 animals (Hindell and Perrin 2009). Males feed near the eastern Aleutian Islands and in the Gulf of Alaska, and females typically feed south of 45^{o} N latitude. Elephant seals prey on deepwater and bottom dwelling organisms, including fish, squid, crab, and octopus. They are extraordinary divers with some dive depths exceeding 1500 m and 120 minutes (Hindell and Perrin 2009).

Acoustics and hearing: Like other pinnipeds, elephant seals are assigned to functional hearing groups based on the medium (air or water) through which they are detecting the sounds, for an estimated auditory bandwidth of 75 Hz to 75 kHz (Southall et al. 2007). Vocalizations range from <4 to 120 kHz (DON 2008a) (Table 4.1).

4.2 Eastern Tropical Pacific (ETP) Ecosystem

Cetaceans

4.2.1 Risso's Dolphin (*Grampus griseus*)

Description: Refer to section 4.1.4 for species description.

Status and trends: Risso's dolphins commonly occur in the ETP and are regularly sighted during surveys of the area. Abundance was estimated after each survey, with the most recent being in 2003 and 2006. The estimated abundance in 2006 was 110,457 (52,510-209,008; 95% confidence intervals; c.i.) and was 81,474 (48,140-122,422; 95% c.i.) in 2003 (Gerrodette et al.

2008). The estimated rate of change from 1986 to 2006 was 0.011 and was 0.039 from 1998 to 2006; density in the ETP was estimated to be 5.173 dolphins/1,000 km^2 (Gerrodette et al. 2008).

Risso's dolphins are not listed under the ESA.

Distribution and habitat preferences: Risso's dolphins are broadly distributed throughout the ETP (Hamilton et al. 2009). However, they most commonly occur in nearshore shelf waters off Mexico, Guatemala, the Gulf of Panama, and in the Peru Current (Wade and Gerrodette 1993). They generally associate with areas of upwelling (Ballance et al. 2006).

Behavior and life history: Refer to section 4.1.4

Acoustics and hearing: Refer to section 4.1.4

4.2.2 Short-Beaked Common Dolphin (*Delphinus delphis*)
Description: Refer to section 4.1.7 for species description

Status and trends: Short-beaked common dolphins are divided into northern, central and southern stocks (Dizon et al. 1994). A hiatus at 13-20° N and at about 3° N divide the offshore populations into the respective stocks. The central form occurs at 3-18° N and the southern common dolphin ranges from 3° N to at least 13° S (Dizon et al. 1994). Short-beaked common dolphins are frequently encountered in the ETP and were the most abundant dolphin in the ETP survey area in 2006. The 2006 ETP abundance estimates for short-beaked common dolphins included parts of the northern and southern stocks, and all of the central stock (Gerrodette et al. 2008). The 2006 estimate was 3,127,203 (1,620,370-4,876,096; 95% c.i.), which was much larger than the 2003 estimate of 1,197,168 (709,369-2,669,497; 95% c.i.) (Gerrodette et al. 2008). The estimated rate of change from 1986 to 2006 was 0.047 and from 1998 to 2006, was -0.006 (Gerrodette et al. 2008). Density in the ETP was estimated to be 146.453dolphins/1,000 km^2 (Gerrodette et al. 2008).

Short-beaked common dolphins are not listed under the ESA.

Distribution and habitat preferences: Short-beaked common dolphins occur worldwide in warm-temperate and tropical waters from about 40-60^o N to about 50^o S latitude (Perrin 2009c). In the ETP, they commonly occur along the coast of Baja California, near the Costa Rica Dome, and in the eastern equatorial Pacific. They are most abundant in cold, upwelling-modified waters (Ballance et al. 2006; Wade and Gerrodette 1993). Common dolphins feed on a wide assortment of prey, including small mesopelagic fish and squid and epipelagic schooling species of fish and squid. Diet varies seasonally and geographically (Perrin 2009c).

Behavior and life history: Refer to section 4.1.7

Acoustics and hearing: Refer to section 4.1.7

4.2.3 Long-Beaked Common Dolphin (*Delphinus capensis*)
Description: Refer to section 4.1.8 for species description.

Status and trends: Few abundance estimates are available for long-beaked common dolphins, other than for select localized areas. The IUCN (cited in Perrin 2009c) estimated an abundance of 55,000 long-beaked common dolphins off the Pacific coast of Mexico. Although sighted during several SWFSC ETP surveys (e.g., Jackson et al. 2004; Kinzey et al. 1999, 2001), no long-beaked common dolphins were seen during the 2006 surveys (Gerrodette et al. 2008). However, sightings during SWFSC surveys conducted 1998-2000, 2000 and 2003 allowed estimation of population abundance (372,429) and density (0.0194/km^2) for the study area.

Long-beaked common dolphins are not listed under the ESA.

Distribution and habitat preferences: Distribution in the ETP is disjunctive. Long-beaked common dolphins are found from southern California to central Mexico and along the coast of Peru (Hamilton et al. 2009; Perrin 2009c). In contrast to short-beaked common dolphins, long-beaked common dolphins prefer shallower, warmer water nearer to the coast.

Behavior and life history: Refer to section 4.1.8

Acoustics and hearing: Refer to section 4.1.8

4.2.4 Rough-Toothed Dolphin (*Steno bredanensis*)

Description: The rough toothed dolphin is so named because of unique vertical ridges on the teeth. They are distinctive in appearance, with a smooth sloping forehead and long beak, tall dorsal fin, and long flippers. They are generally dark in coloration, with a white belly and dark gray to black back. The mouth area and lower sides often have white spots or patches. They can weigh up to 155 kg and be up to 2.6 m in length. Males are larger than females (Jefferson 2009b).

Status and trends: Rough-toothed dolphins belong to the Order Cetacea, Suborder Odontoceti, and Family Delphinidae. Global estimates of abundance are lacking for this species and little is known about rough-toothed dolphin population or stock structure (Jefferson 2009b). The ETP is one of the few places for which abundance has been estimated. The most recent estimates available are for 2006 (107,633; 66,891-153,970: 95% c.i.) and 2003 (47,593; 27,218-92,670: 95% c.i.) (Gerrodette et al. 2008). The estimated rate of change from 1986 to 2006 was 0.026 and from 1998 to 2006, was 0.081 (Gerrodette et al. 2008). Density in the ETP was estimated to be 5.042 rough toothed dolphins/1,000 km^2 (Gerrodette et al. 2008).

Rough-toothed dolphins are not listed under the ESA.

Distribution and habitat preferences: This is a tropical to warm temperate species found in oceanic waters worldwide, as well as over continental shelf and coastal waters in some areas, including the ETP (Jefferson 2009b; May-Collado 2005). In the ETP, they generally associate with warm tropical waters without major upwelling (Jefferson 2009). Wade and Gerrodette (1993) noted that rough-toothed dolphins were seen in low densities throughout much of the area, except in the coldest parts of the Peru and California currents. Little is known about the ecology of the species. Rough-toothed dolphins feed on a variety of fish and cephalopods, and may take some large fish (Jefferson 2009b).

Behavior and life history: Rough-toothed dolphins commonly occur in mixed schools with other delphinids in the ETP. They have, in addition, been observed associating with flotsam (Jefferson 2009b). School size is variable, but commonly in the range of 10-20 (Jefferson 2009b). The maximum recorded dive is 70 m. Rough-toothed dolphins, however, appear well adapted for deeper dives (Jefferson 2009b). The only life history information available is from Japan, where males reach sexual maturity at about 14 years of age and females at about 10 years old. The maximum recorded age was 32-36 years (Jefferson 2009b).

Acoustics and hearing: Rough-toothed dolphins are classified in the mid-frequency functional hearing group, with an estimated auditory bandwidth of 150 Hz-160 kHz (Southall et al. 2007) (Table 4.1). Directional clicks and pulses up to 200 kHz have been recorded (Jefferson 2009b).

4.2.5 Striped Dolphin (*Stenella coeruleoalba*)
Description: Refer to section 4.1.6 for species description.

Status and trends: Striped dolphins are among the most commonly sighted dolphin species in the ETP (Wade and Gerrodette 1993). It was previously thought that geographical stocks existed, but that has since been discounted and all striped dolphins in the ETP are considered one stock (Dizon et al. 1994). The 2006 estimated abundance of striped dolphins in the ETP was 964,362 (616,898-1,404,055; 95% c.i.). This was down from an estimated 1,617,012 in 2003 (Gerrodette et al. 2008). The estimated rate of change from 1986 to 2006 was -0.004 and from 1998 to 2006, was 0.012 (Gerrodette et al. 2008). Density in the ETP was estimated to be 45.163 dolphins/1,000 km^2 (Gerrodette et al. 2008).

Striped dolphins are not listed under the ESA.

Distribution and habitat preferences: Striped dolphins are cosmopolitan and range widely throughout the ETP (Ballance et al. 2006; Hamilton et al. 2009). They commonly occur outside the continental shelf, over the continental slope and out to oceanic waters (Archer 2009). They are rare in the warmest Tropical Surface Water off southern Mexico and in eastern boundary current coastal upwelling regions. Striped dolphins associate with convergence zones, areas with year-round or seasonal upwelling, weak thermoclines, surface temperatures <25° C and surface salinities >34.5 psu (practical salinity units) (Ballance et al. 2006).

Striped dolphins in the ETP prey primarily on mesopelagic species, such as myctophids, a melamphaeid and the enoploteuthid squid. Prey varies by area, with fish dominating the diet in more southerly areas and fish and squid of equal importance closer to the northern tropical convergence (Perrin et al. 2008). Most feeding occurred at night or early in the morning (Perrin et al. 2008).

Behavior and life history: Refer to section 4.1.6

Acoustics and hearing: Refer to section 4.1.6

4.2.6 Spinner Dolphin (*Stenella longirostris orientalis*); Central American Spinner Dolphin (S. *l. centroamericana*) and White-belly Stocks

Description: Spinner dolphins are readily identifiable by their external features and highly acrobatic "spinning" behavior. They have long slender beaks, tipped with black or dark gray, a dark gray cape, light gray sides, light belly, and a dark band that goes from the eye to the flipper. In the eastern and Central American subspecies (see below), the bands of color are muted and the dolphins appear uniformly gray. The dorsal fin on adult males of these subspecies may cant forward, so that it appears to be on backwards (Perrin 2009a). Adults are 1.3-2.4 m long and weigh 23-80 kg. Males are larger than females (Perrin 2009a).

Status and trends: Spinner dolphins belong to the Order Cetacea, Suborder Odontoceti, and Family Delphinidae. Three recognized stocks of spinner dolphins occur in the ETP. The eastern spinner (*Stenella longirostris orientalis*) and the Central American spinner (*S. l. centroamericanus*) are subspecies. Whitebelly spinners are considered hybrids of the eastern spinner and the Gray's spinner (*S. l. longirostris*), which occur in the central and southern Pacific (Perrin 2009a). The whitebelly stock of spinner dolphin is considered a stock for management purposes; however, it should be noted that morphological differentiation from the eastern stock of spinner dolphin was not the basis for stock delineation.

Spinner dolphins, particularly the eastern spinner, suffered significant population declines as a result of high levels of incidental take in the yellowfin tuna (*Thunnus albacares*) purse-seine fishery in the ETP beginning in the 1950s. Yellowfin tuna tend to associate with mixed schools of spinner and spotted dolphins (see below), which makes the tuna more conspicuous to fishermen, but resulted in unprecedented levels of dolphin bycatch (Gerrodette 2009). The spinner dolphin population purportedly decreased to less than half its original size (Gerrodette and Forcada 2005; Perrin 2009a). Through a series of combined actions, including passage of the MMPA in 1972, subsequent amendments, regulations, and mitigation measures, dolphin bycatch in the ETP has since decreased 99% in the international fishing fleet, and was eliminated by the U.S. fleet (Gerrodette and Forcada 2005).

The SWFSC has been conducting research, mandated by the MMPA, on the status of dolphin stocks impacted by the yellowfin tuna fishery in the ETP since the 1970s. A congressional directive in 1997 created the International Dolphin Conservation Program Act (IDCPA). The major objective of the act was to estimate abundance and population trends of affected dolphin stocks in order to assess population recovery since incidental mortality dropped to low levels. A three-year series of surveys in 1998-2000 resulted (Ballance et al. 2002). Data from those surveys indicated that eastern spinner dolphin populations were not recovering as expected (Gerrodette and Forcada 2005). This led to additional population monitoring surveys in 2003 and 2006, from which the most recent estimates were determined (Gerrodette et al. 2008).

The population estimate for eastern spinner dolphins in 2003 was 673,943 and for 2006 it was 1,062,879 (607,428-1,727,235: 95% c.i.) (Gerrodette et al. 2008). The 2006 estimate was 73% higher than the mean estimates from 1998 to 2000. The estimated rate of change from 1986 to 2006 was 0.019 and was 0.092 from 1998 to 2006 (Gerrodette et al. 2008).

The higher estimates for 2003 and 2006 could indicate that the stock is starting to recover. There are, however, several caveats and other factors to consider when interpreting the data. These are being addressed through additional assessment modeling (Gerrodette et al. 2008).

Some of the reasons for higher estimates in 2006 include adjustments to correction factors used and changes to computer code. In addition, unidentified spinner dolphin sightings were included in population estimates for eastern and whitebelly spinners (Gerrodette et al. 2008).

The population estimate for whitebelly spinner dolphins was 531,496 in 2003 and 734,837 in 2006 (154,246-1,802,469; 95% c.i.) (Gerrodette et al. 2008). The estimated rate of change from 1986 to 2006 was -0.005 and from 1998 to 2006 was 0.062 (Gerrodette et al. 2008).

Density in the ETP was estimated to be 34.414 white belly dolphins/1,000 km^2 and 49.777 eastern spinner dolphins/1,000 km^2; no density estimate was available for the Central American stock (Gerrodette et al. 2008). Abundance estimates were not available for the Central American spinner dolphin population in the ETP.

The eastern spinner dolphin is listed as depleted under the MMPA (NOAA Office of Protected Resources website: http://www.nmfs.noaa.gov/pr/species/mammals/cetaceans/). At the time of the MMPA depleted listing, the eastern spinner dolphin was estimated to be at 44 percent of its pre-exploitation population size. It is not listed under the Endangered Species Act (ESA).

Distribution and habitat preferences: Spinner dolphins occur in all tropical and most sub-tropical waters between 30-40° N and 20-40° S latitude, generally in areas with a shallow mixed layer, shallow and steep thermocline, and little variation in surface temperatures (Perrin 2009a). The ranges of eastern and whitebelly spinner dolphins overlap considerably. Eastern spinners, however, predominate in the northeastern portion of the ETP in the Eastern Pacific Warm Pool, characterized by high surface temperature (>25° C) and chlorophyll, low surface density, and shallow thermoclines (<50 m) (Ballance et al. 2006; Hamilton et al. 2009; Reilly et al. 2002). Whitebelly spinner dolphins range farther south and offshore, to the west and south of the Eastern Pacific Warm Pool, where surface temperature is cooler, surface density is higher, and the thermocline deeper (Ballance et al. 2006; Hamilton et al. 2009). The Central American stock occurs in shallow, nearshore waters within 80 km of the Central American coast (Wade and Gerrodette 1993; Perrin 2009a).

Behavior and life history: The most conspicuous behavior of the spinner dolphin – the spinning for which the species is named – is a mystery. Theories as to why spinners spin include communication, play, and knocking off remoras (Perrin 2009a). School size varies from a few animals to over a thousand. Mixed schools with other species, particularly pantropical spotted dolphins, are common (Perrin 2009a). Mating appears to be promiscuous. Gestation is about 10 months and breeding is seasonal. Females reach sexual maturity at 4-7 years, and males at 7-10 years. Calving interval is 3 years and calves nurse for 1-2 years (Perrin 2009a).

Acoustics and hearing: Spinner dolphins produce an array of whistles and burst pulses that vary by activity and geographically (Perrin 2009a). Spinner dolphins are in the mid-frequency functional hearing group of Southall et al. (2007), with an estimated auditory bandwidth of 150 Hz to 160 kHz (Table 4.1).

4.2.7 Pantropical Spotted Dolphin (*Stenella attenuata*); Offshore and Coastal Stocks

Description: Spotted dolphins are characterized by a long, clearly defined beak, prominent falcate dorsal fin, slender body and spots on adults. The larger coastal spotted dolphin is heavily spotted. Adult can be 1.7-2.6 m and up to 119 kg, with a great deal of geographic variation (Perrin 2009b).

Status and trends: Spotted dolphins belong to the Order Cetacea, Suborder Odontoceti, and Family Delphinidae. In the ETP they are represented by the offshore form (*S. attenuata attenuata*) and the coastal form (*S. attenuata graffmani*). The offshore form is further divided into northeastern offshore and western/southern offshore (Dizon et al. 1994; Perrin 2009b).

The northeastern offshore spotted dolphin population was depleted in previous years due to high levels of bycatch in yellowfin tuna purse-seining operations in the eastern tropical Pacific beginning in the 1950s. Yellowfin tuna often associate with mixed schools of spinner and spotted dolphins, which resulted in unprecedented levels of dolphin bycatch (Gerrodette 2009). (Refer to spinner dolphin section above for details). The northeastern offshore spotted dolphin population declined roughly 80% as a result (Perrin 2009b). Annual mortality in the fishery is currently in the 100s due to mitigation measures to decrease bycatch. Chasing and encirclement could, however, still affect fecundity and survival (Perrin 2009b). A congressional directive in 1997 resulted in large scale surveys in 1998-2000 to estimate abundances of dolphins affected by the fishery. Results suggested the population was recovering as expected (Gerrodette and Forcada 2005). This led to additional surveys in 2003 and 2006, from which the most recent estimates were determined (Gerrodette et al. 2008).

The 2006 population estimate for the northeastern offshore spotted dolphins was 857,884 (551,852-1,274,019: 95% c.i.). This was 27% higher than the mean estimates from 1998 to 2000. The rate of change from 1986 to 2006 was 0.010, and was estimated as 0.035 for the period 1998-2006 (Gerrodette et al. 2008). The higher estimate for 2006 compared to 1998-2000 could indicate that the stock is starting to recover. There are, however, several caveats and other factors to consider when interpreting the data. These are being addressed through additional assessment modeling (Gerrodette et al. 2008).

In 2006, the estimated abundance for the western/southern offshore spotted dolphins was 439,208 (227,055-724,675; 95% c.i.). The estimated rate of change from 1986 to 2006 was -0.023 and from 1998 to 2006, was -0.080 (Gerrodette et al. 2008). The decline in abundance of the western/southern stock of offshore spotted dolphin while the northeastern offshore stock increased may indicate dolphins moving across the geographic boundaries that define the two stocks at 120º W and 5º N (Gerrodette et al. 2008).

Density in the ETP was estimated to be 122.625 northeast offshore spotted dolphins/1,000 km^2 , 30.592 western/southern spotted dolphin/1,000 km^2, and 43.435 coastal spotted dolphins/1,000 km^2 (Gerrodette et al. 2008).

The estimated abundance of coastal spotted dolphins in 2006 was 278,155 (31,150-656,534; 95% c.i.). The estimated rate of exponential change from 1986 to 2006 was 0.104 and was 0.077 for 1998 to 2006 (Gerrodette et al. 2008). The coastal and northeastern offshore spotted dolphin stocks are designated as depleted under the MMPA (NOAA Office of Protected Resources website: http://www.nmfs.noaa.gov/pr/species/mammals/cetaceans/). At the time of the MMPA depletion listing, the northeastern offshore spotted dolphin was estimated to be between 19 and 28 percent of its pre-exploitation population size and the coastal stock was estimated to be at 42 percent of its pre-exploitation population size. Neither stock is listed under the ESA.

Distribution and habitat preferences: Distribution of spotted dolphins is worldwide in tropical and some sub-tropical waters between 30-40° N latitude to 20-40° S latitude. The coastal subspecies has a narrow distribution along the Pacific coasts of southern Mexico to northern Peru (Perrin 2009b). Offshore spotted dolphin habitat is characterized by well-stratified water, warm (>25° C) surface temperatures, low salinity, and a sharp, but shallow, thermocline at approximately 50 m (Ballance et al. 2006; Perrin 2009b; Reilly et al. 2002). This overlaps extensively with eastern and whitebelly spinner dolphins. Offshore spotted dolphins primarily eat small epipelagic fish, squid, crustaceans, and flying fish in some areas (Perrin 2009b).

Behavior and life history: Pantropical spotted dolphins often occur in large multi-species schools, particularly with spinner dolphins (Perrin 2009b). In 2006, >50% of the offshore spotted dolphins recorded were in mixed species schools (Jackson et al. 2008). School size ranges from a few hundred to several thousand, with mean school size of 120 in the ETP (Perrin 2009b). Females become sexually mature at 9-11 years old and males at 12-15 years of age. The calving interval is approximately 2-3 years. Gestation ranges from 11.2-11.5 months and weaning occurs between 9 months and 2 years (Perrin 2009b).

Acoustics and hearing: Spotted dolphins are classified in the mid-frequency functional hearing group, with an estimated auditory bandwidth of 150 Hz-160 kHz (Southall et al. 2007) (Table 4.1).

4.2.8 Dusky Dolphin (*Lagenorhynchus obscurus*)

Description: The dusky dolphin has a short beak; dark back and white belly; light gray thoracic and two-pronged flank patches; a two-toned, falcate dorsal fin; and dark lips and eye patches. Average adult size is about 1.85m. They rarely weigh more than 100 kg. Sexual dimorphism is subtle. The male dorsal fin is more curved and broader at the base (Van Waerebeek and Würsig 2009).

Status and trends: Dusky dolphins belong to the Order Cetacea, Suborder Odontoceti, and Family Delphinidae. No abundance estimates are available for the entire population (Van Waerebeek and Würsig 2009); however, sightings during SWFSC surveys conducted 1998-2000, 2003 and 2006 allowed estimation of population abundance (40,211) and density (0.0021/km^2) for the ETP.

Distribution and habitat preferences: Dusky dolphins are distributed around South America. On the Pacific side, they range from northern Peru to Cape Horn. They are one of the most abundant species in Peruvian coastal waters (Van Waerebeek and Würsig 2009). Dusky dolphins usually associate with continental shelves and slopes, but may occur over deeper water near continents or islands. Preferred sea surface temperature is in the 10-18°C range (Van Waerebeek and Würsig 2009).

Prey of dusky dolphins includes a variety of fish and squid species, predominantly small schooling fish, such as anchovies. They are, however, opportunistic feeders and will prey upon what is available in the absence of anchovies off the coast of Peru (Van Waerebeek and Würsig 2009).

Behavior and life history: Dusky dolphins commonly surface feed in large groups. Off the coast of Peru, they often co-occur with long-beaked common dolphins in large feeding aggregations of 100s to 1000s of animals (Van Waerebeek and Würsig 2009). Females off Peru reach sexual maturity at 3.4-5 years of age and males become sexually mature at 3.8-4.7 years. Most calving off Peru occurs in late winter (August-October) after a nearly 13 month gestation period. Calves nurse for approximately a year (Van Waerebeek and Würsig 2009).

Acoustics and hearing: Dusky dolphins are classified in the mid-frequency functional hearing group, with an estimated auditory bandwidth of 150 Hz-160 kHz (Southall et al. 2007) (Table 4.1). Echolocation signals of dusky dolphins have both a low-frequency peak (40-50 kHz) and a high frequency peak (80-110 kHz) (Au and Würsig 2004 cited in Van Waerebeek and Würsig 2009).

4.2.9 Fraser's Dolphin (*Lagenodelphis hosei*)

Description: Fraser's dolphins are stocky dolphins with a short beak, small triangular to falcate dorsal fin, small flukes and flippers and striking black head stripe that is prominent in adult males, variable in adult females and absent in calves. The back is brownish gray, the lower body cream colored and the belly pink or white. The largest male recorded was 2.7 m and the largest female 2.6 m. Large males could be up to 210 kg (Dolar 2009).

Status and trends: Fraser's dolphins belong to the Order Cetacea, Suborder Odontoceti, and Family Delphinidae. The only available abundance estimate for Fraser's dolphins in the ETP was based on data from 1986 to 1990. The resulting estimate was 289,300 (138,000-508,100; 95% c.i.) (Wade and Gerrodette 1993). Gerrodette et al. (2008) considered the species sufficiently rare in the core study area to not warrant attempting to estimate abundance. However, density in the ETP was estimated to be 13.548 dolphins/1,000 km^2 (Gerrodette et al. 2008).

Fraser's dolphins are not listed under the ESA.

Distribution and habitat preferences: Fraser's dolphins are a tropical species generally found between 30° N and 30° S (Dolar 2009). All of the sightings used in above abundance estimate were south of 7° N and far offshore, primarily west of 100° W longitude (Wade and Gerrodette 1993). They are typically oceanic and commonly occur in water depths of 1500-2500 m. They prey primarily on mesopelagic fish, cephalopods, and crustaceans and, in the ETP, are thought to feed at 250 to 500 m depth (Dolar 2009).

Behavior and life history: Fraser's dolphins often occur in tightly grouped, fast moving schools of 100-1,000 individuals. They commonly occur in large mixed-species schools with melon-headed whales in the ETP (Dolar 2009, Wade and Gerrodette 1993). They are deep divers and capable of diving to >600 m (Dolar 2009). Life history data is available for Fraser's dolphins off Japan. The age of sexual maturity appears to be 7-10 years for males and 5-8 years for females (Dolar 2009).

Acoustics and hearing: Fraser's dolphins are classified in the mid-frequency functional hearing group, with an estimated auditory bandwidth of 150 Hz-160 kHz (Southall et al. 2007) (Table 4.1).

4.2.10 Melon-Headed Whale (*Peponocephala electra*)

Description: The melon-headed whale is predominantly gray with a darker gray dorsal cape and a distinct eye patch. They often have white lips and light coloration on the throat region. This species is hard to distinguish from pygmy killer whales at sea. Length for males is 2.5 m and for females is 2.4 m. There is some sexual dimorphism. Males have longer flippers, taller dorsal fins, broader flukes, and are more robust than females (Perryman 2009).

Status and trends: Melon-headed whales belong to the Order Cetacea, Suborder Odontoceti, and Family Delphinidae. The only available abundance estimate for melon-headed whales in the ETP was calculated by Wade and Gerrodette (1993) and was 45,400 (34,200-110,300; 95% c.i.). Density in the ETP was estimated to be 2.126 melon-headed whales/1,000 km^2 (Gerrodette et al. 2008).

This species is not listed under the ESA.

Distribution and habitat preferences: Melon-headed whales are distributed worldwide in tropical and subtropical waters. They generally occur offshore in deep oceanic waters. Nearshore distribution is generally associated with deep water areas near to the coast (Perryman 2009). Squid appear to be the preferred prey, along with some fish and shrimp (Perryman 2009).

Behavior and life history: Melon headed whales are often in large schools (mean school size is about 200), including in mixed schools with Fraser's dolphins (Perryman 2009, Wade and Gerrodette 1993). They may also form mixed schools with spinner, bottlenose, and rough-toothed dolphins (Perryman 2009). Females reach sexual maturity at approximately 11.5 years of age and males at about 15 years (Perryman 2009).

Acoustics and hearing: Melon-headed whales are classified in the mid-frequency functional hearing group, with an estimated auditory bandwidth of 150 Hz-160 kHz (Southall et al. 2007) (Table 4.1).

4.2.11 Bottlenose Dolphin (*Tursiops truncatus*)

Description: Refer to section 4.1.5 for a species description

Status and trends: Bottlenose dolphins in the ETP are considered of one stock. It was previously suggested that offshore and coastal forms may occur there, but that has not been sufficiently examined (Wade and Gerrodette 1993). Bottlenose dolphins are often the second or third most commonly sighted dolphin species during surveys of the ETP (Jackson et al. 2004, 2008; Kinzey et al. 1999, 2001). The estimated abundance of bottlenose dolphins in the ETP in 2006 was 335,834 (231,636-495,304: 95% c.i.) and 312,225 (188,168-509,506; 95% c.i.) in 2003 (Gerrodette et al. 2008). The estimated rate of change from 1986 to 2006 was 0.040 and from 1998 to 2006, was -0.004 (Gerrodette et al. 2008). Density in the ETP was estimated to be 15.728 bottlenose dolphins/1,000 km^2 (Gerrodette et al. 2008).

Bottlenose dolphins are not listed under the ESA.

Distribution and habitat preferences: Bottlenose dolphins occur in all regions of the ETP, but are most concentrated near to the coast (Jackson et al. 2008; Hamilton et al. 2009; Wade and Gerrodette 1993). They commonly frequent coastal waters of Central America, including off Costa Rica and Panama (May-Collado et al. 2005; Rasmussen et al. 2004). Bottlenose dolphins appear to prefer areas of upwelling (Ballance et al. 2006).

Behavior and life history: Refer to section 4.1.5

Acoustics and hearing: Refer to section 4.1.5

4.2.12 Killer Whale (*Orcinus orca*)

Description: Refer to section 4.1.10 for species and ecotype descriptions.

Status and trends: Defined ecotypes have not yet been recognized for the ETP, although observed pursuit and predation on marine mammals would suggest the occurrence of transients in the area (Olson and Gerrodette 2008). Rasmussen et al. (2004) observed killer whales off the coast of Costa Rica pursuing humpback whales in 2003. Pitman et al. (2007) observed a group of 19 killer whales feeding on a blue whale calf about 230 km west of Nicaragua. Genetic analysis from biopsy samples also indicated that the whales differed genetically from northeast Pacific resident killer whales.

The only available estimate of abundance for killer whales in the ETP is 8,500 (4,700-15,900; 95% c.i.) (Wade and Gerrodette 1993). Killer whales are seen in low densities throughout the ETP (Wade and Gerrodette 1993). From 1986 to 2006, 179 groups of killer whales were recorded during SWFSC research cruises (Olson and Gerrodette 2008). Density in the ETP was estimated to be 0.398 killer whales/1,000 km^2 (Gerrodette et al. 2008).

Killer whales in the ETP are not listed under the ESA.

Distribution and habitat preferences: Killer whales are found throughout the ETP, where they occur year-round (Dahlheim et al. 1982 cited in Olson and Gerrodette 2008). They have been sighted both offshore and nearshore, including off the coasts of Costa Rica and Panama (Hamilton et al. 2009; May-Collado et al. 2005; Rasmussen et al. 2004). The distribution and range of killer whales seen in the ETP is not known. Three individually identified killer whales photographed in the ETP matched photographs of whales from Mexico. The whales in Mexico were photographed on both the Pacific side and Gulf of California side of Baja Peninsula (Olson and Gerrodette 2008).

Behavior and life history: Refer to section 4.1.10

Acoustics and hearing: Refer to section 4.1.10

4.2.13 False Killer Whale (*Pseudorca crassidens*)

Description: False killer whales are among the larger members of the dolphin family. Adult males may reach lengths of nearly 6 m and females may be 5 m in length. They are mostly dark gray to black in color, with a rounded head, small falcate dorsal fin, and flippers that distinctively bulge on the leading edge. The common name stems from skull morphology similar to killer whales (Baird 2009).

Status and trends: False killer whales belong to the Order Cetacea, Suborder Odontoceti, and Family Delphinidae. There are no worldwide population estimates for false killer whales that "appear to be naturally uncommon throughout their range" (Baird 2009). Wade and Gerrodette (1993) derived an estimated abundance of 39,800 (11,500-109,500; 95% c.i.) based on data collected from 1986 to 1990 in the ETP. Density in the ETP was estimated to be 1.864 false killer whales/1,000 km^2 (Gerrodette et al. 2008).

False killer whales are not listed under the ESA.

Distribution and habitat preferences: False killer whales occur throughout tropical and warm temperate waters worldwide. They are largely pelagic, but also occur nearshore and in shallow waters around oceanic islands (Baird 2009). Sightings, based on surveys from 1986 to 2005, are distributed across the ETP (Hamilton et al. 2009). They have a diverse diet that includes a variety of squid and fish. They have also been documented preying on smaller dolphins being released from tuna purse-seines in the ETP. There is evidence of false killer whales attacking other marine mammals, including a humpback calf and sperm whales (Barid 2009).

Behavior and life history: They are very social and are often in groups of 20-100 individuals. Not much is known about the diving behavior of false killer whales other than a recorded dive to over 230 m by one tagged animal (Baird 2009). Both males and females reach sexual maturity between 8 and 14 years. A calving interval of 7 years was estimated for one population. False killer whales appear long-lived with males living an estimated 57 years and females for 62 years (Baird 2009).

Acoustics and hearing: False killer whales are classified in the mid-frequency functional hearing group, with an estimated auditory bandwidth of 150 Hz-160 kHz (Southall et al. 2007) (Table 4.1).

4.2.14 Pygmy Killer Whale (*Feresa attenuata*)

Description: Pygmy killer whales have round, blunt heads and lack the characteristic dolphin beak. They have robust bodies that narrow toward the dorsal fin, and long flippers. The back, parts of the sides and belly are dark gray to black, with a pale area often present on the flank. The lips are edged in white. Average length for both sexes is 2.3 m (Donahue and Perryman 2009).

Status and trends: Pygmy killer whales belong to the Order Cetacea, Suborder Odontoceti, and Family Delphinidae. Abundance estimates for pygmy killer whales in the ETP are from surveys conducted from 1986 to 1990. The derived estimate was 38,990 (18,500-63,100; 95% c.i.) (Wade and Gerrodette 1993). Density in the ETP was estimated to be 1.826 pygmy killer whales/1,000 km^2 (Gerrodette et al. 2008).

Pygmy killer whales are not listed under the ESA.

Distribution and habitat preferences: Pygmy killer whales occur in tropical and subtropical waters worldwide, and are regularly sighted in the ETP (Donahue and Perryman 2009). Sightings are more common in warmer coastal waters near to Central America than offshore (Hamilton et al. 2009; Wade and Gerrodette 1993). The feeding behavior of pygmy killer whales is not well known. Remains of cephalopods and small fish have been found in stomachs of stranded and incidentally caught individuals. They may be one of the species of small whales that attack and sometimes eat smaller dolphins caught in the tuna purse-seine fishery (Donahue and Perryman 2009).

Behavior and life history: Pygmy killer whales are generally in small schools of 12-50 animals, although larger schools have been observed. They are known to bow ride. Pygmy killer whale life history is poorly understood.

Acoustics and hearing: Pygmy killer whales are classified in the mid-frequency functional hearing group, with an estimated auditory bandwidth of 150 Hz-160 kHz (Southall et al. 2007) (Table 4.1).

4.2.15 Short-Finned Pilot Whale (*Globicephala macrorhynchus*)
Description: Refer to section 4.1.11 for species description.

Status and trends: Pilot whales are considered a single stock in the ETP survey area (Gerrodette and Forcada 2002). In estimating abundance of pilot whales in the ETP over a 15 year period (1986-2000), Gerrodette and Forcada (2002) assumed that all unidentified pilot whale sightings were short-finned pilot whales, since long-finned pilot whales (*G. melas*) have not been recorded in the ETP area. Wade and Gerrodette (1993), however, noted that some long-finned pilot whales may be encountered as extralimital species at the southern extreme of the survey area in the Peru Current.

The most recent available abundance estimate for short-finned pilot whales in the ETP is for the year 2000 and is 589,315 (516,619-1,728,073: 95% c.i.). This is the highest estimated abundance for the period 1986-2000; the lowest was 136,448 (Gerrodette and Forcada 2002). Density in the ETP was estimated to be 27.599 short-finned pilot whales/1,000 km^2 (Gerrodette et al. 2008).

Interpreting temporal changes in abundance is confounded by several factors, not least of which is distribution that extends beyond the survey area. Movement in or out of the study area in response to changing oceanographic conditions could affect distribution and, subsequently, abundance estimates (Gerrodette and Forcada 2002).

Short-finned pilot whales are not listed under the ESA.

Distribution and habitat preferences: Short-finned pilot whales are most abundant in cold, upwelling-modified waters (Wade and Gerrodette 1993). They are conspicuously absent from the warm tropical waters off the coast of Mexico (Hamilton et al. 2009; Wade and Gerrodette 1993). There is a clear separation between pilot whales off the coast of Baja, Mexico and those occurring south of 15° N; this division may represent different stocks (Wade and Gerrodette 1993). Highest concentrations of pilot whales in the ETP are off the coasts of Costa Rica and

Panama (Ballance et al. 2006; May-Collado et al. 2005). Pilot whales were also commonly seen along the equator, between longitudes 85° W and 110° W, during May-July 1981 (Au and Perryman 1985).

Behavior and life history: Refer to section 4.1.11

Acoustics and hearing: Refer to section 4.1.11

4.2.16 Cuvier's Beaked Whale (*Ziphius cavirostris*)
Description: Refer to section 4.1.14 for species description.

Status and trends: Wade and Gerrodette (1993) calculated an abundance of 20,000 (13,800-34,500; 95% c.i.) Cuvier's beaked whales in the ETP based on survey data from 1986 to 1990. The abundance estimate for unidentified Ziphiids was prorated between Cuvier's beaked whales and *Mesoplodon* spp. The estimate of 20,000 animals was likely an underestimated abundance of Cuvier's beaked whales in the ETP, since it was not adjusted for animals missed along the survey track line. The long dive times and short surface duration of beaked whales makes them more difficult to detect (Barlow et al. 2006, Wade and Gerrodette 1993). Density in the ETP was estimated to be 0.937 Cuvier's beaked whales/1,000 km^2 (Gerrodette et al. 2008).

Cuvier's beaked whales are not listed under the ESA.

Distribution and habitat preferences: Cuvier's beaked whales are distributed throughout the ETP (Hamilton et al. 2009; Wade and Gerrodette 1993). Beaked whales in the ETP were found in much deeper waters than seen in other studies. The mean water depth with which Cuvier's beaked whales associated was 3.4 km, with a maximum depth of 5.1 km (Ferguson et al. 2006). Beaked whales, on average, were 1000 km offshore (sightings ranged from 40-3750 km) and in waters that ranged from well-mixed to stratified (Ferguson et al 2006). Feeding ecology and prey preferences are not well known. Species found in stomach contents, however, are characteristic of species that feed in deep oceanic, mesopelagic, or benthic realms. Fish and squid appear to be prey of Cuvier's beaked whales (Heyning and Mead 2009).

Behavior and life history: Refer to section 4.2.14

Acoustics and hearing: Refer to section 4.2.14

4.2.17 Longman's Beaked Whale (*Indopacetus pacificus*)
Description: Longman's beaked whales, sometimes known as "tropical bottlenose" or "Indo-Pacific beaked whales," are one of the rarest and least known members of the beaked whales (Jefferson et al. 1993; Rice 1998; Dalebout et al 2003). As adults, Longman's beaked whales can reach estimated lengths of about 6-9 m; their weight is unknown. Compared to other beaked whales, this species is relatively large.

Longman's beaked whales have a large, robust body with a fairly large, falcate dorsal fin located far down their back. This species has dark, small, rounded, narrow flippers that fit into a depression on either side of the body. They have a well-defined melon that is almost perpendicular to their long, tube-shaped beak. A crease may distinguish the melon from the beak.

As they grow older, the melon develops into a steeper more bulbous shape that may hang over the beak. Like other beaked whales, they have V-shaped paired throat creases. As scientists have learned more about this species' external appearance and physical description, they have resolved confusion in various sightings at sea.

Longman's beaked whales are usually found in tight groups averaging between 10-20 individuals, but occasionally have been seen in larger groups of up to 100 animals. They have sometimes been observed associating with other marine mammals such as pilot whales, spinner dolphins, and bottlenose dolphins. The feeding behavior and prey of these cetaceans is generally unknown, but scientists believe it is similar to that of other beaked whales. Beaked whales are known to dive deep to forage for their food. The analysis of stomach contents from one stranded specimen implies that cephalopods (e.g., squid and octopus) comprise the majority of the whale's diet.

Status and trends: A 2002 shipboard line-transect survey of the entire Hawaiian Islands EEZ resulted in an abundance estimate of 1,007 (CV=1.25) Longman's beaked whales (Barlow 2006). This is currently the best available abundance estimate for this stock. No data are available on current population trend. The status of Longman's beaked whales in Hawaiian waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. Sighting data collected during SWFSC surveys in 1998-2000, 2003 and 2006 allowed estimation of population abundance (1,007) and density (0.000037/km^2) in the ETP study area. It is not listed as threatened or endangered under the ESA, nor as "depleted" under the MMPA.

Distribution and habitat preferences: The distribution of Longman's beaked whales is poorly known and incomplete, but they are believed to occur in the tropical regions of the Indian and Pacific Oceans. Longman's beaked whales live in generally warm (21-31° C), deep (greater than 1,000 m), and pelagic waters of tropical and subtropical regions. In U.S. waters, this species has been sighted in the Hawaiian EEZ and the equatorial tropical Pacific. Strandings (7 total events) have occurred on the coasts of East (Kenya and Somalia) and South Africa, northern Australia, the Maldives, the Philippines, South Japan, and Sri Lanka. Rare sightings have been documented in the eastern tropical Pacific Ocean. Sightings in the waters surrounding the Maldives archipelago and in the western Indian and Pacific Oceans are more frequent.

Behavior and life history: Nothing is known about the reproduction or lifespan of this species. Due to the rarity, behavior, and infrequent encounters with this species, much of the information available is unreliable. A single young neonate calf was measured at 2.9 m.

Acoustics and hearing: Very little is known; however, like other beaked whales anthropogenic noise is thought to be a threat to this species.

4.2.18 Mesoplodont Beaked Whales

Description: Refer to section 4.1.13 for general species descriptions.

Status and trends: The only available estimate for Mesoplodont beaked whales in the ETP was made for one stock of *Mesoplodon* spp. A majority of the sightings from which the estimate derives were unidentified to species. The remaining Mesoplodont sightings were split among three species: *Mesoplodon* sp. 'A'; Blainville's beaked whale, *Mesoplodon densirostris*; and the

Peruvian beaked whale (also called pygmy beaked whale and lesser beaked whale), *Mesoplodon peruvianus* (Wade and Gerrodette 1993). In addition, although not identified during SWFSC ETP surveys, *M. ginkgodens* is also likely present there. The different species have different likelihoods of being correctly identified, so a pooled abundance estimate was made for all combined as *Mesoplodon* spp. The resulting estimate, based on data from 1986 to 1990, was 25,300 (17,400-34,400; 95% c.i.) (Wade and Gerrodette 1993). Density in the ETP was estimated to be 1.185 Mesoplodont beaked whales/1,000 km^2 (Gerrodette et al. 2008).

Pitman and Lynn (2001) subsequently proposed that *Mesoplodon* sp. "A" is likely *M. peruvianus*. At a minimum, size and dentition are comparable and ranges overlap.

None of the Mesoplodont whales in the ETP are listed under the ESA.

Distribution and habitat preferences: Mesoplodont beaked whales in the ETP are broadly distributed. They prefer deep water with mean and maximum depths of 3.5 km and 5.75 km, respectively, that ranges from well-mixed to stratified (Ferguson et al. 2006). They were sighted 1000 km offshore, on average, but distance from shore ranged from 40 to over 3,700 km (Ferguson et al. 2006).

Modeling predictions indicated two high density areas for *Mesoplodon* spp. in the ETP: 1) waters of the equatorial cold tongue that straddle the equator (e.g., Equatorial Countercurrent and South Equatorial Current) and 2) coastal waters off Central America and Mexico. These areas correspond with sighting distributions for Blainville's beaked whales and Peruvian beaked whales, respectively (Barlow et al. 2009; Pitman and Lynn 2001; Wade and Gerrodette 1993).

Behavior and life history: Refer to section 4.1.13

Acoustics and hearing: Refer to section 4.1.13

4.2.19 Sperm Whale (*Physeter macrocephalus*)

Description: Refer to section 4.1.16 for species description.

Status and trends: Sperm whales in the ETP were considered one stock for the purposes of estimating abundance. Genetics data from the ETP and Hawaii is currently inconclusive regarding population differentiation between these two areas (Mesnick et al. 2011). Gerrodette and Forcada (2002) estimated sperm whale abundance in the ETP in 2000 as 4,145 individuals (354-12,114; 95% c.i.). This was down from an estimated 26,652 in 1999 and was the lowest estimate derived between 1986 and 2000 (the highest was 49,653). Reasons for such disparity in abundance estimates include the likelihood of missing sperm whales on the track line due to their prolonged dives, difficulty in accurately estimating group size, and the possibility that whales, whose range extends beyond the survey boundaries, move readily into or out of the survey area depending on varying oceanographic conditions (Gerrodette and Forcada 2002). Density in the ETP was estimated to be 0.194 sperm whales/1,000 km^2 during the 2006 survey (Gerrodette et al. 2008).

Sperm whales are listed as endangered under the ESA. See section 4.1.16 for further information on historical commercial whaling and current status.

Distribution and habitat preferences: Sperm whales are widely distributed in the ETP, although they appear more abundant in the deep nearshore waters than offshore (Wade and Gerrodette 1993). Sperm whale sightings off southeast Costa Rica, however, were predominantly in deep offshore waters, including near Cocos Island (May-Collado et al. 2005).

Sperm whales in the ETP are predominantly females and immature animals. They are capable of extensive movements that they adapt over an array of temporal and spatial scales relative to the distribution of resources. Movements of 1,000 km (e.g., between the Galápagos Islands and mainland Ecuador or Panama) are common (Whitehead et al. 2008). Males are rare in the area, primarily due to their high-latitude non-breeding distribution and late age at which they return to the breeding areas (Whitehead et al. 2008).

Behavior and life history: Refer to section 4.1.16

Acoustics and hearing: Refer to section 4.1.16

4.2.20 Dwarf Sperm Whale (*Kogia sima*)
Description: Refer to section 4.1.15 for species description.

Status and trends: The worldwide population status and trends are unknown for dwarf sperm whales (McAlpine 2009). The best available population estimate for the ETP is 11,200 (7700-16,200; 95% c.i.) (Wade and Gerrodette 1993). Wade and Gerrodette (1993) considered all unidentified *Kogia* sightings south of 24° N to be *K. sima* when estimating abundance. Density in the ETP was estimated to be 0.525 dwarf sperm whales/1,000 km^2 (Gerrodette et al. 2008).

The species is not listed as threatened or endangered under the ESA, nor as "depleted" under the MMPA.

Distribution and habitat preferences: Dwarf sperm whales are thought to have a more southerly distribution than pygmy sperm whales (*K. breviceps*), which appeared to be corroborated by sightings of *K. breviceps* north of 24° N and *K. sima* south of 24° N during ETP surveys (Wade and Gerrodette 1993). Dwarf sperm whales may, thus, have a more tropical distribution and pygmy sperm whales a more temperate distribution. Dwarf sperm whales are found throughout the ETP, but with a higher sighting frequency near the coast identified off Costa Rica from 1979 to 2001 (May-Collado et al. 2005). *Kogia* spp. (dwarf and pygmy sperm whales) generally prey on mid- or deep-water cephalopods, as well as some fish and crustaceans (McAlpine 2009).

Behavior and life history: Refer to section 4.1.15

Acoustics and hearing: Refer to section 4.1.15

4.2.21 Humpback Whale (*Megaptera novaeangliae)*
Description: Refer to section 4.1.17 for species description.

Status and trends: The coastal regions of the ETP—notably, Costa Rica to Peru—include wintering areas for humpback whales from both the northern and southern hemispheres. Costa

Rica is unique as a region of geographic overlap for stocks of humpback whales that feed off California (California/Oregon/Washington stock) and off the Antarctic Peninsula and southern Chile (Breeding Stock G) (Acevedo and Smultea 1995; Calambokidis et al. 2000; Félix and Botero-Acosta 2011; Rasmussen et al. 2007). Although humpback whales are reportedly seen year-round off Costa Rica, peak numbers occur during January to March and August to October, the northern and southern hemisphere humpback whale wintering seasons, respectively (May-Collado et al. 2005; Rasmussen et al. 2004).

Sighting data collected during SWFSC surveys conducted in 1998-2000, 2003 and 2006 allowed estimation of population abundance (2,566) and density (0.000134/km^2) in the ETP study area. As of 2003, 83 humpback whales had been individually identified off Costa Rica during the boreal winter. Of these, 72 (87%) have been seen off California (Rasmussen et al. 2004). The minimum population estimate for the California/Oregon/Washington stock of humpback whales is 1,250 (Carretta et al. 2012). See Section 4.1.17 for further details on this stock. Of 41 humpback whales individually identified off Central America during the austral winters of 2001-2004, 7 were also photographed off the Antarctic Peninsula, a minimum distance of 8,299-8,461 km (Rasmussen et al. 2007). The estimated size of Breeding stock G was 6,500 in 2006 (Félix et al. in press cited in Félix and Botero-Acosta 2011).

Humpback whales are listed as endangered under the ESA.

Distribution and habitat preferences: Humpback whales have a largely coastal distribution in the ETP (Félix and Botero-Acosta 2011; Jackson et al. 2008; May-Collado et al. 2005). Off Costa Rica, all sightings of humpback whales were close to shore within the neritic zone (May-Collado et al. 2005).

As noted above, the ETP is a breeding and calving (wintering) area for humpback whales from both the northern and southern hemisphere. Individuals from both regions undertake lengthy annual migrations between feeding and breeding areas. Peak occurrence in the ETP for northern hemisphere humpbacks is January to March and for southern hemisphere humpbacks, August to early October (May-Collado et al. 2005). The most northerly extent of the southern hemisphere humpbacks off Costa Rica was 11° N (Rasmussen et al. 2007).

Surveys of humpback whale wintering areas worldwide show that they associate with warm water (21.1–28.3^{o} C), regardless of latitude (Rasmussen et al. 2007).

Behavior and life history: Refer to section 4.1.17 for general information on behavior and life history. Behavior of humpback whales on the wintering grounds differs from that on the feeding, or summering, grounds. It is primarily during winter that males sing long, elaborate songs. Males also form competitive groups wherein they compete for access to females (Clapham 2009).

The overall group composition for humpback whales off Costa Rica (1996-2003) was similar to other wintering areas. The proportion of single animals (singing males and non-singers) was 45%, 23% were pairs (non-mother/calf), and 29% were mother/calf pairs or mother/calf/escort trios (Rasmussen et al. 2004). The mean group size for humpback sightings during ETP surveys ranged from 1.5 to 2.5 (Kinzey et al. 1999, 2001; Jackson et al. 2004, 2008).

Acoustics and hearing: Refer to section 4.1.17

4.2.22 Blue Whale (*Balaenoptera musculus*)
Description: Refer to section 4.1.18 for species description.

Status and trends: The blue whales in the ETP appear to belong to the "California/Mexico" or, more appropriately, the eastern North Pacific stock of blue whales (Carretta et al. 2012; Stafford et al. 1999). It was previously thought that blue whales from both the southern and northern hemispheres frequented the Costa Rica Dome during their respective winters, since blue whales were observed there year-round (Ballance et al. 2006; Reilly and Thayer 1990). Acoustic data from moored hydrophones has since revealed that blue whale calls in the ETP are consistent with the A-B call of eastern North Pacific blue whales (Stafford et al. 1999). Additionally, several tagged blue whales moved between California and the Costa Rica Dome (Matteson 2009), further corroborating the inclusion of ETP blue whales in the eastern North Pacific stock.

The most recent estimate of abundance for blue whales in the ETP is 1,415 (1,078-2,501; 95% c.i.) (Wade and Gerrodette 1993). Population abundance and trends for the feeding stock off the U.S. West Coast are described in Section 4.1.18. Density in the ETP was estimated to be 0.194 blue whales/1,000 km^2 (Gerrodette et al. 2008).

The blue whale is listed as endangered under the ESA. Refer to Section 4.1.18 for further information on historical whaling and stock status.

Distribution and habitat preferences: Blue whale distribution in the ETP coincides with colder, nutrient rich waters of the California and Peru currents and the Costa Rica Dome (Wade and Gerrodette 1993). More than 90% of blue whale sightings in the ETP were along the coast of Baja California, Mexico or in the vicinity of the Costa Rica Dome. Other sightings occur near the Galapagos Islands, and along the coasts of Ecuador and Peru (Hamilton et al. 2009, Reilly and Thayer 1990). These colder, upwelling areas are productive regions with relatively large standing stocks of euphausiids (krill), a preferred prey of blue whales (Reilly and Thayer 1990).

Patterns in acoustic detections (Stafford et al. 1999), along with movements of tagged whales (Matteson 2009), suggest a seasonal migration between the ETP and the northeast Pacific. The A-B calls were most frequently recorded during summer/fall on the northeastern Pacific hydrophones and during winter/spring on the ETP hydrophones (Stafford et al. 1999). Although blue whales are seen year-round near the Costa Rica Dome, relative abundance was highest during January to March (Reilly and Thayer 1990). The year-round occurrence of blue whales near the Costa Rica Dome may be due to some of the population not migrating (Stafford et al. 1999).

Behavior and life history: Refer to section 4.1.18

Acoustics and hearing: Refer to section 4.1.18

4.2.23 Fin Whale (*Balaenoptera physalus*)
Description: Please refer to Section 4.1.19 for a full description of the fin whale.

Fin whales sightings are rare in the ETP (Carretta et al. 2012, Wade and Gerrodette 1993). Only one fin whale was recorded during surveys from 1986 to 1990 and it was north of the study area along the coast of Baja California, Mexico (Wade and Gerrodette 1993). Between 1998 and 2008, 10 out of 13 fin whales sighted during surveys were along the Baja coast on either the Pacific or the Gulf of California sides. Two were observed offshore to the west of Baja (1999 and 2003) and one (in 2003) was sighted at the southern extent of the ETP off the coast of Peru (Kinzey et al. 1999, 2000, 2001, Jackson et al. 2004, 2006). From sighting data collected during SWFSC surveys conducted in 1998-2000, 2003 and 2006 population abundance (574) and density (0.00003/km^2) were estimated for the ETP study area.

The fin whale is listed as endangered under the ESA.

Due to their rarity in the survey area, they will not be further discussed in this section.

4.2.24 Sei Whale (*Balaenoptera borealis*)

Description: Please refer to section 4.1.20 for an account of this species.

There were no sightings of sei whales during SWFSC surveys conducted in 1998-2000, 2003 and 2006. Thus, from these data we estimated population abundance and density are both zero for the ETP study area.

The species is listed as endangered on the ESA.

Sei whales are extremely rare in the ETP, generally occurring farther north; there were only 2 confirmed sightings compared to more than 200 confirmed Bryde’s whale sightings in the 8 years of data considered (Gerrodette and Forcada 2002). Please see comments below for Bryde’s whale and possible confusion in identification of the two species.

4.2.25 Common Minke Whale (*Balaenoptera acutorostrata*)

Description: Please refer to Section 4.1.21 for a full description of the minke whale.

Minke whales are also uncommon in the ETP (Oleson et al. 2003, Wade and Gerrodette 1993). There were six sightings of minke whales during surveys in 1986-1990 (Wade and Gerrodette 1993) and only two sightings since, in 2000 and 2006 (Kinzey et al. 1999, 2000, 2001, Jackson et al. 2004, 2006). Most sightings were in the northern part of the survey area west to southwest of Baja, Mexico (Hamilton et al. 2009). In 2003, minke whales were acoustically detected in that area, but not visually detected. From limited sighting data collected during SWFSC surveys conducted in 1998-2000, 2003 and 2006 population abundance (115) and density (0.000006/km^2) were estimated for the ETP study area.

The species is listed as endangered on the ESA. Due to the infrequency with which minke whales occur in the survey area, they will not be further discussed in this section.

4.2.26 Bryde's Whale (*Balaenoptera edeni*)

Description: Bryde’s whales are among the least well known of the larger baleen whales. They are medium sized balaenopterids that may attain lengths of 15.5 m, although most are smaller.

Females are larger than males (Kato and Perrin 2009). Bryde's whales closely resemble, and are often confused with, sei whales. The feature that most readily distinguishes them from other species, including sei whales, is the presence of three prominent ridges on the rostrum. The rostrum is V-shaped and the dorsal fin is strongly falcate. They are dark gray above and white below, although the dark areas extend to the throat grooves and flippers (Kato and Perrin 2009).

Status and trends: Bryde's whales belong to the Order Cetacea, Suborder Mysticeti, and Family Balaenopteridae. The International Whaling Commission (IWC) recognizes three stocks of Bryde's whales in the North Pacific—the eastern, western, and East China Sea stocks—plus the cross-equatorial Peruvian stock (Carretta et al. 2007 and citations therein). Wade and Gerrodette (1993) suggested that Bryde's whales in the ETP may comprise two stocks based on a gap in distribution between 7° N and 9° N. Gerrodette and Forcada (2002), however, considered Bryde's whales in the ETP a single stock when generating population estimates.

The most recent estimate of abundance for Bryde's whales in the ETP was 10,411 (6,531-14,747; 95% c.i.) in 2000 (Gerrodette and Forcada 2002). Sightings recorded as Brydes's/sei whale (*B. edeni/B. borealis*) during surveys were considered to be Bryde's whales and included in the analysis. Sightings were recorded as such when it was not possible to get a good enough view to confirm species identity. As mentioned above at 4.2.24, sei whales are extremely rare in the ETP, generally occurring farther north; there were only 2 confirmed sightings compared to more than 200 confirmed Bryde's whale sightings in the 8 years of data considered (Gerrodette and Forcada 2002). Density in the ETP was estimated to be 0.488 Bryde's whales/1,000 km^2 (Gerrodette et al. 2008).

The species is not listed under the ESA or designated as depleted under the MMPA.

Distribution and habitat preferences: Bryde's whales occur throughout tropical and warm temperate waters (16.3°C and warmer) between 40° N and 40° S worldwide and year-round. They do not undertake long migrations, but show a general movement toward the equator in winter and toward higher latitudes in summer (Kato and Perrin 2009). They are the most commonly sighted baleen whale in the ETP, with a distribution that appears relatively uniform throughout the study area (Barlow et al. 2009, Wade and Gerrodette 1993). An area of concentration exists around the equator east of 110° W (Carretta et al. 2007 and citations therein).

They primarily feed on pelagic schooling fishes, such as pilchard, anchovies, sardines, and herring. As opportunistic feeders, however, they also consume krill and copepods, as well as cephalopods and pelagic red crabs (Kato and Perrin 2009).

Behavior and life history: Female Bryde's whales in the North Pacific attain sexual maturity at approximately 11.6-11.8 m length and males reach sexual maturity at 11.0-11.4 m length. Gestation is approximately 11 months and calves wean at about 6 months of age and the calving interval is 2 years (Kato and Perrin 2009). Similar to other baleen whales, Bryde's whales are often alone or in small groups. The mean group size in the ETP was 1.7 (Wade and Gerrodette 1993).

Acoustics and hearing: Bryde's whales are categorized in the low frequency functional hearing group along with all other baleen whales. The estimated auditory bandwidth is 7 Hz to 22 kHz (Southall et al. 2007) (Table 4.1).

Bryde's whales produce low-frequency tonal and swept calls similar to other balaenopterids (Oleson et al. 2003). Six call types associated with Bryde's whales were recorded in the ETP. Frequencies ranged from 20 to 60 Hz. The calls were separated geographically, with three detected only north of 9° N and three only heard south of 5° N (Oleson et al. 2003).

4.2.27 South American Sea Lion
South American sea lions are one of the largest of the otariids. Adult males can be up to 3 m long and weigh 300-350 kg; the much smaller females reach about 2 m in length and 150 kg (Cappozzo and Perrin 2009). South American sea lions occur along both the Atlantic and Pacific coasts of South America. They range from Cape Horn to northern Peru on the Pacific side. There is no reliable information on the Pacific population, which is assumed to be smaller than that on the Atlantic side. Primary prey off Peru includes anchovy and lobster, but a diverse assemblage of demersal fishes is consumed in the absence of preferred prey. Males reach sexual maturity at 6 years of age and females begin pupping at 5 years. The breeding and pupping season is mid-December to early February (Cappozzo and Perrin 2009).

4.2.28 Other Pinnipeds
Four species of pinnipeds positively identified to species during marine mammal surveys of the ETP between 1998 and 2006 were the California sea lion (*Zalophus californianus*), South American sea lion (*Otaria flavescens*), Guadalupe fur seal (*Arctocephalus townsendi*), and the northern elephant seal (*Mirounga angustirostris*) (Kinzey et al. 1999, 2000, 2001, Jackson et al. 2004, 2006). With the exception of the South American sea lion, all of the other species were sighted at the northern end of the survey area along the coast of Baja California, Mexico. The South American sea lions were observed along the Peruvian coast, with the majority of sightings (31) during 2003; four were sighted in 1998 (Jackson et al. 2004, Kinzey et al. 1999).

For additional information please refer to Sections 4.1.23, 4.1.25, and 4.1.28 for descriptions of California sea lions, Guadalupe fur seals, and northern elephant seals.

4.3 Antarctic Ecosystem

Cetaceans

4.3.1 Spectacled Porpoise (*Phocoena dioptrica)*
Description: Spectacled porpoise are poorly known and few observations of live animals have been recorded; most of what is known is based on examination of stranded animals, mostly from Tierra del Fuego. The following account and information is based on two recent publications on the species, Goodall (2009a) and Sekiguchi et al. (2006). The porpoise is a robust animal with rounded head and no beak; the flippers are small and situated well forward on the body. Spectacled porpoises are known to be strongly sexually dimorphic. Adult males appear to be larger than females. The largest male studied measured 2.24 m and the largest female measured 2.04 m. The dorsal fin is broadly triangular and shows strong sexual dimorphism, being much larger and more rounded in males. In overcast conditions, body color appears mainly dark or

even black. At very close range, the white ventral coloration, including above and below the black lips, and the white ‘spectacles’ are evident. Under good lighting conditions, females and juveniles appeared lighter in color; grayer than adult males. When viewed from above, the tail stock appears lighter on the sides as well as the dorsal side of the fluke, joining with the white coloration of the ventral part and along the sides of the tail stock. A pale area or saddle is evident around the dorsal fin.

Status and trends: Spectacled porpoise belong to the Order Cetacea, Suborder Odontoceti, and Family Phocoenidae. While data are sparse on abundance and density and this species has not been observed during AMLR visual surveys, the IUCN Red List (iucnredlist.org) assessment of this species allows a calculation of estimated population density of 0.0015/km^2 for the larger Antarctic ecosystem.

The species is not listed under the ESA or designated as depleted under the MMPA.

Distribution and habitat preferences: They have a circumpolar distribution; however, longitudinally they are somewhat concentrated in the Pacific Ocean sector (60°W-130°E) of the Antarctic. Fifteen sighting records (53.6%) are from the region between New Zealand and the Ross Sea. The sea surface temperature recorded at the time of each sighting ranged between 0.9° C and 10.3° C; however, the most frequent ranked temperatures were between 1.0-1.9° C and 5.0-5.9° C, which were recorded in half of the sightings.

Behavior and life history: There is little or no information on spectacled porpoise natural history, food habits, or breeding season. Spectacled porpoises are very difficult to sight at sea, mainly because of their small body and group sizes and inconspicuous behavior. Almost all sightings of spectacled porpoises are recorded close to the vessels and under excellent survey condition. Group size averages 2.0 individuals; the most frequent group size is one followed by three.

Acoustics and hearing: There is no information on the acoustics of the spectacled porpoise although it is assumed that it has much the same characteristics as other species in the family. Harbor porpoise, which are also in the family Phocoenidae, are in the high-frequency functional hearing group, whose estimated auditory bandwidth is 200 Hz to 180 kHz (Southall et al. 2007). Their vocalizations range from 110 to 150 kHz (DON 2008a) (Table 4.1).

4.3.2 Hourglass Dolphin (*Lagenorhynchus cruciger*)
Description: As with spectacled porpoise above, little is known of the hourglass porpoise. A recent summary by Goodall (2009b) is used here as the principal source for information on this species. The dolphin is mainly black to dark gray with two elongated lateral white areas joined in some animals with a white line that resembles an hourglass. It is a rather stocky dolphin with large re-curved dorsal fin that is variable in shape from erect to hooked; the tail stock is often keeled. Total length for males is 1.63-1.87 m and for females 1.42-1.83 m. Males weigh about 100 kg and females 88 kg but sample size is very small and each can be longer and heavier.

Status and trends: Hourglass dolphins belong to the Order Cetacea, Suborder Odontoceti, and Family Delphinidae. Nothing is known of abundance and trends for this species. However, during the 2008/2009 AMLR surveys to estimate abundance and map krill and fish, marine mammal observers recorded a density of 0.00151 hourglass dolphins/km within the survey area (Santora et al. 2009).

The species is not listed under the ESA or designated as depleted under the MMPA.

Distribution and habitat preferences: This porpoise is pelagic and circumpolar in the Southern Ocean in both Antarctic and sub-Antarctic waters. Most specimens have been found between 45^o S and 60^o S. Hourglass dolphins are often seen near islands and banks, especially in turbulent waters. They are often seen in the Drake Passage.

Behavior and life history: Hourglass dolphins are commonly seen associated with fin whales and were once used as cues by whalers hunting whales. They bow-ride with ships. School size varies from 1 to 60 animals. Nothing is known of the movements or migratory habits. Prey from stranded animals includes myctophids, hake, small squid, crustaceans, and polychaetes.

Acoustics and hearing: There is no information on the acoustics of the hourglass dolphin, but it is likely that these dolphins exhibit similar acoustic characteristics as other dolphins in the same genus and family, such as the Pacific white-sided dolphin (*L. obliquidens*). As discussed above, vocalizations produced by Pacific white-sided dolphins include whistles and clicks. Whistles are in the frequency range of 2 to 20 Hz. Peak frequencies of the pulse trains for echolocation fall between 50 and 80 kHz; the peak amplitude is 170 dB re 1µPa-m. Underwater hearing sensitivity of the Pacific white-sided dolphin is from 75 Hz through 150 kHz. The greatest sensitivities were from 4 to 128 kHz. Below 8 Hz and above 100 kHz, this dolphin's hearing was similar to that of other toothed whales.

4.3.3 Killer Whale (*Orcinus orca*)
Please refer to Section 4.1.10 above for a full description of the killer whale. Recent reports show that three distinct forms of killer whales have been described from Antarctic waters; referred to as types A, B, and C, they are purported prey specialists on Antarctic minke whales (*Balaenoptera bonaerensis*), seals, and fish, respectively (Pitman and Ensor 2003). Information on the status, and population trends, and distribution in the AMLR survey area are scant but suggest that they are an abundant species. Line transect survey have yielded estimates of 25,000 killer whales in the Southern Ocean (Ford 2009). During the 2008/2009 AMLR surveys to estimate abundance and map krill and fish, marine mammal observers recorded a density of 0.00151 killer whales/km within the survey area (Santora et al. 2009).

Killer whales in the Antarctic area are not listed under the ESA or designated as depleted under the MMPA.

4.3.4 Sperm Whale (*Physeter macrocephalus*)
Please refer to Section 4.1.16 above for a full description of the sperm whale. Regarding the status and trends of sperm whales within the SWFSC AMLR survey area, there is no information on status and trends. It is known that female and young sperm whales are not often seen in higher latitudes; males can be found over almost any ice-free deep water area including waters within the SWFSC AMLR survey area (Whitehead 2009), though they have not been observed during these surveys. Based on data reported by Whitehead (2002) the density of this population is estimated to be 0.00065/km^2 for the larger Antarctic ecosystem.

The species is listed as endangered under the ESA and depleted under the MMPA.

4.3.5 Arnoux's Beaked Whale (*Berardius arnuxii*)
Description: Arnoux's beaked whales (as with Baird's beaked whale described at 4.1.12) are one of the largest members of the family Ziphiidae. The entire body is dark brown with the ventral side paler with irregular white patches; tooth marks of conspecifics are numerous on the back, particularly on adult males (Kasuya 2009). The body is slender with a small head, low falcate dorsal fin and small flippers that fit into depressions on the body. The melon is small and its front surface is almost vertical with a slender projecting rostrum (ibid). Mean body length is somewhat smaller than Baird's beaked whale with length of whales 8.5-9.6 m.

Status and trends: Arnoux's beaked whales belong to the Order Cetacea, Suborder Odontoceti, and Family Ziphiidae. Data on population abundance and density for the AMLR study area are limited, and this species has not been identified during past surveys. However, the IUCN Red List Assessment (iucnredlist.org) for this species allows calculation of an estimated density of 0.0006/km^2 using the available information from the larger Antarctic ecosystem.

The species is not listed under the ESA or designated as depleted under the MMPA.

Distribution and habitat preferences: Arnoux's beaked whales inhabit vast areas of the Southern Hemisphere outside the tropics reaching northward to the shores of the Southern Hemisphere continents (Kasuya 2009). Specific information on habitat preferences is not known but likely is similar to that for Baird's beaked whale, discussed at 4.1.12.

Behavior and life history: Most of what is known for the genus is based on information on Baird's beaked whale in the Northern Hemisphere. Please refer to section 4.1.12 for a summary of behavior, diet and dive behavior for the genus.

Acoustics and hearing: Please refer to section 4.1.12 for information on Baird's beaked whale.

4.3.6 Southern Bottlenose Whale (*Hyperoodon planifrons*)
Description: The southern bottlenose whale is a large, robust beaked whale distinguished by their large bulbous forehead and short dolphin-like beak (Gowans 2009). They may be 6-9 m long. They are chocolate brown to yellow in color, and lighter on the flanks and belly (ibid). Males possess a single pair of conical teeth at the tip of the lower jaw; they do not erupt in females (ibid).

Status and trends: Southern bottlenose whales belong to the Order Cetacea, Suborder Odontoceti, and Family Ziphiidae. There is no information on population status or trends in the Southern Hemisphere. However, during the 2008/2009 AMLR surveys to estimate abundance and map krill and fish, marine mammal observers recorded a density of 0.00061 southern bottlenose whales/km within the survey area (Santora et al. 2009).

The species is not listed under the ESA or designated as depleted under the MMPA.

Distribution and habitat preferences: Southern bottlenose whales are found throughout the Southern Hemisphere, from ice edges to 30^{o} S; there are no known areas of concentration (Gowans 2009).

Behavior and life history: Bottlenose whales are typically found in small groups of 1-4 individuals but groups up to 20 have been observed. There is no information on the life history of southern bottlenose whales. They are believed to be deep divers feeding primarily on squid, with fish and benthic invertebrates infrequently consumed (Gowans 2009). Northern bottlenose whales have been recorded to dive to 1,400 m (ibid).

Acoustics and hearing: There is no information on acoustics for this species. However, DON (2008b) reviewed the literature on beaked whale acoustics and reported that beaked whales use frequencies of between 300 Hz and 129 kHz for echolocation, and between 2 and 10 kHz, and possibly up to 16 kHz, for social communication. There is no information on the hearing abilities of southern bottlenose whales. They are likely in the mid-frequency functional hearing group, with an estimated auditory bandwidth of 150 Hz to 160 kHz (Southall et al. 2007). Vocalizations ranges are similar at 300 Hz to 135 kHz (DON 2008a) (Table 4.1).

4.3.7 Long-Finned Pilot Whale (*Globicephala melas edwardii*)
Description: Pilot whales appear black or dark gray; the body is robust with a thick tailstock. The melon is exaggerated and bulbous and there is either no beak or a barely discernable one (Olson 2009). They exhibit striking sexual dimorphism with adult males reaching an average length of 6 m and they are larger than females; the broad-based dorsal fin of a male is larger than that of a female (Olson 2009). They are very difficult to distinguish from the short-finned pilot whale discussed at 4.1.11 in that the flippers are marginally longer and they exhibit a noticeable 'elbow' (Olson 2009).

Status and trends: Long-finned pilot whales belong to the Order Cetacea, Suborder Odontoceti, and Family Delphinidae. The long-finned pilot whale population in the Antarctic has been estimated at 200,000 whales in the mid-1990s but no recent estimate exist (Olson 2009). There are no estimates of abundance or information on status and trends of the long-finned pilot whale in the Southern Hemisphere or in the SWFSC AMLR survey area. However, during the 2008/2009 AMLR surveys to estimate abundance and map krill and fish, marine mammal observers recorded a density of 0.00757 long-finned pilot whales/km within the survey area (Santora et al. 2009).

The species is not listed under the ESA or designated as depleted under the MMPA.

Distribution and habitat preferences: Long-finned pilot whales inhabit the cold temperate waters of the North Atlantic and Southern Ocean; those in the Southern Ocean are of the subspecies *G. melas edwardii*. They are circumpolar in the Southern Hemisphere and occur as far north as 14^{o} S in the Pacific and south to the Antarctic Convergence (Olson 2009).

Behavior and life history: Pilot whales are very social and may travel in groups of several to hundreds of animals, often with other cetaceans. They appear to live in relatively stable, female-based groups (DON 2008b). Sexual maturity occurs at 9 years for females and 17 years for males. The mean calving interval is 4 to 6 years. Pilot whales are deep divers; the maximum dive depth measured is about 971 m (Baird et al. 2002).

Acoustics and hearing: The calls of long-finned pilot whales are of a lower frequency and a narrower frequency range than those of the short-finned pilot whale. The mean frequency for long-finned pilot whales is 4,480 Hz versus 7,870 for short-finned pilot whales (Olson 2009). *Globicephala* spp. are in the mid-frequency functional hearing group, with an estimated auditory bandwidth of 150 Hz to 160 kHz (Southall et al. 2007) (Table 4.1).

4.3.8 Antarctic Minke Whale (*Balaenoptera bonaerensis*)

Description: Antarctic minke whales are similar in shape and coloration to the common and dwarf minke whales (see section 4.1.21 and 4.4.10) but they lack the characteristic white flipper chevron of the northern species (Perrin and Brownell 2009). Antarctic minke whales are estimated to average 9.0 m at maturity for females and to 8.5 m for males (Perrin and Brownell 2009). The baleen plates are black on the left beyond the first few plates and on the right they are white in the first third and black in the rear two-thirds of the row (ibid).

Status and trends: The Antarctic minke whale belongs to the Order Cetacea, Suborder Mysticeti, and Family Balaenopteridae. Abundance in the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) survey area during 2000, which included the Scotia Sea and Antarctica Peninsula, was estimated to be 18,125 (CV% =28.28) minke whales (Reilly et al. 2004). There are no current estimates of status or trends however the species is considered stable and in good shape. During the 2008/2009 AMLR surveys to estimate abundance and map krill and fish, marine mammal observers recorded a density of 0.00182 minke whales/km within the survey area (Santora et al. 2009).

The species is not listed under the ESA or designated as depleted under the MMPA.

Distribution and habitat preferences: Antarctic minke whales are abundant from 60^{o} S to the ice edge during the austral summer then retreat in the austral winter to breeding grounds in mid-latitudes 10^{o}-30^{o} S in the Pacific and other locations off Australia and South Africa (Perrin and Brownell 2009). In these regions they are distributed beyond the continental shelf break and oceanic.

Behavior and life history: Little is known of the natural history of Antarctic minke whales but they are assumed to have similar traits as the common minke whale. They are assumed to breed in winter in warm waters of low latitudes, give birth to a single calf every other year, and reach sexual maturity when 7-9 m long (Perrin and Brownell 2009). Antarctic minke feed mainly on euphausiids (ibid). There are no data on dive depth for minke whales. Antarctic minke whales are predated upon by Type A killer whales (Pitman and Ensor 2003).

Acoustics and hearing: Minke whales are in the low-frequency functional hearing group with an estimated auditory bandwidth of 7 Hz to 22 kHz (Southall et al. 2007). Vocalizations range from 60 Hz to 20 kHz (DON 2008a) (Table 4.1).

4.3.9 Southern Right Whale (*Eubalaena australis*)

Description: As summarized in Kenney (2009), right whales have an extremely robust body form with a thick blubber layer and the girth at times exceeding 60% of total body length. The head is relatively large, comprising about one quarter to one third of the body length and the upper jaw is arched. The body is mostly black, sometimes with irregular white ventral patches. There is no dorsal fin and the pectoral flippers are large, broad, and blunt; the flukes are very broad. Baleen plates are relatively narrow and 2-2.8 m long. The most conspicuous external characteristic of right whales are the callosities on the head which are irregular patches of keratinized tissue inhabited by dense populations of specialized amphipod crustaceans, known as cyamids or 'whale lice'. Adults are typically 13-16 m long.

Status and trends: The Southern right whale belongs to the Order Cetacea, Suborder Mysticeti, and Family Balaenidae, however the taxonomic name and position of the three right whale species and of bowhead whales is equivocal and under investigation. The total abundance of Southern right whales in 1997 was 7,571 whales with those in some areas increasing at 7-8% annually. Assuming continued increase during the period from 1997 to the present, the total abundance could currently exceed 15,000 animals (Kenney 2009). Abundance in the CCAMLR survey area during 2000, which included the Scotia Sea and Antarctica Peninsula, was estimated to be 1,755 (CV% =61.67) right whales (Reilly et al. 2004). This species has been sighted as recently as 2010 during AMLR visual surveys. Estimates of status and trends specific to the SWFSC AMLR survey area are not available.

The species is listed as endangered under the ESA and designated as depleted under the MMPA.

Distribution and habitat preferences: Southern right whales are found in the middle latitudes of the Southern Ocean between approximately 20^{o} and 60^{o} S. Multiple stocks have been hypothesized off Argentina/Brazil, South Africa, east Africa, western Australia, southeastern Australia, New Zealand, and Chile. They migrate annually between high-latitude feeding grounds and low-latitude calving and breeding grounds. Feeding grounds for this species appears to be offshore, pelagic regions in areas of high productivity (Kenney 2009). Calving often occurs in shallow coastal waters and bays.

Behavior and life history: Right whales have a three-year reproductive cycle; mating likely occurs in or near the calving grounds. DON (2008a) summarized the literature on northern right whale foraging behavior; likely southern right whale foraging behavior is similar. Dives of 5-15 min or longer have been reported, but can be much shorter when feeding. Foraging dives in the known feeding high-use areas are frequently near the bottom and the average depth of a dive was strongly correlated with both the average depth of peak copepod abundance and the average depth of the mixed layer. Right whale feeding dives are characterized by a rapid descent from the surface to a particular depth between 80 and 175 m, remarkable fidelity to that depth for 5 to 14 min, and then rapid ascent back to the surface. Longer surface intervals have been observed for reproductively active females and their calves. Killer whales and large sharks are likely predators of Southern right whales.

Acoustics and hearing: DON (2008a) summarized acoustics and hearing for northern right whales that may be analogous to that of the southern right whale. Sounds can be divided into three main categories: (1) blow sounds; (2) broadband impulsive sounds; and (3) tonal call types.

Blow sounds are those coinciding with an exhalation; broadband sounds include non-vocal slaps (when the whale strikes the surface of the water with parts of its body) and the "gunshot" sound; data suggests that the latter serves a communicative purpose. Tonal calls can be divided into simple, low-frequency, stereo-typed calls and more complex, frequency-modulated, higher-frequency calls. Most of these sounds range in frequency from 0.02 to 15 kHz (dominant frequency range from 0.02 to less than 2 kHz; durations typically range from 0.01 to multiple seconds) with some sounds having multiple harmonics. Source levels for some of these sounds have been measured as ranging from 137 to 192 dB root-mean-square (rms) re 1 µPa-m (decibels at the reference level of one micro Pascal at one meter). Morphometric analyses of North Atlantic right whale inner ears estimate a hearing range of approximately 0.01 to 22 kHz based on established marine mammal models. In addition, the estimated functional hearing range for right whales may be 15 Hz to 18 kHz. Right whales are, thus, in the low-frequency functional hearing group of Southall et al. (2007). Their vocalizations range from 20 Hz to 15 kHz (DON 2008b) (Table 4.1).

4.3.10 Fin Whale (*Balaenoptera physalus*)
Please refer to Section 4.1.19 for a full description of the fin whale. Abundance in the CCAMLR survey area during 2000, which included the Scotia Sea and Antarctica Peninsula, was estimated to be 4,672 (CV% = 42.37) fin whales (Reilly et al. 2004). Population status and trend information for this species within the SWFSC AMLR survey area are lacking. However, during the 2008/2009 AMLR surveys to estimate abundance and map krill and fish, marine mammal observers recorded a density of 0.08391 fin whales/km within the survey area (Santora et al. 2009).

The species is listed as endangered under the ESA and designated as depleted under the MMPA.

4.3.11 Blue Whale (*Balaenoptera musculus*)
Please refer to Section 4.1.18 for a full description of the blue whale. There is no information regarding the status and trends of blue whales within the SWFSC AMLR survey area. In the Southern Ocean, where the blue whale was historically most abundant, it is rare today with abundance estimates at 1,700 whales and that discrete feeding stocks exist (Sears and Perrin 2009). Branch et al. (2007) reported a range of densities for blue whales in the Antarctic ecosystem based on trackline sightings, the low end of which is 0.00012/km. There are no estimates of blue whale density within the AMLR survey area, and there have been no recent sightings of this species during AMLR surveys.

The species is listed as endangered under the ESA and designated as depleted under the MMPA.

4.3.12 Humpback Whale (*Megaptera novaeangliae*)
Please refer to Section 4.1.17 for a full description of the humpback whale. In the Southern Hemisphere, humpbacks feed in circumpolar waters around the Antarctic and migrate to relatively discrete breeding grounds in tropical waters to the north (Clapham 2009). Abundance in the CCAMLR survey area during 2000, which included the Scotia Sea and Antarctica Peninsula, was estimated to be 9,484 (CV% = 27.92) humpback whales (Reilly et al. 2004). There is no information on the status and population trends for humpback in the Antarctic. However, during the 2008/2009 AMLR surveys to estimate abundance and map krill and fish,

marine mammal observers recorded a density of 0.03605 humpback whales/km within the survey area (Santora et al. 2009).

The species is listed as endangered under the ESA and designated as depleted under the MMPA.

PINNIPEDS

4.3.13 Antarctic Fur Seal (*Arctocephalus gazella*)
Description: Antarctic fur seals are similar in size and appearance to Guadalupe fur seals described above. Adult females weigh about 45 kg and adult males 188 kg (Arnould 2009; Forcada and Stanland 2009). Fur seals in general can be distinguished from sea lions by the presence of a dense under fur and their smaller size. Pelage color is generally uniform dark brown to dark gray on the dorsal surface with a grizzled appearance caused by the tips of guard hairs being pale or white (ibid). Some individuals on South Georgia Island have a white (not albino) pelage.

Status and trends: Antarctic fur seals belong to the Order Carnivora, Suborder Pinnipedia, Family Otariidae, and Subfamily Otariinae. Presently the species numbers about 1,600,000 animals throughout its range and is increasing at about 9.8%/year (Arnould 2009). The species was thought to be extinct until a small colony was discovered in 1950 at Bird Island, near South Georgia Island in the South Atlantic Ocean (Arnould 2009). The species now breeds at colonies from South Georgia to Macquarie Island off New Zealand. The SWFSC maintains a research site at Cape Shirreff, Livingston Island, where it monitors Antarctic fur seal status and trends. Pup production there during the 2008/2009 field season totaled 1569 pups born, a decrease of 13.3% from the 2007/2008 field season (Goebel et al. 2009). Leopard seal predation is significant and may be an important top-down factor controlling recovery of fur seal populations as well as penguin populations, in the South Shetland Islands (ibid). During the 2008/2009 AMLR surveys to estimate abundance and map krill and fish, marine mammal observers recorded a density of 0.09996 fur seals/km within the survey area (Santora et al. 2009).

The species is not listed under the ESA or designated as depleted under the MMPA.

Distribution and habitat preferences: Large-scale hunting during the commercial sealing era severely depleted the populations of many southern fur seal species, including the Antarctic fur seal; pre-sealing distribution and population size is not known for many species especially those whose range overlap such as the Antarctic and Subantarctic fur seals (Arnould 2009; Forcada and Stanland 2009).

Behavior and life history: Most species in the genus reach sexual maturity at 3-5 years of age; males also mature at about the same age but are unable to attain reproductive status (obtain a reproductive territory) until 7-10 years of age. Timing of pupping is variable for the genus but for Antarctic fur seals it is November-January. Southern fur seals, including the Antarctic fur seal, feed on a variety of prey including fish, cephalopods and crustaceans, depending on prey abundance and location. Most southern fur seals forage in upwelling zones, oceanic fronts, or continental shelf-edge region; however female Antarctic fur seals on foraging trips originating at Cape Shirreff forage mostly over the shelf and rarely use the shelf edge (M. Goebel, SWFSC, personal communication, March 2011). Species in this genus forage mainly in the surface mixed layer (<50-60 m) at night (Arnould 2009). Antarctic fur seals at Cape Shirreff feed mainly on krill, cephalopods, and fish; females there have feeding trips that last about 2-4 days and dive to <100 m (Arnould 2009; M. Goebel, SWFSC, personal communication, March 2011).

Acoustics and hearing: Like other pinnipeds, these fur seals are assigned to functional hearing groups based on the medium (air or water) through which they are detecting the sounds, for an estimated auditory bandwidth of 75 Hz to 75 kHz (Southall et al. 2007). Vocalizations range from <4 to 120 kHz (DON 2008a) (Table 4.1).

4.3.14 Southern Elephant Seal (*Mirounga leonina*)

Description: Southern elephant seals are the largest of all pinnipeds. The species is sexually dimorphic with males weighing as much as 3,700 kg and females weighing about 800 kg (Hindell and Perrin 2009). Males have a large inflatable proboscis and a pronounced chest shield associated with fighting with other males on land to acquire females. Females lack the proboscis and chest shield (ibid). Both males and females are gray to brown in color.

Status and trends: Southern elephant seals belong to the Order Carnivora, Suborder Pinnipedia, Family Phocidae. Status and trend information for this species at specific sites within the SWFSC survey area is not available. Between the 1950s and 1990s the southern elephant seal underwent large decreases in population size throughout most of its breeding range in the Southern Ocean. While current population estimates suggest a recent recovery, some breeding populations have continued to decrease in recent years (Macquarie and Marion Islands), others have either remained stable (South Georgia, Kerguelen and Heard Island) or have increased (Peninsula Valdés, Argentina) (McMahon et al. 2005). The total population size in 2000 was 640,000 southern elephant seals (Hindell and Perrin 2009). During the 2008/2009 AMLR surveys to estimate abundance and map krill and fish, marine mammal observers recorded a density of 0.0003 elephant seals/km within the survey area (Santora et al. 2009).

The species is not listed under the ESA or designated as depleted under the MMPA.

Distribution and habitat preferences: Southern elephant seals breed on islands around the subantarctic with pups occasionally born on the Antarctic mainland (Hindell and Perrin 2009). The range extends north from Patagonia and the Falkland Islands; when ashore for the annual molt or for breeding they utilize most of the Southern Ocean north of the Antarctic Polar Front to the high Arctic pack ice (ibid). They spend as much as 80% of their annual cycle at sea, migrating long distances to favorable foraging locations (ibid).

Behavior and life history: Adult breeding males haulout onto deserted beaches in August; adult females arrive soon thereafter and a single pup is born about 2-5 days later. Elephant seals are highly polygynous with large dominant males presiding over large aggregations of females, known as harems consisting of up to 100 animals (Hindell and Perrin 2009). Males tend to feed in shallower water over the shelf while females forage in deep water. In the Antarctic, juvenile males remain in the pack ice to forage (Hindell and Perrin 2009). Elephant seals prey on deepwater and bottom dwelling organisms, including fish, squid, crab, and octopus. They are extraordinary divers with some dive depths exceeding 1,500 m and 120 minutes (Hindell and Perrin 2009).

Acoustics and hearing: Like other pinnipeds, elephant seals are assigned to functional hearing groups based on the medium (air or water) through which they are detecting the sounds, for an estimated auditory bandwidth of 75 Hz to 75 kHz (Southall et al. 2007). Vocalizations range from <4 to 120 kHz (DON 2008a) (Table 4.1).

4.3.15 Crabeater Seal (*Lobodon carcinophaga*)
Description: Crabeater seals weigh about 200 kg (males) to 215 kg (females) and are 2.05 to 2.40 m long (Bengtson 2009). They are medium brown to silver over most of the body with darker coloration and spotting on the flippers and flank and a high incidence of scarring, likely caused by leopard seals (ibid). They have finely divided lobed teeth (hence the scientific name lobodon) with multiple cusps that interlock to filter crustaceans.

Status and trends: Crabeater seals belong to the Order Carnivora, Suborder Pinnipedia, Family Phocidae. They may be the most abundant pinniped in the world, numbering in the millions around Antarctica (Bengtson 2009). There is presently no reliable eatimate of overall abundance but past estimates range from 2 million to 75 million, with 5-10 million a more likely estimate (Bengtson 2009). While they have not been recorded at sea during SWFSC AMLR surveys, the IUCN Red List Assessment (iucnredlist.org) indicates a population density estimate of 0.649/km^2 for the AMLR study area may be reasonable.

The species is not listed under the ESA or designated as depleted under the MMPA.

Distribution and habitat preferences: Crabeater seals have a circumpolar Antarctic distribution, spending the entire year in the pack ice zone; occasional they can be found along the southern fringes of South America, Australia, New Zealand, and Africa (Bengtson 2009). They migrate over large distances in association with the annual advance and retreat of pack ice (ibid).

Behavior and life history: Crabeater seals form 'family groups' of a female, her pup, and an attending male during the breeding season; peak pupping is mid to late October with some pups born into December. After weaning the male and female form a mated pair and remain together for 1-2 weeks (Bengtson 2009). As summarized in Burns et al. (2004), crabeater seals often dive to 92 m or greater with dive duration of 5 min (up to 23 min), haul out during the night rather than the day, and show seasonal shifts in foraging patterns consistent with foraging on vertically migrating prey. Some animals made long distance movements (furthest movements 664 km to northeast, 1,147 km to southwest), but most seals remained within 300 km of their tagging location. Within the Marguerite Bay/Crystal Sound region, seals appeared to favor foraging locations on the continental shelf within the 50 to 450 m depth range, with a tendency to avoid depths of 600 m or greater. Seals remained deep within the pack ice throughout the winter, and did not move into regions with less ice cover. Seals were more likely to be located in shallow water where the bathymetric gradients were greatest, and in areas of higher sea-ice concentration. Crabeater seal diet is almost exclusively Antarctic krill with an occasional fish and squid consumed (Bengtson 2009).

Acoustics and hearing: As above, crabeater seals are assigned to functional hearing groups based on the medium (air or water) through which they are detecting the sounds, for an estimated auditory bandwidth of 75 Hz to 75 kHz (Southall et al. 2007). Vocalizations range from <4 to 120 kHz (DON 2008a) (Table 4.1).

4.3.16 Weddell Seal (*Leptonychotes weddelli*)

Description: Weddell seals are rather large pinnipeds but do not exhibit sexual dimorphism; both sexes weigh 400-500 kg and are 2.5-3.3 m in length with females slightly larger; only the leopard seal and elephant seal are larger (Kooyman 1981a; Thomas and Terhune 2009). The fur covers the entire body except a small portion of the underside of the fore and hind flippers; they are black with grayish silver streaks; they do not have an under-fur (ibid). The canine and incisor teeth are robust and project forward, used perhaps as an ice ream, which allows the animal to maintain breathing holes and remain in the ice year-round (Kooyman 1981a).

Status and trends: Weddell seals belong to the Order Carnivora, Suborder Pinnipedia, Family Phocidae. There have been no systematic, large-scale population census studies but it is known that the Weddell seal is abundant with the estimated number of seals ranging from 500,000 to 1 million (Thomas and Terhune 2009). There are no estimates of abundance within the SWFSC AMLR survey areas nor have they been recorded at sea during SWFSC AMLR surveys so density estimates at sea within the SWFSC survey area are not available. However, the IUCN Red List Assessment (iucnredlist.org) indicates a population density estimate of 0.054/km^2 around Antarctic. Because this is the best information available, we have applied this density to the AMLR study area as well.

The species is not listed under the ESA or designated as depleted under the MMPA.

Distribution and habitat preferences: The Weddell seal has a circumpolar distribution around Antarctica, preferring land-fast ice habitats that have access to open water (Thomas and Terhune 2009). They haul out through cracks in the ice. Occasionally seals are seen at subantarctic islands and single animals have been seen on the Falkland Islands, Australia, New Zealand, and elsewhere (ibid).

Behavior and life history: Weddell seals breed and pup on the fast ice; males establish underwater territories and exhibit a variation of harem defense polygamy; mating takes place in the water (Kooyman 1981a; Thomas and Terhune 2009). Females give birth on the fast ice in late September to early November. There is no predictable migration. Weddell seals diet includes Antarctic cod and smaller fish. They forage in the upper water column but may dive to 600 m for up to 82 min, although shallow dives are more typical (Kooyman 1981a; Thomas and Terhune 2009). They may range out to 5 km from a breathing hole and return on a single dive (ibid). Type B or ‘pack ice’ ecotype killer whales are known to consume Weddell seals off the western Antarctic Peninsula (Pitman and Durban 2012).

Acoustics and hearing: Males patrol their territories using loud trills (up to 193 dB re 1 μPa) to advertise and defend their underwater territories (Thomas and Terhune 2009). As above, Weddell seals are assigned to functional hearing groups based on the medium (air or water) through which they are detecting the sounds, for an estimated auditory bandwidth of 75 Hz to 75 kHz (Southall et al. 2007). Vocalizations range from <4 to 120 kHz (DON 2008a) (Table 4.1).

4.3.17 Leopard Seal (*Hydruga leptonyx*)

Description: Leopard seals are large, sexually dimorphic mammals with females larger than males. Females can be up to 3.8 m in length and weigh 500 kg relative to males, which are generally 3.3 m long and weigh 300 kg (Rogers 2009). They are the second largest seal in Antarctica behind the elephant seal. Leopard seals have a dark gray back and light gray on its stomach. Its throat is whitish with the black spots that give the seal its common name. Compared to most phocids, the leopard seal is highly evolved for its role as a predator. Although it is a true seal and swims with its hind limbs, it has powerful and highly developed forelimbs similar to sea lions, giving it a similar maneuverability. The leopard seal has an unusually loose jaw that can open more than 160 degrees allowing it to bite larger prey (Kooyman 1981b).

Status and trends: Leopard seals belong to the Order Carnivora, Suborder Pinnipedia, Family Phocidae. There have been no systematic, large-scale population census studies but it is known that the leopard seal is abundant with the estimated population size ranging from 220,000 to 440,000 seals (Rogers 2009). Population densities are greatest in areas of abundant cake ice and least in areas with larger floes; densities range from 0.003-0.051 seals/square km (Rogers 2009). During the 2008/2009 AMLR surveys to estimate abundance and map krill and fish, marine mammal observers recorded a density of 0.0003 leopard seals/km within the survey area (Santora et al. 2009).

The species is not listed under the ESA or designated as depleted under the MMPA.

Distribution and habitat preferences: The leopard seal has a circumpolar distribution around Antarctica, preferring pack ice habitats although they are regular visitors to the subantarctic islands with juveniles typically more mobile (Rogers 2009). Because they do not rely on pack ice to breed they can escape food shortages in winter by dispersing northward (ibid).

Behavior and life history: Leopard seals breed on the outer fringes of the pack ice where females give birth during October to mid-November; mating occurs December to early January (Rogers 2009). Lactation lasts about 4 weeks (ibid). Leopard seals consume a variety of prey including fish, cephalopods, seabirds, and seals (Kooyman 1981b; ibid).

Acoustics and hearing: Acoustics play an important role in the mating system and they become highly vocal prior to and during breeding. As above, leopard seals are assigned to functional hearing groups based on the medium (air or water) through which they are detecting the sounds, for an estimated auditory bandwidth of 75 Hz to 75 kHz (Southall et al. 2007). Vocalizations range from <4 to 120 kHz (DON 2008a) (Table 4.1).

5. TYPE OF INCIDENTAL TAKE AUTHORIZATION REQUESTED AND THE METHOD OF INCIDENTAL TAKING

Regulations and Letters of Authorization (LOA) for the incidental taking of marine mammals is requested pursuant to Section 101 (a) (5) (A) of the MMPA.

The term "take", as defined in Section 3 (16 U.S. Code [U.S.C.] 1362) of the MMPA, means "to harass, hunt, capture, or kill, or attempt to harass, hunt, capture or kill any marine mammal." "Harassment" was further defined in the 1994 amendments to the MMPA, which provided two levels of "harassment", "Level A" (potential non-serious injury) and "Level B" (potential disturbance).

The SWFSC requests an LOA to authorize potential lethal and non-lethal incidental takes during its planned scientific operations. The requested numbers of authorized lethal and serious injury[1] takes and non-serious injury "Level A" and "Level B" harassment takes per year are discussed in Section 6. Although serious injury or mortality are rare during Center research activities, the SWFSC requests that the regulations and subsequent LOAs authorize a small number of incidental, non-intentional, injurious or lethal takes of marine mammals in the event that they might occur, and in spite of the monitoring and mitigation efforts described in Sections 11, 13, and 14.

As discussed in Section 1, SWFSC surveys involve the use of gear that has the potential to take marine mammals, including mid-water trawl-nets (CCE), pelagic longlines (CCE/ETP), and bottom trawl nets (AMLR). Bottom trawl nets deployed in AMLR are not expected to take marine mammals, in part, due to SWFSC having no historical interactions with these species in bottom trawl gear used in the Scotia Sea Antarctic ecosystem. Researchers conduct visual and acoustic surveys prior to deploying bottom trawl gear to assess the bathymetry and whether marine mammals are present in the area. These visual and acoustic surveys have resulted in very few detections of marine mammals during trawling operations, possibly because there is infrequent spatial-temporal overlap between bottom trawl surveys and significant densities of protected species. This may help to explain the absence of marine mammal interactions with this gear during past AMLR surveys.

The possible take during SWFSC surveys using modified Cobb mid-water trawl nets and the Northeast Trawl Systems (NETS) Nordic 264 two-warp rope trawl net may occur in two forms: (1) take by accidental entanglement that may cause mortality and serious injury, and (2) take by accidental entanglement that may cause non-serious injury ("Level A" harassment take). The surveys using these nets are conducted to assess coastal pelagic species (e.g. sardines), juvenile salmon, and juvenile rockfish in the CCE. Incidental take resulting in mortality and serious injury and "Level A" harassment may also occur by longline gear sampling highly migratory species, swordfish and sharks within the CCE and the ETP (longline surveys are being considered for use in the ETP over the next 5-6 years).

[1] NMFS interprets the regulatory definition of serious injury (i.e., "any injury that will likely result in mortality") as any injury that is "more likely than not" to result in mortality, or any injury that presents a greater than 50 percent chance of death to a marine mammal. Thus, the definition does not require that all such injured animals actually die, but rather requires only that the animal is more likely than not to die. Further, an injury must directly contribute to the death or likely death of the animal to be classified as a serious injury.

The “Level B” harassment may occur in the Antarctic when pinnipeds hauled out on ice are incidentally disturbed by close approaches of the survey vessel and as the result of acoustic gear used during survey operations in all three ecosystems surveyed by the SWFSC. Level B harassment by acoustic sources may be manifested as a temporary threshold shift (Southall et al. 2007) within the zone of audibility where the received levels of sound exposure are high enough that a marine mammal can hear it, or in the zone of responsiveness where the received level is such that the animal responds by causing behavioral modifications (Holt 2008). No hearing loss or physiological damage (permanent threshold shift, Southall et al. 2007) is expected to occur to marine mammals by the acoustic gear or vessel movements during SWFSC surveys in the CCE, the ETP, or the AMLR regions.

6. POTENTIAL TAKE OF MARINE MAMMALS

6.1 Estimated Number of Potential Marine Mammal Takes by Mortality, Serious Injury, or ‘Level A’ Harassment and Derivation of the Number of Potential Takes

6.1.1 Introduction

As stated in the response to Question 5 above, potential take during SWFSC surveys using Modified Cobb mid-water trawl nets and the NETS Nordic 264 two-warp rope trawl net may occur in two forms: (1) take by accidental entanglement that may cause mortality and serious injury, and (2) take by accidental entanglement that may cause non-serious injury (“Level A” harassment take). The surveys using these nets are conducted to assess coastal pelagic species (e.g., sardine), juvenile salmon, and juvenile rockfish in the CCE. Incidental take resulting in mortality and serious injury and “Level A” harassment may also occur by longline gear sampling highly migratory species and sharks within the CCE and ETP. Although not anticipated, incidental take is also possible during bottom trawls used to sample benthic invertebrates and fish during the Antarctic survey. The justification for potential take of marine mammal species and the estimated mortalities and injuries is discussed below.

Use of historical interactions as a basis for take estimates

It was anticipated that all species that interacted with SWFSC survey gear historically could potentially be taken in the future. For the duration of the regulations, we estimated the numbers of marine mammals that may be caught during SWFSC surveys based on historic interaction data for a species. Historical interactions with marine mammals during SWFSC surveys (Table 6.1) were input into NOAA’s Protected Species Incidental Take (PSIT) database, a real-time internal monitoring tool for reporting interactions with marine mammals. The discussion below describes how SWFSC estimated potential encounters with survey gear based on historical interactions during 2008-2012 in mid-water trawl nets and in longline gear. These estimates are based on the assumption that annual effort (e.g., total annual trawl tow time) over the requested 5-year authorization period will not exceed the annual effort during the period 2008-2012.

For purposes of estimating potential serious injury/mortality takes and Level A harassment takes, the SWFSC calculated the average number of reported interactions for each marine mammal species in both trawl and longline gear deployed during 2008-2012. The SWFSC take estimates (for serious injury/mortality and Level A harassment) for historically captured species for this request was determined by rounding the annual average of take for a particular species by gear interaction up to the nearest whole number (to reflect a value that was representative of an entire animal) and multiplying by 5 to account for the 5-year authorization period (Table 6.2). For example, if a species interacted with SWFSC mid-water trawl gear 1.2 times per year, on average, this number was rounded up to 2 and then multiplied by 5 to determine a take request of 10. Based on past experience, the SWFSC expects there to be some variability in the actual number of annual gear interactions. By using an average based approach, it is expected to capture the variability that may occur on an annual basis over the period of this authorization. Furthermore, mitigation measures have been developed and implemented subsequent to some of the years upon which the take estimates are based, further reducing the likelihood that these estimates would be exceeded.

Because there is a very fine line between the two take categories (serious injury/mortality and Level A harassment) and insufficient data exist to understand the circumstances that lead to one event or the other, the SWFSC believes it would be unjustified to estimate potential takes in each category based only on historic interactions in that category; a Level A harassment take could easily have been a serious injury or mortality under a slightly different set of circumstances and vice versa. For example, during 2008 fifteen California sea lions interacted with SWFSC trawl gear; however, two of those animals were released alive (Table 6.1). It is believed that these two animals were released alive uninjured; however, insufficient information was collected during 2008-2012 to determine the nature and extent of injuries resulting from these interactions. Therefore, rather than use 13 serious injury/mortality events as a basis for estimating take, SWFSC used 15 in Table 6.2 because were similar interactions to recur, they could result in different numbers of serious injury/mortality and non-serious injury. Therefore as a worst-case scenario, these estimates are considered in this document as potential incidences of serious injury/mortality. However, the estimates realistically represent potential interactions, which would likely result in an unknown number of both non-serious injury and serious injury/mortality. Therefore, these take estimates are conservative in that they are likely higher than the actual number of animals that could potentially be killed or seriously injured during SWFSC fisheries research activities.

Historical interaction: summary of potential mid-water trawl survey efforts

Marine mammals have the potential to be caught in modified Cobb mid-water and NETS Nordic 264 trawl nets. These nets are used in the juvenile rockfish, juvenile salmon and sardine surveys at fixed stations from southern California to Washington annually from April-July and in August-September. The tows are conducted near the surface down to approximately 15-30 m deep, mainly at night using a charter vessel or a NOAA vessel (Table 1.1). In addition, these nets are used in juvenile salmon surveys between southern California and Oregon during daytime trawls that last at the target depth for approximately 30 min. In total, these surveys deploy about 250 tows per year. During the past 5 years about 1,250 tows using these trawl nets captured 58 marine mammals, of which 50 were killed and eight were released alive (Table 6.1). It should be noted that most of the mortalities occurred during 2008 and have not been repeated before or since that year (including 2012). Furthermore, several mitigation measures intended to further minimize potentially adverse interactions with protected species during SWFSC research surveys were initiated after 2008. The SWFSC predicts that about the same number of tows will be deployed using these nets over the duration of the authorization period.

The species that have been historically caught in these trawl nets include California sea lions, northern fur seals, northern right whale dolphins, and Pacific white-sided dolphins. Given the timing and geographic scope of its trawl surveys, the SWFSC believes it could take any age class of marine mammal for which it estimates potential take. California sea lions pup and breed at California Channel Islands during May-June (section 4.1.23) so adult females caught in close proximity to these islands during this period could be pregnant or nursing a pup. Males could be of breeding age and participate in the breeding population. Similarly northern fur seals pup and breed during June-August at San Miguel Island and animals caught near this location may be part of the breeding population (section 4.1.26); Pribilof Islands fur seals (which are designated as ‘depleted’ under the MMPA) would likely be at or near the breeding islands in Alaska during SWFSC surveys and less susceptible to incidental capture. Pacific white-sided dolphins calve during May-September (section 4.1.3) so animals caught during this period may be part of the California-Oregon-Washington stock and actively engaged in breeding activities. Northern right whale dolphin calving seasonality is unknown, but small calves are seen in winter and early spring (section 4.1.9). In addition to these species, which SWFSC has historically captured, other species SWFSC requests to take in the course of this research have similar distributions, life histories and/or vulnerabilities to these gears, so it follows that multiple age classes of these species could be susceptible to take.

Historical interaction: summary of potential longline survey efforts

Five California sea lions were caught and released in the SWFSC longline surveys for thresher sharks and highly migratory species (HMS) during 2008-2012 (Table 6.1). These surveys occur in the Southern California Bight (thresher shark) and from southern to central California (HMS). The thresher shark surveys are conducted in September each year from a charter vessel and the HMS surveys are conducted June-July from a NOAA vessel or a charter vessel. Each uses pelagic longline consisting of 2-4 mile mainline with 10-15 foot gangions (i.e., a unit consisting of a leader, a monofilament line, and a baited hook attached to the line) 50-100 feet apart using 200-400 9/0 J-type or 16/0 circle-type hooks with a soak time of 2-4 hours; however, when targeting swordfish a number of modifications to the longline gear are made (Table 1.1). The SWFSC currently does not conduct longline surveys in the ETP, but the SWFSC take estimates reflect the possibility that these surveys may occur over the next five-year period.

Over the past 5 years the SWFSC deployed on average over 200-400 hooks/set on longline gear which was under water for over 2-4 hours for each longline set. There are typically about 40 (thresher shark survey) to 60 (HMS survey) sets per year (~100 total) resulting in 400-1,600 hook hours (hooks x hours) per set, or 40,000-160,000 hook hours /year. The SWFSC expects to deploy about the same number of sets for the duration of the authorization, but as noted above it may deploy additional sets in the ETP. If longline surveys are conducted in the ETP, the SWFSC anticipates that it will deploy an equal number (or less) of longline sets in the ETP relative to the number of sets currently being deployed in the CCE. This deployment may result in the incidental capture (and release) of California sea lions and other species which are believed to have similar vulnerabilities to longlines and/or which are taken in commercial longline gear. In general, marine mammal interactions in SWFSC longline surveys have been isolated events never exceeding one animal per set. As with marine mammal interactions in trawl gear, SWFSC believes potential take in longline gear could include animals of multiple age classes.

Approach for estimating take of species captured historically

To date, interactions of trawl and longline gear with marine mammals have only occurred in the CCE. The SWFSC does not trawl in the ETP and currently does not conduct longline surveys in the region, but may over the next five-year period. Historically, there have been no marine mammal interactions with SWFSC bottom trawls in the Antarctic Ecosystem. The SWFSC interaction rates in the CCE have exhibited some inter-annual variation in numbers, possibly due to changing marine mammal densities and distributions and dynamic oceanographic conditions. Excluding the isolated event where northern right whale dolphins were captured by trawl gear in the CCE in 2008, the same species tend to interact with certain gear types during SWFSC surveys (Tables 6.1 and 6.2). Occurrences when more than 10 marine mammals per year may be caught during survey operations are possible, as in 2008, but are rare. Thus, the SWFSC estimates take based on the average number of historical marine mammal species interactions during 2008-2012 to account for the fluctuations in inter-annual variability observed during that time period.

During 2008-2012, the SWFSC interacted with marine mammals on longline and mid-water trawl surveys in the CCE, including: Pacific white-sided dolphins (trawl), northern right whale dolphins (trawl), California sea lions (trawl and longline) and northern fur seals (trawl). Sixty three marine mammals interacted with SWFSC research gears during 2008-2012, of which, 13 were released alive and 50 were killed. As described above, an average based approach (Level A and serious injury/mortality combined) for each species in each gear was used as a basis for estimating potential take (Table 6.2). The 5-year serious injury/mortality and Level A harassment take request for the CCE is as follows (Table 6.3): 35 Pacific white-sided dolphins, 20 California sea lions, 10 northern right whale dolphins, and 5 northern fur seals (all stocks combined) in trawls along with 5 California sea lions on longlines. Assuming a similar rate of interaction with longline gear is possible for California sea lions in the ETP due to a lack of information to indicate otherwise, the SWFSC requests 5 takes of California sea lions on longlines in the ETP. The SWFSC requests no take for Northern fur seals on longlines in the CCE due to lack of previous interactions with SWFSC longline gear and little evidence to suggest this species interacts with commercial longline fisheries gear based on recent stock assessment reports and the 2012 List of Fisheries (NMFS 2012; http://www.nmfs.noaa.gov/pr/interactions/lof/).

Although the SWFSC take estimates for species captured historically are based on an average take during 2008-2012, it should be emphasized that there is still an inherent level of uncertainty in estimating potential take both in terms of numbers and species of marine mammals that may actually be taken. Further, the SWFSC continues to invest significant resources in better understanding the factors that contribute to interactions and developing mitigation measures and evaluating its operations to minimize these occurrences in the future.

Approach for estimating take of 'other' species (i.e., those not historically taken by the SWFSC)

In addition to those species SWFSC has interacted with in longlines and trawl nets over the last 5 years, the SWFSC believes it is possible that other species with similar vulnerabilities to these gears – due to similar behaviors, distributions, etc. – may be taken in the future. While such take could potentially occur, the SWFSC believes that any occurrences in the CCE would likely be rare given that no such take has occurred over the past five years (2008-2012). Given the infrequent and low number of historical marine mammal interactions with longline gear in the CCE, the SWFSC predicts a similar pattern of interactions of marine mammals may occur if regular longline surveys for highly migratory species are conducted in the ETP with the same amount of effort as are currently being conducted in the CCE.

The approach outlined below reflects: (1) concern that some species with which we have not had historical interactions may interact with these gears, (2) acknowledgment of variation between sets, and (3) understanding that many marine mammals are not solitary, so in many cases if a set results in take, the take is likely to be greater than one animal particularly with trawl gear. The approach takes into account the possibility that additional species could interact with SWFSC surveys, while also reflecting that, absent significant range shifts or changes in habitat usage, such events would likely remain rare occurrences at most. As for the ETP, the approach addresses the uncertainty of potential takes on longline gear in an ecosystem where surveys have not historically been conducted by the SWFSC, making it more difficult to estimate potential take. Recognizing these uncertainties, additional mitigation measures may be implemented if take far exceeds the maximum number estimated per year, such that it appears that the total estimated take over the 5 year authorization period may be exceeded.

In the CCE, several species were deemed to have a similar vulnerability to trawl gear as some historically taken species. A number of factors were taken into account to determine whether another species may have a similar vulnerability (e.g., density, abundance, behavior, feeding ecology, travel in groups, commonly associated with other species historically taken, prior interactions with similar gear in the 2012 List of Fisheries (NMFS 2012) or reported interactions with other NMFS Science Center surveys etc.) to certain types of gear as historically taken species. In these particular instances, the SWFSC estimates the annual take of these 'other' species to be equal to the maximum interactions per any given set of a similar species that was historically taken during 2008-2012 (Table 6.4). Several species were deemed to have a similar vulnerability to trawl gear as the Pacific white-sided dolphin. For this species, the maximum take in any set during 2008-2012 was 11 individuals (Table 6.4). Therefore, the SWFSC requests 11 potential takes over the authorization period for each of the following species in trawls in the CCE: Risso's dolphin, striped dolphin, short-beaked common dolphin, long-beaked common dolphin, and bottlenose dolphin (Table 6.3). In addition, several pinniped species are similar in vulnerability to trawl gear as California sea lions, which have interacted as many as 9 times in a single set during the past five years (Table 6.2). For the effective period of the regulations, the SWFSC requests 9 takes in mid-water trawl gear for the following species in the CCE: Steller sea lion and harbor seal (Table 6.3).

For the remaining species that were deemed likely to be taken in trawls in the CCE, the SWFSC estimates 5 potential takes during the 5-year authorization period: Northern elephant seal, harbor porpoise, and Dall's porpoise (Table 6.3). An estimate of 5 potential takes for these last three species takes into account the higher likelihood that more than one individual may be taken in a trawl at any given time, high pinniped densities in survey locations, and documented takes of porpoises in trawls by commercial fisheries and other NMFS Science Centers. The SWFSC does not anticipate take of Guadalupe fur seals in trawls due to their lower abundance and limited distribution in the CCE. Furthermore, the SWFSC is not requesting the take of large whales and several other cetaceans by trawl gear due to lack of historical interactions and the low probability of take in a trawl due to several factors (e.g., density, abundance, behavior, etc.).

Steller sea lions and South American sea lions may be vulnerable to longline gear in the CCE and ETP, respectively. Steller sea lions have previously been taken in commercial longline fisheries. As California sea lions have never interacted more than one time in a single set during the previous five years in SWFSC longline gear in the CCE (Table 6.4), it was assumed that no more than one Steller sea lion would likely be caught at a time on longline gear. Therefore, the SWFSC requests 1 potential Steller sea lion take in longline gear in the CCE. However, given that there is no history to inform the estimate of potential interactions of South American sea lions with SWFSC longline gear in the ETP, the SWFSC requests a higher number of potential takes of South American sea lions assuming that the rate of interaction could equal that observed by California sea lions in the CCE. Therefore, the SWFSC requests 5 potential takes of South American sea lions in the ETP. Adaptive management would be employed as necessary should it turn out that catch rates are higher in the ETP than have been recorded in CCE. For example, the SWFSC may implement additional mitigation measures if the number of actual takes in the ETP is higher than expected.

While the SWFSC has not historically interacted with large whales or other cetaceans in its longline gear, it is well documented that some of these species are taken in commercial longline fisheries. The 2012 List of Fisheries (NMFS 2012) classifies commercial fisheries based on prior interactions with marine mammals. Although the SWFSC used this information to help make an informed decision on the probability of specific cetacean and large whale interactions with longline gear, many other factors were also taken into account (e.g., relative survey effort, survey location, similarity in gear type, animal behavior, prior history of SWFSC interactions with longline gear etc.). Therefore there are several species that have been shown to interact with commercial longline fisheries but for which SWFSC is not requesting take. For example, the SWFSC is not requesting take of large whales in longline gear. Although large whale species could become entangled in longline gear, the probability of interaction with SWFSC longline gear is extremely low considering a lower level of survey effort relative to that of commercial fisheries. Although data on commercial fishing effort are not publically available, based on the amount of fish caught by commercial fisheries versus SWFSC fisheries research, the “footprint” of research effort compared to commercial fisheries is very small.

There were several species of cetaceans that were identified to have a higher probability of interaction with SWFSC longline gear based on the factors outlined previously. Since these interactions would probably be rare occurrences and groups of marine mammals are less likely to be taken on longlines (relative to trawls), the SWFSC requests only one potential take per ecosystem for each cetacean species (all stocks included) outlined below. The SWFSC requests the potential take of the following cetaceans during the 5-year authorization period in longline gears in both the ETP and CCE: Risso’s dolphin, bottlenose dolphin, striped dolphin, short-beaked common dolphin, long-beaked common dolphin, and short-finned pilot whale. Additionally, the SWFSC also estimates one potential take of either a pygmy or dwarf sperm whale in the CCE plus the following species in the ETP: Pantropical spotted dolphin, false killer whale, and dwarf sperm whale. As discussed previously, there is no history to inform the interaction of these species with longline gear in the ETP. Therefore, adaptive management and additional mitigation measures may be implemented if catch rates are higher than expected in the ETP.

Undetermined species

There are situations when a caught animal cannot be identified to species with certainty. One such case might occur if a female California sea lion was caught in longline gear and quickly released. Those animals are very difficult to differentiate at sea in poor lighting from other otariids or large phocids making exact identification difficult. Similarly some cetacean species are difficult to identify to species under poor field conditions. Thus, under those situations, the SWFSC requests a small number of potential takes of undetermined pinniped and delphinid species per year based on gear type. In all, the SWFSC requests one potential undetermined pinniped take and one undetermined delphinid take in trawl gear in the CCE as well as one potential undetermined pinniped take in longline gear in both the CCE and the ETP ecosystems (Table 6.3).

Surveys for which SWFSC Anticipates no Level A, Serious Injury or Mortality Takes

AMLR Surveys

The SWFSC has no historical interactions with marine mammals in bottom trawl gear used in the Scotia Sea Antarctic ecosystem. AERD researchers conduct visual and acoustic surveys prior to deploying bottom trawl gear to assess the bathymetry and whether marine mammals are present in the area. These visual and acoustic surveys have resulted in very few detections of marine mammals during trawling operations, possibly because there is infrequent spatial-temporal overlap between bottom trawl surveys and significant densities of protected species. This may help to explain the absence of marine mammal interactions with this gear during past AMLR surveys. Given this history and little future planned survey effort, no take of marine mammals resulting from gear interaction is anticipated while conducting fisheries research in the Antarctic ecosystem. As a result, SWFSC is requesting no injury, serious injury or mortality takes for these research activities.

Deep-Set Buoy Gear Surveys

Based on the proposed gear and methods to be utilized, SWFSC does not anticipate deep-set buoy surveys to results in any marine mammal takes. This determination is based on the following factors:

- The history of this gear not resulting in marine mammal takes, as well as in similar gear used in the Atlantic, both of which have been designed specifically to eliminate protected species interactions. In the Pacific, no takes have occurred during the previous 54 sets (approximately 2,200 hook hours). In the Atlantic no protected species interactions have occurred in the Swordfish Buoy Fishery using similar gear configuration and higher effort levels than surveys conducted in the Pacific.
- The minimal visual and/or sensory attractants to the gear in the upper water column (e.g., no surface chumming or offal discharge, no visual cues from multiple hooks that are sinking to depth slowly) SWFSC believes minimizes hooking and entanglement risk.
- This gear features a single weighted monofilament line with virtually no slack or sag that is expected to minimize entanglement risk.

Sablefish Life History Surveys

SWFSC does not anticipate that sablefish life history surveys will result in any marine mammal takes. A primary factor in this determination is this survey’s extremely small scale and low level of effort (approximately 200 hooks per month), which further reduces likelihood of taking marine mammals (an already rare event). In addition, because this gear fishes at the bottom it poses a significantly reduced risk of hooking and entanglement relative to surface gears. To date, this gear has resulted in no marine mammal takes.

Mitigation and minimization of takes

Following marine mammal interaction events in 2008, the SWFSC initiated a series of discussions and workshops to better understand the factors contributing to gear interactions and to implement mitigation measures to reduce potential gear interactions. These discussions were summarized by Hewitt (2009). Because of the suite of mitigation measures SWFSC has implemented since 2008, it expects the total number of marine mammals taken in these gears to decrease in the future and be substantially less than the estimated level of take when summed across all species. Current mitigation protocols are described elsewhere, so they are just mentioned briefly here: use of a marine mammal excluder device in the Nordic 264 trawl, use of acoustic pingers on mid-water trawls, limits on trawl tow times, and visual watches and a "move-on" rule to minimize opportunities for gear to be deployed with marine mammals and other protected species closer than 1nm. The SWFSC is currently reviewing historical fisheries research data to determine whether sufficient information exists to examine any links between various variables (e.g., pinger presence, trawl speed, etc.) and observed marine mammal bycatch (see Section 11 of this application for more details).

Additionally, a marine mammal excluder device is being tested by the SWFSC to eliminate marine mammal captures in the Modified Cobb mid-water trawl net. The SWFSC continues to look for additional ways to minimize marine mammal takes during the course of its fisheries research, such as conducting retrospective analyses to pinpoint the most significant contributors to take in each gear and to develop new sampling methods that eliminate the possibility of marine mammal mortalities (e.g., video and acoustic sampling). The results of these studies are expected to influence future sampling protocols and gear development.

6.1.2 Conclusion

The SWFSC has used its historical interactions with marine mammals in fisheries research surveys as a basis for estimating potential takes of these species and of other species it hasn't interacted with, but which it believes shares similar vulnerabilities to longline and mid-water trawl gears. Because of the low level of survey effort, the survey's small geographic footprint, historical interactions, and predicted takes (lethal, serious injury, and non-serious injury combined) relative to population size, and the fact that take will likely be minimized through the implementation of the Center's proposed mitigation measures, the SWFSC believes that its activities will have a negligible impact on marine mammals in the California Current Ecosystem, Eastern Tropical Pacific, and Antarctic Ecosystem. The basis for this statement is discussed in greater detail in Section 7 of this application.

Further, the SWFSC notes that despite its best efforts to estimate realistic potential marine mammal takes it believes actual takes will be substantially lower than its take estimates. Nevertheless, the SWFSC considers the take estimates presented here as the best approximation of future events because they are based on the best information available. There is substantial inherent uncertainty in estimating numbers and species that could be potentially taken, and the SWFSC's take estimates reflect this uncertainty. Our understanding of the potential effects of SWFSC activities on marine mammals is continually evolving. Reflecting this, the Center proposes to include an adaptive management component within the application (see Section 13 of this application). This allows the Center, in concert with NMFS' Office of Protected Resources, to consider, on a case-by-case basis, new data to determine whether mitigation should be modified.

Table 6.1. Historical number of interactions with marine mammals during SWFSC surveys from 2008 to 2012.

Survey Name	Protected Species Taken	Gear	# Killed	# Released Alive[1]	Total # of Animals
2012					
Sardine	Pacific White-Sided Dolphin	NETS Nordic 264	2	0	2
Sardine	Pacific White-Sided Dolphin	NETS Nordic 264	1	0	1
Sardine	Pacific White-Sided Dolphin	NETS Nordic 264	0	1	1
Highly Migratory Species	California Sea Lion	Longline	0	1	1
2011					
Sardine	Pacific White-Sided Dolphin	NETS Nordic 264	1	0	1
Juvenile Salmon	California Sea Lion	NETS Nordic 264	1	0	1
Juvenile Salmon	Pacific White-Sided Dolphin	NETS Nordic 264	6	0	6
2010					
Sardine	Pacific White-Sided Dolphin	NETS Nordic 264	0	1	1
Sardine	Pacific White-Sided Dolphin	NETS Nordic 264	1	0	1
Highly Migratory Species	California Sea Lion	Longline	0	1	1
Juvenile Rockfish	Pacific White-Sided Dolphin	Cobb mid-water trawl	1	0	1
2009					
Juvenile Rockfish	California Sea Lion	Cobb mid-water trawl	0	1	1
Sardine	Pacific White-Sided Dolphin	NETS Nordic 264	0	3	3
Thresher Shark	California Sea Lion	Longline	0	1	1
2008					
Sardine	California Sea Lion	NETS Nordic 264	1	0	1
Sardine	California Sea Lion	NETS Nordic 264	1	0	1
Sardine	Pacific White-Sided Dolphin	NETS Nordic 264	2	0	2
Sardine	Pacific White-Sided Dolphin	NETS Nordic 264	1	0	1
Highly Migratory Species	California Sea Lion	Longline	0	1	1
Highly Migratory Species	California Sea Lion	Longline	0	1	1
Juvenile Rockfish	California Sea Lion	Cobb mid-water trawl	1	2	3
Sardine	Northern Fur Seal (San Miguel	NETS Nordic 264	1	0	1
Sardine	California Sea Lion	NETS Nordic 264	9	0	9
Sardine	Northern Fur Seal (San Miguel	NETS Nordic 264	1	0	1
Sardine	California Sea Lion	NETS Nordic 264	1	0	1
Sardine	Pacific White-Sided Dolphin	NETS Nordic 264	1	0	1
Sardine	Northern Right Whale Dolphin	NETS Nordic 264	6	0	6
Sardine	Pacific White-Sided Dolphin	NETS Nordic 264	11	0	11
Sardine	Northern Fur Seal (Eastern Pacific)	NETS Nordic 264	1	0	1
Total			**50**	**13**	**63**

[1] During 2008-2012 insufficient information was collected to determine the nature and extent of injuries resulting from these interactions. As outlined in Section 11 of this application, SWFSC will implement a data collection protocol that will facilitate serious injury determinations for any future interactions.

Table 6.2. The estimated number of potential interactions of historically taken marine mammal species by gear type that may be taken on SWFSC surveys during the authorization period. Each interaction represents the incidental take of one animal.

	Historical Interactions							**Estimated Number of Interactions Over 5 years**
	2008	**2009**	**2010**	**2011**	**2012**	**Average**	**Round-Up**	
Trawl								
Pacific White-Sided Dolphin	15	3	3	7	4	6.4	7	**35**
California Sea Lion	15	1	0	1	0	3.4	4	**20**
Northern Right Whale Dolphin	6	0	0	0	0	1.2	2	**10**
Northern Fur Seal	3	0	0	0	0	0.6	1	**5**
Longline								
California Sea Lion	2	1	1	0	1	1	1	**5**

Table 6.3. The potential number of animals of each marine mammal species (unless otherwise noted, all stocks have been combined) that could be taken by mortality and serious injury (M&SI) and Level A harassment in each ecosystem over the next 5 years. The take estimates are based on the following gear types: trawl and longline. It should be noted that longline gear is not presently being used in the ETP but may be used in the next 5 years.

	Historical Interactions (2008-2012)	Potential Take (2013-2018) M&SI and Level A	
		Trawl	Longline
California Current Ecosystem			
Harbor Porpoise		5	
Dall's Porpoise		5	
Pacific White-sided Dolphin	Trawl	35	
Risso's Dolphin		11	1
Bottlenose Dolphin (All stocks)			1
Bottlenose Dolphin (Coastal)		3	
Bottlenose Dolphin (OR, WA Offshore)		8	
Striped Dolphin		11	1
Short-Beaked Common Dolphin		11	1
Long-Beaked Common Dolphin		11	1
Northern Right Whale dolphin	Trawl	10	
Short-Finned Pilot Whale			1
Pygmy and Dwarf Sperm Whale			1
California Sea Lion	Trawl, Longline	20	5
Steller Sea Lion		9	1
Northern Fur Seal	Trawl	5	
Harbor Seal		9	
Northern Elephant Seal		5	
Undetermined Pinniped Species		1	1
Undetermined Delphinid Species		1	
Eastern Tropical Pacific			
Risso's Dolphin			1
Short-Beaked Common Dolphin			1
Long-Beaked Common Dolphin			1
Striped Dolphin			1
Pantropical Spotted Dolphin			1
Bottlenose Dolphin			1
False Killer Whale			1
Short-Finned Pilot Whale			1
Dwarf Sperm Whale			1
California Sea Lion			5
South American Sea Lion			5
Undetermined Pinniped Species			1

Table 6.4. The maximum number of interactions (mortality, serious injury, and Level A harassment) for marine mammal species in any given set of trawl and longline gear deployed during 2008-2012. Each interaction represents the incidental take of one animal.

	Maximum interactions per any given set*	
Species with past interactions (2008-2012)	**Trawl**	**Longline**
Pacific White-sided Dolphin	11	0
Northern Right Whale dolphin	6	0
California Sea Lion	9	1
Northern Fur Seal (San Miguel Islands Stock)	1	0
Northern Fur Seal (Eastern Pacific Stock)	1	0

*The maximum interactions per any given *set* was used in the approach for estimating take of (‘other’) species *with no historic interactions*.

6.2 Estimated Level B Harassment of Marine Mammals due to Acoustic Sources and Derivation of the Estimate

Estimating sound exposures leading to behavioral and physical effects of intermittent high frequency sounds from active acoustic devices used in fisheries research is challenging for a variety of reasons. Among these are the wide variety of operating characteristics of these devices, variability in sound propagation conditions throughout the typically large areas in which they are operated, uneven (and often poorly understood) distribution of marine species, differential (and often poorly understood) hearing capabilities in marine species, and the uncertainty in the potential for effects from different acoustic systems on different species. The SWFSC took a dual approach in assessing the impacts of high-frequency active acoustic sources used in fisheries research in three different geographical areas where it operates these devices (California Current, Eastern Tropical Pacific, and the Antarctic).

The first approach was a qualitative assessment of potential impacts across species and sound types. This analysis considers a number of relevant biological and practical aspects of how marine species likely receive and may be impacted by these kinds of sources. This assessment (described in greater detail in section 7.2) considered the best available current scientific information on the impacts of noise exposure on marine life and the potential for the types of acoustic sources used in SWFSC surveys to have behavioral and physiological effects. The results indicate that a subset of the sound sources used are likely to be entirely inaudible to all marine species, that some of the lower frequency and higher power systems will be detectable over moderate ranges for some species (although this depends strongly on inter-specific differences in hearing capabilities). As discussed in more detail (see section 7.2), current scientific information supports the conclusion that direct physiological harm is quite unlikely but behavioral avoidance may occur to varying degrees in different species. Consequently, any potential direct injury (as defined by NMFS relative to the U.S. Marine Mammal Protection Act as Level A harassment and currently estimated as 180 and 190 dB RMS received levels respectively for cetaceans and pinnipeds) from these fisheries acoustic sound sources was deemed highly unlikely and were not directly calculated.

Building on this assessment to attempt to quantify behavioral impacts, an analytical framework was derived and applied to estimate potential Level B harassment by acoustic sources (as defined relative to the MMPA). This analysis used characteristics of active acoustic systems, their expected patterns of use in each of the three SWFSC operational areas, and characteristics of the marine mammal species that may interact with them to estimate Level B harassment of marine mammals. This approach is relatively straightforward and (although certain adaptations enable a more realistic spatial depiction of exposed animals in the water column) relies on average density values of marine species. While the SWFSC believes this quantitative assessment benefits from its simplicity and consistency with the current NMFS guidelines regarding estimates of Level B harassment by acoustic sources, based on a number of deliberately precautionary assumptions, the resulting take estimates should be seen as a very likely substantial overestimate of behavioral harassment from the operation of these systems. Additional details on the approach used and the assumptions made that result in a conservative estimate (i.e., higher numbers of exposures at received levels identified as Level B harassment) are described below.

6.2.1 Framework for quantitative estimation of potential Level B harassment by acoustic sources

The discussion in section 7.2 considers the differential frequency bands of hearing in marine animals in deriving a qualitative assessment of the probable risk of particular acoustic impacts from general categories of active acoustic sources, and is likely a more appropriate means of assessing their overall impact from a limited set of deployments given the level of scientific uncertainty in a variety of areas. However, in order to meet the compliance requirements for assessing the potential environmental impact of SWFSC operations, in this case acoustic impacts, a quantitative estimate of individual Level B harassment was required.

Different sound exposure criteria are typically used for impulsive and continuous sources (Southall et al., 2007). Under the current NMFS guidelines for calculating Level B harassment, an animal is taken if it is exposed to continuous sounds at a received level of 120 dB RMS or impulsive sounds at a received level of 160 dB RMS. These are simple step-function thresholds that do not consider the repetition or sustained presence of a sound source nor does it account for the known differential hearing capabilities between species. Sound produced by the fisheries acoustic sources here are very short in duration (typically on the order of milliseconds), intermittent, have high rise times, and are operated from moving platforms. They are consequently considered impulsive sources, which would be subject to the 160 dB RMS criterion. A mathematical method for estimating Level B harassment according to this step-function was derived and applied in each of the SWFSC ecosystem areas of operation - the California Current, Eastern Tropical Pacific, and Scotia Sea/Antarctic - to calculate Level B harassment by acoustic sources.

The assessment paradigm for active acoustic sources used in SWFSC fisheries research is relatively straightforward and has a number of key simplifying assumptions, most of which are deliberately precautionary given the known areas of uncertainty. These underlying assumptions (described in greater detail below) very likely lead to an overestimate of the number of animals that may be exposed at the 160 dB RMS level in any one year on average for each area. Conceptually, Level B harassment may occur when a marine mammal interacts with an acoustic signal. Estimating the number of exposures at the specified received level requires several determinations, each of which is described sequentially below:

1) A detailed characterization of the acoustic characteristics of the effective sound source or sources in operation;
2) The operational areas exposed to levels at or above those associated with Level B harassment when these sources are in operation;
3) A method for quantifying the resulting sound fields around these sources; and
4) An estimate of the average density for marine mammal species in each ecosystem area of operation.

Quantifying the spatial and temporal dimension of the sound exposure footprint (or "swath width") of the active acoustic devices in operation on moving vessels and their relationship to the average density of marine mammals enables a quantitative estimate of the number of individuals for which sound levels exceed NMFS' Level B harassment threshold for each area. The number of Level B harassment events is ultimately estimated as the product of the volume of water insonified at 160 dB RMS or higher and the volumetric density of animals determined from simple assumptions about their vertical stratification in the water column. Specifically, reasonable assumptions based on what is known about diving behavior across different marine mammal species were made to segregate those that predominately remain in the upper 200m versus those that regularly dive deeper during foraging and transit. Methods for estimating each of these calculations are described in greater detail in the following sections, along with the simplifying assumptions made, and followed by the take estimates for each region.

6.2.2 SWFSC Sound source characteristics

An initial characterization of the general source parameters for the primary SWFSC vessels operating active acoustic sources was conducted (Appendix A). This process enabled a full assessment of all sound sources, including those within the category 1 sources (identified in section 7.2) that are entirely outside the range of marine mammal hearing (not shown here). This auditing of the active sources also enabled a determination of the predominant sources that, when operated, would have sound footprints exceeding those from any other simultaneously used sources. These sources were effectively those used directly in acoustic propagation modeling to estimate the zones within which the 160 dB RMS received level would occur.

The full range of sound sources used in fisheries acoustic surveys were considered (Appendix A). Many of these sources can be operated in different modes and with different output parameters. In modeling their potential impact areas for these vessels when used and also when they are operated from non-NOAA vessels used for SWFSC survey operations, those features among those given below that would lead to the most precautionary estimate of maximum received level ranges (i.e. largest ensonified area) were used (e.g., lowest operating frequency). The effective beam patterns took into account the normal modes in which these sources are typically operated. While these signals are very brief and intermittent, a very conservative assumption was taken in ignoring the temporal pattern of transmitted pulses in calculating Level B harassment events. This assumption would not be appropriate in the context of assessing potential auditory effects. These operating characteristics of each of the predominant sound sources were used in the calculation of effective line km (section 6.2.3) and area of exposure (section 6.2.4) for each source in each survey.

Sources operating at frequencies above the functional hearing range of any marine mammal (typically above 180 kHz; see section 7.2) were excluded from quantitative analysis. Among those operating within the audible band of marine mammal hearing, five predominant sources were identified as having the largest potential impact zones during operations, based on their relatively lower output frequency, higher output power, and their operational pattern of use. In determining the effective line km for each of these predominant sources (Table 6.5) the operational patterns of use relative to one another were further applied to determine which source was the predominant one operating at any point in time for each survey. When multiple sound sources were used simultaneously, the one with the largest potential impact zone in each relevant depth strata was used in calculating takes. For example, when species (e.g., sperm whales) regularly dive deeper than 200m, the largest potential impact zone was calculated for both depth strata and in some cases resulted in a different source being predominant in either depth strata. This enabled a more comprehensive way of accounting for maximum exposures for animals diving in a complex sound field resulting from simultaneuous sources with different spatial profiles. This overall process effectively resulted in three sound sources (SX90, EK60, and

ME70) comprising the total effective line km, their relative proportions depending on the nature of each survey in each region (see Tables 6.6a to 6.8b).

Table 6.5. Output characteristics for five predominant SWFSC acoustic sources.

Acoustic system	Operating frequencies (kHz)	Source level (dB re 1 µPa at 1 m)	Nominal beam width (deg)	Effective exposure area: Sea surface to 200 m depth (km^2)	Effective exposure area: Sea surface to depth at which sound is 160 dB SPL (km^2)
Simrad EK500 and EK60 Narrow Beam Scientific Echo Sounders	18, 38, 70, 120, 200	224	7	0.013072	0.135404
Simrad ME70 Multi-Beam Echo Sounder	70-120	205	130	0.018184	0.018184
Teledyne RD Instruments Acoustic Doppler Current Profiler (ADCP), Ocean Surveyor	75	223.6	30	0.0086	0.0187
Simrad MS70 Multi-Beam Sonar	75-112	206	60	0.007952[*]	0.007952
Simrad SX90 Narrow Beam Sonar	20-30	219	7	0.065275[*]	0.1634

6.2.3 Calculating effective line km for each survey

As described below, based on the operating parameters for each source type, an estimated volume of water insonified to above a 160 dB RMS received level was determined. In all cases where multiple sources are operated simultaneously, the one with the largest estimated acoustic footprint (and thus leading to higher estimated Level B harassment) was used as the effective source. This was calculated for each depth strata (0-200m and below 200m), which in some cases resulted in different sources being predominant in each depth strata for all line km when multiple sources were in operation; this was accounted for in estimating overall exposures for species that utilize both depth strata (deep divers). For each ecosystem area, the total number of line km that would be surveyed was determined, as was the relative percentage of surveyed linear km associated with each source type. The total line km for each vessel in each region, the effective percentages associated with each of the resulting three predominant source types (SX90, EK60, and ME70), and the effective total line km of operation for each source type in each region is given below.

[*] *NOTES:* MS70-Effective exposure areas from 0-200m depth were not separately calculated because it operates in a side-looking mode. The estimated area ensonified to the maximum range of the 160 dB received level was used for this source in determining the effective exposure area for both depth strata. SX90- Exposure area varies greatly depending on the tilt angle setting of this system. To approximate the varied usage this system might receive, the exposure area for each depth strata was averaged by assuming equal usage at tilt angles of 5, 20, 45, and 80 degrees.

Table 6.6a. Annual linear survey km for each vessel type and its predominant sources within the two depth strata for the California Current ecosystem.

Vessel	Line kms/ Vessel	Source	Overall % Source Usage	% Time Source Dominant (0-200m)	Line km/ Dominant Source (0-200m)	% Time Source Dominant (>200m)	Line km/ Dominant Source (>200m)
Lasker	67760	SX90	50%	50%	33880	50%	33880
		EK60	100%	50%	33880	50%	33880
Shimada	39456	ME70	50%	50%	19728	0%	0
		EK60	100%	50%	19728	100%	39456
Other	26304	EK60	100%	100%	26304	100%	26304

Table 6.6b. Effective total annual survey km for which each source type is the predominant acoustic source in each of the two depth strata for take calculations for the California Current ecosystem.

Source	Summed line kms/source (0-200m)	Summed line kms/source (>200m)	Summed Dominant Source % of total line km (0-200m)	Summed Dominant Source % of total line km (>200m)
SX90	33880	33880	25%	25%
EK60	79912	99640	60%	75%
ME70	19728	0	15%	0%

Table 6.7a. Annual linear survey km for each vessel type and its predominant sources within the two depth strata for the Eastern Tropical Pacific ecosystem.

Vessel	Line kms/ Vessel	Source	Overall % Source Usage	% Time Source Dominant (0-200m)	Line km/ Dominant Source (0-200m)	% Time Source Dominant (>200m)	Line km/ Dominant Source (>200m)
Lasker	37710	SX90	25%	25%	9428	25%	9428
		EK60	100%	75%	28283	75%	28283
Shimada	37710	ME70	25%	25%	9428	0%	0
		EK60	100%	75%	28283	100%	37710
Other	18985	EK60	100%	100%	18985	100%	18985

Table 6.7b. Effective total annual survey km for which each source type is the predominant acoustic source in each of the two depth strata for take calculations for the Eastern Tropical Pacific ecosystem.

Source	Summed line kms/source (0-200m)	Summed line kms/source (>200m)	Summed Dominant Source % of total line km (0-200m)	Summed Dominant Source % of total line km (>200m)
SX90	9428	9428	10%	10%
EK60	75550	84978	80%	90%
ME70	9428	0	10%	0%

Table 6.8a. Annual linear survey km for each vessel type and its predominant sources within the two depth strata for the Scotia Sea/Antarctic ecosystem.

Vessel	Line kms/ Vessel	Source	Overall % Source Usage	% Time Source Dominant (0-200m)	Line km/ Dominant Source (0-200m)	% Time Source Dominant (>200m)	Line km/ Dominant Source (>200m)
Other	20846	EK60	100%	100%	20846	100%	20846

Table 6.8b. Effective total annual survey km for which each source type is the predominant acoustic source in each of the two depth strata for take calculations for the Scotia Sea/Antarctic ecosystem.

Source	Summed line kms/source (0-200m)	Summed line kms/source (>200m)	Summed Dominant Source % of total line km (0-200m)	Summed Dominant Source % of total line km (>200m)
EK60	20846	20846	100%	100%

6.2.4 Calculating volume of water insonified to 160 dB RMS received level

The cross-sectional area of water insonified to 160+ dB RMS received level was calculated using a simple model of sound propagation loss, which accounts for the loss of sound energy over increasing range. We used a spherical spreading model (where propagation loss = 20 * log (range) - such that there would be 60 dB of attenuation over 1000 m), a reasonable approximation over the relatively short ranges involved, and accounted for the frequency dependent absorption coefficient and beampattern of the highly directional nature of most of these sound sources. The lowest frequency was used for systems that are operated over a range of frequencies. The vertical extent of this area is calculated for two depth strata (surface to 200 m and surface to range at which the on-axis received level reaches 160 dB RMS). This was applied differentially based on the typical vertical stratification of marine mammals (see Tables 6.9-6.11). A simple visualization of a 2-dimensional slice of modeled sound propagation is shown below to illustrate the predicted area ensonified to the 160 dB level by an EK-60 operated at 18 kHz.

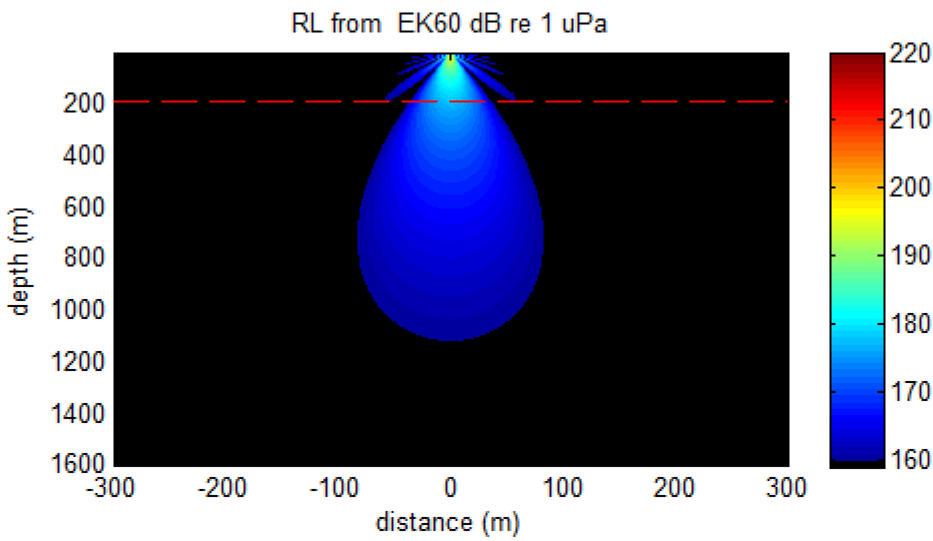

Figure 6.1. Visualization of a 2-dimensional slice of modeled sound propagation to illustrate the predicted area ensonified to the 160 dB level by an EK-60 operated at 18 kHz. The dashed red line marks the transition between the two depth strata (0-200m and >200m).

Following the determination of effective sound exposure area for transmissions considered in two dimensions, the next step was to determine the effective volume of water insonified >160 dB RMS for the entirety of each survey in each region. For each of the three predominant sound sources, the volume of water insonified is estimated as the athwartship cross-sectional area (in km^2) of sound above 160 dB RMS (as shown in the figure above) multiplied by the total distance traveled by the ship. Where different sources operating simultaneously would be predominant in each different depth strata (e.g. ME70 and EK60 operating simultaneously may be predominant in the shallow and deeper bins respectively), the resulting cross sectional area calculated took this into account. Specifically, for shallow-diving species this cross-sectional area was determined for whichever was predominant in the shallow strata whereas for deeper diving species this area was calculated from the combined effects of the predominant source in the shallow strata and the (sometimes different) source predominating in the deeper strata) This creates an effective total volume characterizing the area insonified when each predominant source is operated and accounts for the fact that deeper diving species may encounter a complex sound field in different portion of the water column.

6.2.5 Species-specific marine mammal densities

One of the primary limitations to traditional estimates of behavioral harassment takes from acoustic exposure is the assumption that animals are uniformly distributed in time and space across very large geographical areas, such as those being considered here. There is ample evidence that this is in fact not the case and marine species are highly heterogeneous in terms of their spatial distribution, largely as a result of species-typical utilization of heterogeneous ecosystem features. Some more sophisticated modeling efforts have attempted to include species typical behavioral patterns and diving parameters in movement models that more adequately assess the spatial and temporal aspects of distribution and thus exposure to sound. While simulated movement models were not used to mimic individual diving or aggregation parameters in the determination of animal density in this estimation, the vertical stratification of marine mammals based on known or reasonably assumed diving behavior was integrated into the density estimates used.

First, typical two-dimensional marine mammal density estimates (animals/km^2) were obtained from various sources for each ecosystem area. These included marine mammal Stock Assessment Reports for the California Current (Table 3.1), from abundance estimates using ship-based surveys of marine mammals in the ETP (Gerrodette et al. 2008; Table 3.2), and from ship-based surveys in the Antarctic (Table 3.3). There are a number of caveats associated with these estimates:

(1) They are often calculated using visual sighting data collected during one season rather than throughout the year. The time of year when data were collected and from which densities were estimated may not always overlap with the timing of SWFSC fisheries surveys (see section 1.6 or Table 1.1 for survey dates). ETP and California Current marine mammal densities are calculated from sightings collected during August – November. Antarctic densities were calculated from sightings collected during January – March.

(2) The densities used for purposes of estimating acoustic harassment takes do not take into account the patchy distributions of marine mammals in an ecosystem, at least on the moderate to fine scales over which they are known to occur. Instead, animals are considered evenly distributed throughout the assessed area and seasonal movement patterns are not taken into account.

In addition and to account for at least some coarse differences in marine mammal diving behavior and the effect this has on their likely exposure to these kinds of sometimes highly directional sound sources, a volumetric density of marine mammals of each species was determined. This value is estimated as the abundance averaged over the two-dimensional geographic area of the surveys and the vertical range of typical habitat for the population. Habitat ranges were categorized in two generalized depth strata (0-200 m, and 0 to >200 m) based on gross differences between known generally surface-associated and typically deep-diving marine mammals (Reynolds and Rommel, 1999; Perrin et al., 2008). Animals in the shallow diving strata were reasonably estimated, based on empirical measurements of diving with monitoring tags and reasonable assumptions of behavior based on other indicators to spend a large majority of their lives (>75%) at depths of 200 m or shallower. Their volumetric density and thus exposure to sound is thus limited by this depth boundary. In contrast, species in the deeper diving strata were reasonably estimated to regularly dive deeper than 200 m and spend significant time at these greater depths. Their volumetric density and thus potential exposure to sounds up to the 160 dB RMS level is extended from the surface to the depth at which this received level condition occurs.

The volumetric densities are estimates of the three-dimensional distribution of animals in their typical depth strata. For shallow diving species the volumetric density is the area density divided by 0.2 km (i.e., 200 m). For deeper diving species, the volumetric density is the area density divided by a nominal value of 0.5 km (i.e., 500 m). The two-dimensional and resulting three-dimensional (volumetric) densities for each species in each ecosystem area are shown in the tables below.

Table 6.9. Volumetric densities for each species in the California Current ecosystem.

	Typical Depth Strata		Area Density (#/km^2)	Volumetric Density (#/km^3)
	0-200 m	0-200m & >200 m		
CC Cetaceans				
Harbor porpoise	X		0.03775	0.18873
Dall's porpoise	X		0.07553	0.37765
Pacific white-sided dolphin	X		0.02093	0.10465
Risso's dolphin	X		0.01046	0.05230
Bottlenose dolphin	X		0.00178	0.00890
Striped dolphin	X		0.01667	0.08335
Short-beaked common dolphin	X		0.30935	1.54675
Long-beaked common dolphin	X		0.01924	0.09620
Northern right-whale dolphin	X		0.00975	0.04875
Killer whale	X		0.00071	0.00355
Short-finned pilot whale		X	0.00031	0.00062
Baird's beaked whale		X	0.00088	0.00176
Mesoplodont beaked whales		X	0.00103	0.00206
Cuvier's beaked whale		X	0.00382	0.00764
Pygmy sperm whale		X	0.00109	0.00218
Dwarf sperm whale		X	0.00109	0.00218
Sperm whale		X	0.00170	0.00340
Humpback whale	X		0.00083	0.00415
Blue whale	X		0.00136	0.00680
Fin whale	X		0.00184	0.00920
Sei whale	X		0.00009	0.00045
Common Minke whale	X		0.00072	0.00360
Gray whale	X		0.01913	0.09565
CC Pinnipeds				
California sea lion	X		0.23800	1.19000
Steller sea lion, eastern subspecies	X		0.05833	0.29165
Guadalupe fur seal	X		0.00741	0.03705
Northern fur seal	X		0.33655	1.68275
Harbor seal	X		0.05040	0.25200
Northern elephant seal		X	0.12400	0.24800

Table 6.10. Volumetric densities for each species in the Eastern Tropical Pacific ecosystem.

	Typical Depth Strata		Area Density (#/km^2)	Volumetric Density (#/km^3)
	0-200 m	**0-200m & >200 m**		
ETP Cetaceans				
Risso's Dolphin	X		0.00517	0.02587
Short beaked common dolphin	X		0.14655	0.73277
Long beaked common dolphin	X		0.01945	0.09726
Rough toothed dolphin	X		0.00504	0.02521
Striped dolphin	X		0.04516	0.22582
Spinner dolphin	X		0.04978	0.24889
Pantropical spotted dolphin	X		0.12263	0.61313
Dusky dolphin	X		0.00210	0.01050
Fraser's dolphin	X		0.01355	0.06774
Melon headed whale	X		0.00213	0.01063
Bottlenosed dolphin	X		0.01573	0.07864
Killer whale	X		0.00040	0.00199
False killer whale	X		0.00186	0.00932
Pygmy killer whale	X		0.00183	0.00913
Short finned pilot whale		X	0.02760	0.05520
Cuvier's beaked whale		X	0.00094	0.00187
Longman's beaked whale		X	0.00004	0.00007
Mesoplodont beaked whale		X	0.00119	0.00237
Sperm whale		X	0.00019	0.00039
Dwarf sperm whale		X	0.00053	0.00105
Humpback whale	X		0.00013	0.00067
Blue whale	X		0.00019	0.00097
Fin whale	X		0.00003	0.00015
Sei whale	X		0.00000	0.00000
Minke whale	X		0.00001	0.00003
Bryde's whale	X		0.00049	0.00244

Table 6.11. Volumetric densities for each species in the Scotia Sea/Antarctic ecosystem.

	Typical Depth Strata		Area Density ($\#/km^2$)[1]	Volumetric Density ($\#/km^3$)
	0-200 m	0-200m & >200 m		
Antarctic Cetaceans				
Spectacled porpoise	X		0.00150	0.00750
Hourglass porpoise	X		0.00150	0.00750
Killer whale	X		0.00150	0.00750
Sperm whale		X	0.00065	0.00130
Arnoux's beaked whale		X	0.00060	0.00120
Southern bottlenose whale		X	0.00060	0.00120
Long-finned pilot whale		X	0.00760	0.01520
Antarctic minke whale	X		0.00180	0.00900
Southern right whale	X		0.00041	0.00203
Fin whale	X		0.08390	0.41950
Blue whale	X		0.00012	0.00062
Humpback whale	X		0.03610	0.18050
Antarctic Pinnipeds				
Antarctic fur seal	X		0.09990	0.49950
Southern elephant seal		X	0.00030	0.00060
Crabeater seal	X		0.64865	3.24324
Weddell seal	X		0.05405	0.27027
Leopard seal	X		0.01622	0.08108

6.2.6 Using areas insonified and volumetric density to calculate Level B harassment by acoustic sources

Level B harassment by acoustic sources, according to current NMFS guidelines, could be calculated for each area by using (1) the combined results from output characteristics of each source and identification of the predominant sources in terms of acoustic output (6.2.2); (2) their relative annual usage patterns for each operational area (6.2.3); (3) a source-specific determination made of the area of water associated with received sounds at either the extent of a depth boundary or the 160 dB RMS received sound level (6.2.4); and (4) determination of a biologically-relevant volumetric density of marine mammal species in each area (6.2.5). Estimates of Level B harassment by acoustic sources are the product of the volume of water insonified at 160 dB RMS or higher for the predominant sound source for each portion of the total line km for which it is used and the volumetric density of animals for each species. These annual estimates are given in the tables below for each ecosystem area.

[1] Densities for the hourglass dolphin, killer whale, southern bottlenose whale, long finned pilot whale, humpback whale, Antarctic fur seal, southern elephant seal and leopard seal were estimated using data from visual surveys conducated at sea during AMLR 2008/2009 season. These density estimates were made using strip transect methods rather than the line transect methods used in many marine mammal visual surveys.

Table 6.12a. Estimated annual Level B harassment by acoustic sources by sound type for each marine mammal species in the California Current ecosystem. For each species and sound source, the cross sectional area for the relevant depth strata (Table 6.5) was multiplied by the effective line km for each respective depth strata for the relevant survey area (from tables 6.6b, 6.7b, or 6.8b) and the volumetric density (shown here) to estimate Level B harassment.

	Volumetric density (#/km^3)	Estimated Level B Harassment (#s of animals) in 0-200m depth stratum			Estimated Level B Harassment in >200m depth stratum		Total Take
		EK60	ME70	SX90	EK60	SX90	
CC Cetaceans							
Harbor porpoise	0.18873	197	68	417	0	0	**682**
Dall’s porpoise	0.37765	394	135	835	0	0	**1365**
Pacific white-sided dolphin	0.10465	109	38	231	0	0	**378**
Risso’s dolphin	0.05230	55	19	116	0	0	**189**
Bottlenose dolphin	0.00890	9	3	20	0	0	**32**
Striped dolphin	0.08335	87	30	184	0	0	**301**
Short-beaked common dolphin	1.54675	1616	555	3421	0	0	**5591**
Long-beaked common dolphin	0.09620	100	35	213	0	0	**348**
Northern right-whale dolphin	0.04875	51	17	108	0	0	**176**
Killer whale	0.00355	4	1	8	0	0	**13**
Short-finned pilot whale	0.00062	1	0	1	8	2	**12**
Baird’s beaked whale	0.00176	2	1	4	21	6	**34**
Mesoplodont beaked whales	0.00206	2	1	5	25	7	**39**
Cuvier’s beaked whale	0.00764	8	3	17	93	25	**146**
Pygmy sperm whale	0.00218	2	1	5	27	7	**42**
Dwarf sperm whale	0.00218	2	1	5	27	7	**42**
Sperm whale	0.00340	4	1	8	41	11	**65**
Humpback whale	0.00415	4	1	9	0	0	**15**
Blue whale	0.00680	7	2	15	0	0	**25**
Fin whale	0.00920	10	3	20	0	0	**33**
Sei whale	0.00045	0	0	1	0	0	**2**
Common Minke whale	0.00360	4	1	8	0	0	**13**
Gray whale	0.09565	100	34	212	0	0	**346**
CC Pinnipeds							
California sea lion	1.19000	1243	427	2632	0	0	**4302**
Steller sea lion, eastern subsp.	0.29165	305	105	645	0	0	**1054**
Guadalupe fur seal	0.03705	39	13	82	0	0	**134**
Northern fur seal	1.68275	1758	604	3721	0	0	**6083**
Harbor seal	0.25200	263	90	557	0	0	**911**
Northern elephant seal	0.24800	259	89	548	3023	824	**4744**

Table 6.12b. Estimated annual Level B harassment by acoustic sources by sound type for each marine mammal species in the Eastern Tropical Pacific ecosystem. For each species and sound source, the cross sectional area for the relevant depth strata (Table 6.5) was multiplied by the effective line km for each respective strata (from tables 6.6b, 6.7b, or 6.8b) and the volumetric density (shown here) to estimate Level B harassment.

	Volumetric density (#/km^3)	Estimated Level B Harassment (#s of animals) in 0-200m depth stratum			Estimated Level B Harassment in >200m depth stratum		Total Take
		EK60	ME70	SX90	EK60	SX90	
ETP Cetaceans							
Risso's Dolphin	0.02587	26	4	16	0	0	**46**
Short beaked common dolphin	0.73277	724	126	451	0	0	**1300**
Long beaked common dolphin	0.09726	96	17	60	0	0	**173**
Rough toothed dolphin	0.02521	25	4	16	0	0	**45**
Striped dolphin	0.22582	223	39	139	0	0	**401**
Spinner dolphin	0.24889	246	43	153	0	0	**442**
Pantropical spotted dolphin	0.61313	605	105	377	0	0	**1088**
Dusky dolphin	0.01050	10	2	6	0	0	**19**
Fraser's dolphin	0.06774	67	12	42	0	0	**120**
Melon headed whale	0.01063	10	2	7	0	0	**19**
Bottlenosed dolphin	0.07864	78	13	48	0	0	**140**
Killer whale	0.00199	2	0	1	0	0	**4**
False killer whale	0.00932	9	2	6	0	0	**17**
Pygmy killer whale	0.00913	9	2	6	0	0	**16**
Short finned pilot whale	0.05520	55	9	34	574	51	**723**
Cuvier's beaked whale	0.00187	2	0	1	19	2	**25**
Longman's beaked whale	0.00007	0	0	0	1	0	**1**
Mesoplodont beaked whale	0.00237	2	0	1	25	2	**31**
Sperm whale	0.00039	0	0	0	4	0	**5**
Dwarf sperm whale	0.00105	1	0	1	11	1	**14**
Humpback whale	0.00067	1	0	0	0	0	**1**
Blue whale	0.00097	1	0	1	0	0	**2**
Fin whale	0.00015	0	0	0	0	0	**0**
Sei whale	0.00000	0	0	0	0	0	**0**
Minke whale	0.00003	0	0	0	0	0	**0**
Bryde's whale	0.00244	2	0	2	0	0	**4**

Table 6.12c. Estimated annual Level B harassment by acoustic sources by sound type for each marine mammal species during surveys in the Scotia Sea/Antarctica ecosystem. For each species and sound source, the cross sectional area for the relevant depth strata (Table 6.5) was multiplied by the effective line km for each respective strata (from tables 6.6b, 6.7b, or 6.8b) and the volumetric density (shown here) to estimate Level B harassment.

	Volumetric density (#/km^3)	Estimated Level B Harassment (#s of animals) in 0-200m depth stratum	Estimated Level B Harassment in >200m depth stratum	Total
		EK60	EK60	
Antarctic Cetaceans				
Spectacled porpoise	0.00750	2	0	**2**
Hourglass porpoise	0.00750	2	0	**2**
Killer whale	0.00750	2	0	**2**
Sperm whale	0.00130	0	3	**4**
Arnoux's beaked whale	0.00120	0	3	**3**
Southern bottlenose whale	0.00120	0	3	**3**
Long-finned pilot whale	0.01520	4	39	**43**
Antarctic minke whale	0.00900	2	0	**2**
Southern right whale	0.00203	1	0	**1**
Fin whale	0.41950	114	0	**114**
Blue whale	0.00062	0	0	**0**
Humpback whale	0.18050	49	0	**49**
Antacartic Pinnipeds				
Antarctic fur seal	0.49950	136	0	**136**
Southern elephant seal	0.00060	0	2	**2**
Crabeater seal	3.24324	884	0	**884**
Weddell seal	0.27027	74	0	**74**
Leopard seal	0.08108	22	0	**22**

6.2.7 Summary of the total estimates of Level B harassment due to acoustic sources

The results given in Tables 6.12a-c were based on the approach taken here to estimate marine mammal Level B harassment under the MMPA and should be interpreted with considerable caution. This method is prescribed by the current definition of acoustic thresholds associated with Level B harassment given in NMFS policy guidelines for acoustic impacts with several modifications specific to the directional nature of high-frequency fisheries acoustic sources and the vertical stratification of marine species applied. Given the simplistic step-function approach and lack of species-specific hearing parameters inherent in the NMFS prescribed approach, significant uncertainty in some areas, and a number of underlying assumptions based on how these sources may be used variably in the field, this approach should be considered to result in a highly precautionary estimate of impact (e.g., higher number of estimated Level B harassment than are in fact likely). Factors believed to result in the estimated Level B harassment by acoustic sources being conservative (i.e., higher than what may actually occur *in situ*) include the following:

- Based on current NMFS guidelines, the known differences in hearing sensitivities of different marine mammal species (see section 7.2 below) are not considered in SWFSC estimates of Level B harassment by acoustic sources; all species are assumed to be equally sensitive to all acoustic systems below 180 kHz.
- Other known aspects of hearing as they relate to transient sounds (specifically auditory integration times) are also not taken into account in this estimation. Specifically, sounds associated with these fisheries acoustic sources are typically repetitive and quite brief in duration. While some animals may potentially hear these signals well (e.g. odontocete cetaceans), for other animals, the perceived sound loudness will be considerably reduced based on their brief nature and the fact that auditory integration times in many species likely exceed the duration of individual signals.
- Density estimates underlying take calculations presume a uniform distribution of animals, while in reality for more species they are considerably patchy. The use of vertical stratification and volumetric density here is an improvement over simple geographical density estimates, although a homogenous distribution (albeit in three dimensions) is still used.
- Several other precautionary assumptions are made, including a fairly conservative interpretation of beamwidth of these directional sources and the use of the lowest frequencies (with greatest potential propagation to higher received levels) in cases where multiple frequencies are used.

In conclusion, the estimated Level B harassment likely overestimates the actual magnitude of behavioral impacts of these operations for the reasons given above. This approach is deemed appropriate, however, given some of the uncertainties in terms of response thresholds to these types of sounds, overall density estimates, and other complicating factors.

6.3 Estimated number of potential marine mammal takes by incidental harassment of animals on ice due to Antarctic survey transects during austral winter

During Antarctic ecosystem surveys conducted in the austral winter (i.e., June 1 – through August 31) it is anticipated that pinniped species hauled out on ice may be disturbed. These studies do not entail intentional approaches to pinnipeds on ice, only behavioral disturbance incidental to shipboard activities. Behavioral disturbance may include visible reactions of hauled out animals to the ship, such as some animals leaving haulout locations and entering the water. To account for this source of incidental harassment, we have estimated the number of individuals of each pinniped species that may react to vessel movements and activities using the vessel distance traveled (20,846 km) during a typical AMLR survey, an effective strip width of 200 m (animals are assumed to react if they are less than 100 m from the vessel – see below), and the estimated population density for each species. Population densities are the same as those to estimate acoustic harassment takes using a similar approach and are listed in Table 6.13. We believe the SWFSC approach to calculating these estimates is justifiable, though we acknowledge there is likely to be variation between individuals and species in reactions to a passing research vessel. In other words, some animals assumed to react in this calculation will not react, and others assumed not to react because they are outside the effective strip width may in fact react. However, we have no information to indicate that our approach is biased either negatively or positively. SWFSC used an effective strip width of 200 m to be consistent with the regional marine mammal viewing guidelines that NMFS has established for Alaska that restrict approaches to marine mammals to a distance of 100 m or greater in order to reduce the potential to cause inadvertent harm to marine mammals. (The Alaska region is believed to have the most similar environment to the Antarctic of all regions for which NMFS has established viewing guidelines.) We request the following annual incidental harassment takes associated with these activities for all age classes of the following pinniped species: Antarctic fur seal (417), southern elephant seal (2), Weddell seal (226), crabeater seal (2,705), and leopard seal (68).

Table 6.13. Estimated annual incidental harassment take of pinnipeds associated with AMLR vessel transects.

Species	Estimated density	Annual survey distance (km)	Effective strip width (km)	Estimated incidental harassment take
Antarctic fur seal[1]	0.0999/km	20,846	0.2	417
Southern elephant seal[1]	0.0003/km	20,846	0.2	2
Weddell seal[2]	$0.0541/km^2$	20,846	0.2	226
Crabeater seal[2]	$0.6486/km^2$	20,846	0.2	2,705
Leopard seal[1]	0.0162/km	20,846	0.2	68

[1] Densities were estimated using data from visual surveys conducted at sea during AMLR 2008/2009 season. These density estimates were made using strip transect methods rather than the line transect methods used in many marine mammal visual surveys.
[2] IUCN Red List Assessment (iucnredlist.org)

7. THE ANTICIPATED IMPACT OF THE ACTIVITY UPON THE SPECIES OR STOCK

We anticipate that the specified activities could impact the species or stocks of marine mammals by causing mortality, serious injury, and/or Level A (non-serious injury) harassment (through gear interaction) or by causing Level B (behavioral) harassment (through use of active acoustic sources and close vessel approaches to pinnipeds hauled out on ice when conducting Antarctic fisheries research activities). These could occur through the following:

- Entanglement in nets or longlines;
- Accidental hooking;
- Alterations in behavior caused by acoustics sources and by close vessel approaches to pinnipeds hauled out on ice during AMLR research activities

Other potential effects of the activity could include hearing impairment, masking, or non-auditory physiological effects, such as stress responses, resonance, and other types of organ or tissue damage related to the use of active acoustics. However, for reasons described below, we do not expect that these effects would occur. In addition, we do not expect that the anticipated impact of the activity upon the species or stocks would include the potential for effects on marine mammals from the following:

- Collision or vessel strike;

The SWFSC does not expect its survey operations or its cooperative surveys with other research entities would cause the marine mammal populations in the CCE, ETP, or Antarctic to experience reductions in reproduction, numbers, or distribution that might appreciably reduce their likelihood of surviving and recovering in the wild. Although these surveys have the potential to adversely impact the health and condition of an individual marine mammal, we anticipate no adverse effects on annual rates of recruitment or survival of the affected marine mammal species or stocks. The Center notes, however, that marine mammal distribution and abundance is not uniform in all parts of the study area, and varies substantially in different seasons. Most marine mammal surveys are conducted during the summer and fall; however, density information is not available for every season in all the study regions. The Center believes that the direct effects on species or stocks are minor because over the course of the operations during 2008-2012 only 63 marine mammals have been incidentally caught of which thirteen have been released alive. These animals caught include Pacific white-sided dolphins, northern right-whale dolphins, California sea lions, and northern fur seals (Table 6.1). From a population perspective, the impacts of these incidental captures are negligible.

While there are different approaches that could be taken to evaluating the significance of anticipated interactions with marine mammals during the course of fisheries research, the Potential Biological Removal (PBR) level used in classifying commercial fisheries is well established and applicable to removals of marine mammals in fisheries research activities, as well. PBR is defined by the MMPA as the maximum number of animals that may be removed from a marine mammal stock, not including natural mortalities, while allowing that stock to reach or maintain its optimum sustainable population. The PBR level is the product of the minimum population estimate of the stock, one-half the maximum theoretical or estimated net productivity rate of the stock at a small population size, and a recovery factor of between 0.1 and 1.0.

In using PBR to evaluate the impact of SWFSC fisheries research activities on affected marine mammal stocks, two assumptions should be noted. First, as described in Section 6 of this application, SWFSC has requested a single number of takes in each gear for each stock in a combined category that includes Level A injury, serious injury and mortality. It is likely that some marine mammals that interact with SWFSC research gears will experience only non-serious injuries. However, for purposes of evaluating the significance of the SWFSC take request relative to PBR we assume the worst-case outcome that all animals in this combined category will be seriously injured or killed. The rationale for binning Level A injury, serious injury and mortality takes is described in greater detail in Section 6 of this application.

Second, SWFSC is assuming its anticipated take will equal its actual take of marine mammals in fisheries research activities. PBR was developed as a tool to evaluate actual human-caused removals from a population, not anticipated future removals. Nonetheless, the take request described in Section 6 is based on historical interactions, and as such SWFSC believes its request is a reasonable approximation of the number of takes that may occur in the future. Clearly, the actual number of serious injuries and mortalities that result from SWFSC research will need to be evaluated to understand the significance of these activities. As described in Section 14 of this application, SWFSC plans to implement an adaptive management approach to evaluating its actual takes and continuing to revisit its mitigation measures in light of take events to ensure they are appropriate.

7.1 Physical Interactions with Gear

The SWFSC incidentally caught 63 marine mammals during research activities within the California Current Ecosystem from 2008 to 2012 (Table 6.1). The mortalities occurred in the CCE during trawls conducted on sardine, juvenile salmon, and juvenile rockfish surveys. Additional non-lethal takes also occurred during trawl operations on sardine and juvenile rockfish surveys in the CCE, as well as on longlines set during highly migratory species (HMS) and thresher shark surveys in the CCE. The majority of incidental takes of marine mammals (over 92% from 2008 to 2012) were the result of surveys conducting trawls, with only five California sea lions caught and released alive during longline surveys. Rigorous mitigation measures have been employed since 2009 to minimize the incidental take of marine mammals (summarized at section 11). To reduce or eliminate incidental take the SWFSC has initiated use of a marine mammal excluder device on nets (MMED). This device was developed with the premise and supporting documentation of a similar device to minimize incidental take of turtles. The effectiveness of the MMED in tests during 2009 may be viewed in Appendix A and Dotson et al. (2010).

SWFSC is currently investigating whether data are sufficient to conduct a multivariate analysis of factors influencing research interactions with protected species, including whether environmental factors or mitigation measures implemented by SWFSC have an effect on interaction rates. This effort is still underway; however, initial efforts have uncovered that important information on when and how mitigation measures are being used (e.g., sets in which operational pingers are used, number used, placement, etc.) has not been collected systematically for some surveys. Unfortunately, this lack of information may compromise SWFSC's ability to draw definitive conclusions at this time about the effectiveness of measures it has implemented to reduce protected species interactions. As described in later sections of this application, SWFSC is now seeking to make more systematic its training, operations, data collection, animal handling and sampling protocols, etc. in order to improve its ability to understand how mitigation measures influence interaction rates and ensure its research operations are conducted in an informed manner and consistent with lessons learned from those with experience operating these gears in close proximity to marine mammals.

Because of the low level of historical takes, as well as the low level of predicted future takes associated with the use of trawl gear and longline gear in research activities in the CCE, ETP, and AMLR, the SWFSC believes that the surveys described below: (1) will have a negligible impact on the affected species or stocks of marine mammals (based on the likelihood that the activities will not affect annual rates of recruitment or survival); and (2) will not have an unmitigable adverse impact on the availability of the species or stock(s) for subsistence uses. The basis for this determination is that no historical takes or those requested for the future exceed a stock's PBR.

7.1.1 Anticipated impact of mid-water trawl and longline surveys conducted in the California Current Ecosystem (CCE) on marine mammal stocks

As described in Section 6, SWFSC relied heavily on its historic marine mammal interactions with its longline surveys that occur in the CCE and used other relevant information in developing its take request. Table 7.1 compares the SWFSC combined take request for mid-water trawl and longline gear in the CCE relative to each stock's PBR.

Included in Table 7.1 are takes requested for 1 unidentified delphinid species in trawl gear and 2 unidentified pinniped species, one each in longline and trawl gear. In other words, for every delphinid and pinniped stock for which SWFSC has requested take in trawl gear an additional take has been added in the "Total SWFSC Take Request" column to account for potential take of a delphinid and a pinniped that is not identified to species/stock. For the same reason, an additional take has also been added to each pinniped stock for which take is requested in longline gear. As a result, the SWFSC take request in this table differs in comparison to stock-specific takes requested in Table 6.3.

For each of the seventeen stocks for which take is requested, no take request exceeds its PBR. Because of the low level of predicted future takes associated with the use of mid-water trawl gear in research activities in the CCE relative to PBR, the SWFSC believes that the surveys for CPS, juvenile rockfish and juvenile salmon will neither affect annual recruitment or survival nor the health and condition of marine mammal species or stocks.

Table 7.1. Stocks for which SWFSC is requesting trawl and/or longline take in the CCE, cumulative numbers requested by stock, and evaluation of impact relative to PBR

	Total SWFSC Take Request[1,2] (2013-2018)	PBR (Annual Potential Biological Removal)	% PBR Requested Annually
Risso's Dolphin	13	39	6.67
Harbor Porpoise[3]	6	10	12.00
Dall's Porpoise	6	257	0.47
Pacific White-sided Dolphin	36	193	3.73
Bottlenose Dolphin (Coastal)	4	2.4	33.33
Bottlenose Dolphin (OR, WA Offshore)	10	5.5	32.73
Striped Dolphin	13	82	3.17
Short-Beaked Common Dolphin	13	3,440	0.08
Long-Beaked Common Dolphin	13	610	0.43
Northern Right Whale Dolphin	11	48	4.58
Short-finned Pilot Whale	1	4.6	4.35
Pygmy and Dwarf Sperm Whale	1	2.7	7.41
California Sea Lion	27	9,200	0.06
Steller Sea Lion	12	2,378	0.10
Northern Fur Seal	6	324	0.37
Harbor Seal (All Stocks)	10	1,600	0.13
Northern Elephant Seal	6	4,382	0.03

[1] Because SWFSC requested 1 unidentified delphinid species in trawl gear and 2 unidentified pinniped species, one each in longline and trawl gear, these additional takes have been included in this table for analytical purposes. In this table one take has been added to each delphinid for which take is requested in trawl gear, 1 take has been added to each pinniped for which take is requested in trawl gear, and 1 take has been added to each pinniped for which take is requested in longline gear (i.e., the impact of 2 additional takes of Steller and California sea lions was analyzed because it is anticipated these may be taken in longline and trawl gear), and these takes are incorporated in the % PBR Requested figures. As a result, the SWFSC take request in this table differs in comparison to stock-specific takes requested in Table 6.3.
[2] The SWFSC request is for Level A and serious injury and mortality takes. For purposes of evaluating impact of this request, all takes are assumed to result in serious injury / mortality.
[3] Harbor porpoise take request is across all stocks, and PBR used is the lowest calculated for any stock (Monterey Bay).

7.1.2 Anticipated impact of longline surveys conducted in the Eastern Tropical Pacific (ETP) Ecosystem on marine mammal stocks

The SWFSC has not historically conducted longline surveys in the ETP. However, as described in previous sections SWFSC believes it is likely it will conduct these surveys for sharks and HMS during 2013-2018, and in estimating its future take SWFSC used information from its CCE longline surveys and other relevant information. Table 7.2 shows a comparison of the SWFSC take request for longline gear in the ETP to a calculated PBR for each stock using accepted calculations for minimum population estimates (Nmin) and PBR (NMFS 2005).

Included in Table 7.2 are takes requested for 1 unidentified pinniped species in longline gear. In other words, for every pinniped stock for which SWFSC has requested take in longline gear an additional take has been added in the "Total SWFSC Take Request" column to account for potential take of a pinniped that is not identified to species/stock. As a result, the SWFSC take request in this table differs in comparison to stock-specific takes requested in Table 6.3.

For each of the eleven stocks for which take is requested, no take request exceeds 2% of PBR. Because of the low level of predicted future takes associated with the use of longline gear in research activities in the ETP, the SWFSC believes that the HMS survey, habitat/swordfish survey and thresher shark pelagic survey will neither affect annual recruitment or survival nor the health and condition of marine mammal species or stocks.

Table 7.2. Stocks for which SWFSC is requesting longline take in the ETP and numbers requested relative to an approximation for PBR.

<table>
<tr><th></th><th>SWFSC Longline Take Request (2013-2018)</th><th>Population Estimate[3] (N)</th><th>Coefficient of Variation[3] (CV)</th><th>N_{min}[1]</th><th>PBR Calculation</th><th>% PBR Proxy Requested Annually</th></tr>
<tr><td>Risso's Dolphin</td><td>1</td><td>110,457</td><td>0.348</td><td>83,092</td><td>831</td><td>0.12</td></tr>
<tr><td>Bottlenose Dolphin</td><td>1</td><td>335,834</td><td>0.197</td><td>284,952</td><td>2,850</td><td>0.04</td></tr>
<tr><td>Striped Dolphin</td><td>1</td><td>964,362</td><td>0.207</td><td>811,592</td><td>8,116</td><td>0.01</td></tr>
<tr><td>Short-Beaked Common Dolphin</td><td>1</td><td>3,127,203</td><td>0.264</td><td>2,513,269</td><td>25,133</td><td>0.004</td></tr>
<tr><td>Long-Beaked Common Dolphin</td><td>1</td><td>372,429</td><td>0.355</td><td>278,651</td><td>2,787</td><td>0.01</td></tr>
<tr><td>Coastal Spotted Dolphin</td><td rowspan="3">1
(take request is for Pantropical spotted dolphin)</td><td>161,596</td><td>0.308</td><td>125,414</td><td>1,254</td><td rowspan="3">0.08</td></tr>
<tr><td>Western/Southern Spotted Dolphin</td><td>758,985</td><td>0.265</td><td>609,493</td><td>6,095</td></tr>
<tr><td>Northeastern Spotted Dolphin</td><td>822,157</td><td>0.157</td><td>720,929</td><td>7,209</td></tr>
<tr><td>False Killer Whale</td><td>1</td><td>39,800</td><td>0.636</td><td>24,365</td><td>244</td><td>0.41</td></tr>
<tr><td>Short-finned Pilot Whale</td><td>1</td><td>589,315</td><td>0.26</td><td>475,141</td><td>4,751</td><td>0.02</td></tr>
<tr><td>Dwarf Sperm Whale</td><td>1</td><td>11,200</td><td>0.294</td><td>8,789</td><td>88</td><td>1.14</td></tr>
<tr><td>California Sea Lion[2]</td><td>6</td><td>105,000</td><td>0[4]</td><td>105,000</td><td>1,050</td><td>0.57</td></tr>
<tr><td>South American Sea Lion[2]</td><td>6</td><td>150,000</td><td>0[4]</td><td>150,000</td><td>1,500</td><td>0.40</td></tr>
</table>

[1] Nmin was calculated based on the Guidelines for Assessing Marine Mammal Stocks (GAMMS; NMFS 2005). Nmin is defined as the 20th percentile of a log-normal distribution based on an estimate of the number of animals in a stock (which is equivalent to the lower limit of a 60% 2-tailed confidence interval): $Nmin = N/exp(0.842 * (ln(1+CV(N)^2))^{½})$. PBR = Nmin*0.5Rmax*Fr; values for the recovery factor (Fr) and for Rmax were assumed to be 0.5 and 0.04, respectively.
[2] Because SWFSC requested 1 unidentified pinniped species in longline gear, these additional takes have been included in this table for analytical purposes (1 each for the sea lion species), and these takes are incorporated in the % PBR Requested figures to illustrate the impact if one unidentified take came from each of the pinniped stocks.
[3] Sources for population estimates (N) and associated CVs are as cited in footnote to Table 3.2. Surveys from which abundance estimates were made for long-beaked common dolphin, California sea lion and South American sea lion are over 8 years old. According to the GAMMS (NMFS 2005), the minimum population estimate of a stock should be considered unknown in these cases. However, because this is the best information available to evaluate the

potential impacts of the SWFSC take request on these stocks the most recent abundance information, even if older than 8 years, is being used in the calculation of Nmin and PBR.
[4] Population estimates for California and South American sea lions were made based on counts of animals in aerial photographs. Because photographic counts are usually considered as actual population size there is no error around the population estimates.

7.1.3 Survey gears for which no take of marine mammals by mortality or serious injury and by non-serious injury (Level A harassment) is being requested

As described in Section 6 of this application, the only SWFSC research gears that have taken marine mammals are mid-water trawls (NETS Nordic 264 and Modified Cobb) and longline gears used in surveys for sharks and HMS. The other net and hook gears used in SWFSC fisheries research – a variety of plankton nets, CTDs, ROVs, deep set buoy gear, AMLR snapper bottom trawl, and (deep set) longline gear for sablefish – have had no marine mammal interactions during the period 2008-2012. In addition, they are not considered to have the potential to take marine mammals given their physical characteristics, how they are fished, and the environments where they are used, and in the case of the bottom longline survey for sablefish the low level of effort virtually eliminates any potential to take marine mammals. Because of this, SWFSC is not requesting marine mammal take for these gears, and as such they are not expected to have an impact on marine mammal stocks in the SWFSC study areas.

7.2 Disturbance and Behavioral Changes

7.2.1 Due to close approach

As described previously, during AMLR surveys conducted during the southern hemisphere winter pinnipeds are expected to be hauled out on ice and at times experience close approaches by the survey vessel during the course of its fisheries research activities. SWFSC expects some of these animals will exhibit a behavioral response to the visual stimuli (e.g., including flushing, vocalizing and head alerts), and as a result estimates of Level B harassment have been calculated. These events are expected to be infrequent and cause only a very temporary disturbance (minutes). However, relevant studies of pinniped populations that experience more regular vessel disturbance indicate that population level impacts are unlikely to occur. Some key findings from these studies are summarized below.

In a popular tourism area of the Pacific Northwest where human disturbances were frequent to occur, past studies observed stable populations of seals over a 20-year period (Calambokidis et al. 1991). Despite high levels of seasonal disturbance by tourists using both motorized and non-motorized vessels, Calambokidis et al. (1991) observed an increase in site use (pup rearing) and classified this area as one of the most important pupping sites for seals in the Pacific Northwest. Another study observed an increase in seal vigilance only when vessels passed the haul out site, but then vigilance relaxed within 10 minutes of the vessels' passing (Fox 2008). If vessels were frequent to occur within a short time period (e.g., 24 hours), a reduction in the total number of seals present was also observed (Fox 2008).

Based on these studies, repeated disturbance can cause behavioral disturbance and alter normal activity patterns, and as such minimizing these types of disturbances, particularly those that are frequent and prolonged, is important. However, if disturbances resulting from research activities are brief and infrequent (often the case during SWFSC surveys conducted in the ALMR), SWFSC does not expect the close approaches to result in prolonged or permanent separation of mothers and pups or to result in responses of the frequency or magnitude that would adversely affect annual recruitment or survival or the health and condition of pinniped species or stocks.

7.2.2 Due to noise

Characteristics of hearing and the effects of noise on marine life have been reviewed extensively (Richardson et al. 1995; Wartzok and Ketten 1998; Nowacek et al. 2007; Southall et al. 2007; Au and Hastings 2008). General characteristics of hearing in marine mammals is described briefly here primarily for the purposes of categorization with regard to the potential impacts of high frequency active acoustic sources, as well as current information regarding sound exposures that may be detectable, disturbing, or injurious to marine mammals.

7.2.2.1 Hearing in marine mammals

Within marine taxa, there is probably the most known about the hearing capabilities of marine mammals. However many species and in fact entire taxa (e.g., large whales) have not been measured directly in controlled/laboratory settings. Current knowledge is based on direct measurements (using behavioral testing methods with trained animals and electrophysiological measurements of neural responses to sound production), as well as various ways of predicting hearing sensitivity using ranges of vocalization, morphology, observed behavior, and/or taxonomic relatedness to known species (e.g., Ketten 1997; Houser et al. 2001). While less than a third of the >120 marine mammal species have been tested directly, sufficient data exist to indicate general similarities and differences within taxa (e.g., Richardson et al. 1995; Wartzok and Ketten 1999; Au and Hastings 2008) and reasonably assign marine mammal species into functional hearing groups (as in Southall et al. 2007). Based on the functional hearing groupings made in Southall et al. (2007) conclusions may be made about marine mammal hearing, as described below.

No direct measurements of hearing exist in large whales, primarily because of their sheer size and the resulting difficulties in housing and testing them in normal captive settings. Conclusions about their hearing capabilities must be considered somewhat speculative, but some general conclusions and predictions are possible (Richardson et al. 1995; Ketten 1997; Wartzok and Ketten 1999; Houser et al. 2001; Erbe 2002; Clark and Ellison 2004). The thirteen species of baleen whales have been determined to comprise a low frequency cetacean functional hearing group with estimated functional hearing between 7 Hz and 22 kHz (Southall et al. 2007; Figure 7.1). Humpback whales produce sounds with some energy above 24 kHz (Au et al. 2006), so it is possible that functional hearing could extend slightly higher in this group. Empirical measurements of Frankel (2005) in demonstrating minor avoidance behavior in gray whales to 21-25 kHz sounds and the anatomical predictions of Parks et al. (2007) are consistent with the interpretation of a slightly higher upper frequency hearing cut-off in mysticetes, perhaps extending close to 30 kHz in some species.

Odontocetes are segregated into two functional hearing groups based on their relative specialization (or lack thereof) to detect very high frequency sounds (Tables 4.1). Southall et al. (2007) distinguished these into the mid-frequency cetaceans including 32 species and subspecies of “dolphins”, 6 species of larger toothed whales, and 19 species of beaked and bottlenose whales. These species are determined, based on direct behavioral and electrophysiological methods, to have functional hearing between approximately 150 Hz and 160 kHz (see references in Southall et al. 2007).

High frequency cetaceans include eight species and subspecies of true porpoises, six species and subspecies of river dolphins plus the Franciscana (*Pontoporia blainvillei*)), *Kogia,* and four species of cephalorhynchids and have functional hearing between 200 Hz and 180 kHz (Southall et al. 2007, and citations therein).

The pinnipeds (seals and sea lions) function in both air and water and have functional hearing in each media. Only underwater hearing is considered here, given that the active acoustic sources associated with SWFSC research vessels are operated in water. This group includes 16 species and subspecies of sea lions and fur seals (otariids), 23 species and subspecies of true seals (phocids), and two subspecies of walrus (odobenids). Based on the existing empirical data on hearing in laboratory individuals of nine pinniped species, Southall et al. (2007) estimated functional underwater hearing sensitivity in this group to be between 75 Hz and 75 kHz, but noted that there is considerable evidence that phocid seals have a broader range of hearing sensitivity than the otariids; the use of this bandwidth is thus a precautionary estimate in terms of how high frequency sounds might affect otariid pinnipeds.

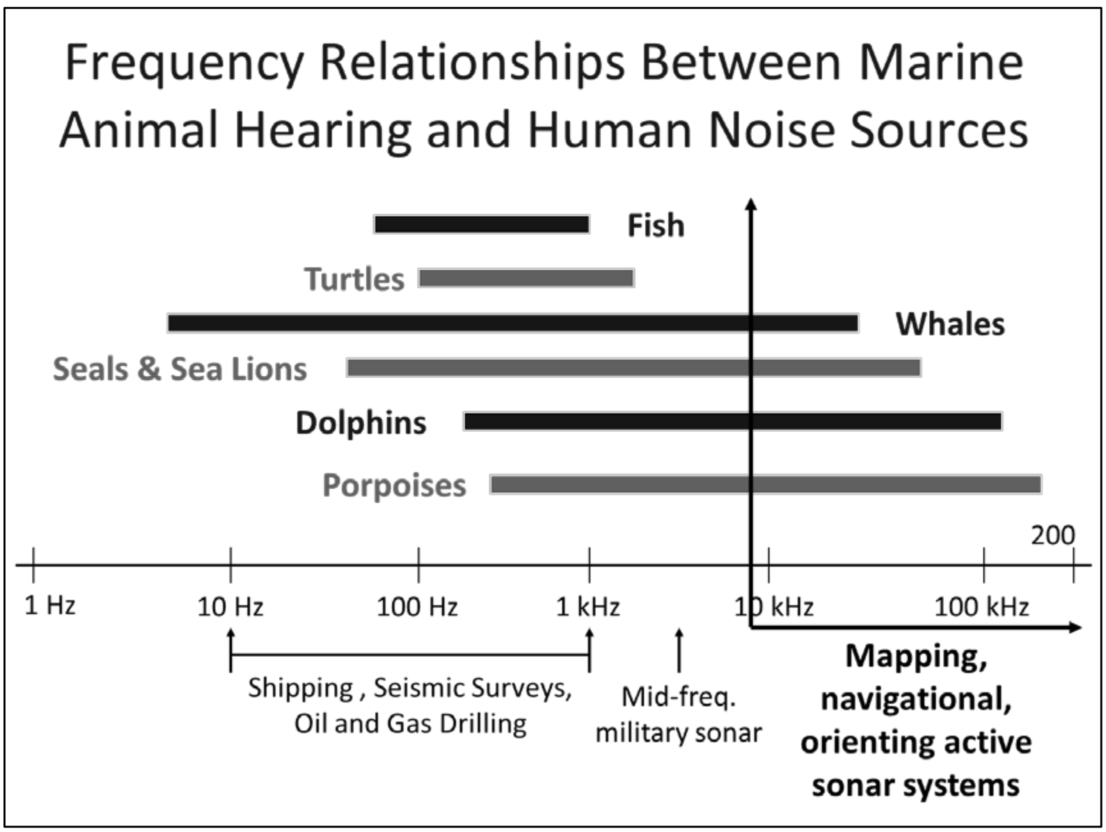

Figure 7.1. Typical frequency ranges of hearing in marine animals shown relative to various underwater sound sources, particularly high frequency active acoustic source.

7.2.2.2 Effects of anthropogenic noise on marine mammals

Anthropogenic sounds cover a broad range of frequencies and sound levels and can have a range of impacts on marine life, from no or minor responses to potentially severe, depending on received levels, behavioral context and various other factors. Many of the kinds of sources that have been investigated included sounds that are either much lower frequency and/or higher total energy (considering output sound levels and signal duration) than the high frequency mapping and fish-finding sonars used by the Center. These include low- and mid-frequency military sonars, seismic airguns used in geophysical research, pile-driving sounds associated with marine construction, and low- and mid- frequency sounds associated with vessel operations (NRC 1994, 2000, 2003, 2005; Nowacek et al. 2007; Southall et al. 2007; Popper and Hastings 2009). Other than the Navy's studies on the High-Frequency Marine Mammal Monitoring (HF/M3) active sonar system since 2001, there has been relatively little attention given to the potential impacts of high-frequency sonar systems on marine life, largely because their combination of high output frequency and relatively low output power is likely to render them less likely to impact many marine species than some of the other acoustic sources. However, it should be noted that some species of marine animals do hear and produce sounds at some of the frequencies used in these sources and ambient noise is much lower at high frequencies, increasing the relative probability of their detection relative to other sounds in the environment. Because, as seen in Figure 7.1, there is very little probability of fish even hearing active high frequency acoustic sources, the primary discussion here is related to marine mammals, with particular emphasis on the odontocete cetaceans.

Sounds must presumably be audible to be detected and the known or estimated functional hearing capabilities for different species are indicated in Figure 7.1. Additionally, Southall et al. (2007) provided a recent and extensive review on the effects of noise on marine mammal hearing and behavior.

The results of that review indicate that relatively high levels of sound are likely required to cause temporary hearing threshold shifts (TTS) in most pinnipeds and odontocete cetacean species (e.g., Schlundt et al. 2000; Finneran et al. 2000, 2002, 2005, 2007b, 2010a and b; Kastak et al. 1999, 2005, 2007). The exposures required are often measured with a variety of sound exposure metrics related to level (e.g., RMS, peak, or peak-peak sound pressure level) or sound energy (e.g., sound exposure level that considers level as well as exposure duration). While clearly dependent on sound exposure frequency, level, and duration, based on the results of these studies, for the kinds of relatively brief exposures associated with transient sounds such as the active acoustic sources usd by the Center, RMS sound pressure levels in the range of approximately 180-220 dB re: 1µPa are required to induce onset TTS levels for most species. Recently, Lucke et al. (2009) found a TTS onset in a harbor porpoise exposed to airgun noise at much lower (>20 dB) levels than reported by Finneran et al. (2002) for belugas using a similar impulse noise source; Kastelein (unpubl. data) has similarly observed increased sensitivity in this species. Additionally, Finneran and Schlundt (2010) indicate relatively lower TTS onset levels for higher sound exposure frequencies (20 kHz) than for lower frequencies (3 kHz) in some cetaceans. However, for these animals, which are better able to hear higher frequencies and may be more sensitive to higher frequencies, exposures on the order of ~170 dB RMS or higher for brief transient signals are likely required for even temporary (recoverable) changes in hearing sensitivity that would likely not be categorized as physiologically damaging. The corresponding estimates for permanent threshold shift (PTS), which would be considered injurious, would still be at quite high received sound pressure levels that would rarely be experienced in practice.

Southall et al. (2007) provided a number of extrapolations to assess the potential for permanent hearing damage (permanent threshold shift or PTS) from discrete sound exposures and concluded that very high levels (exceeding 200 dB re: 1µPa received sound pressure levels) would be required; typically quite large TTS is required (~40 dB) to result in PTS from a single exposure. Southall et al. (2007) also provided some frequency weighting functions for different marine mammal groups, which essentially account for the fact that impacts of noise on hearing depends in large part on the frequency overlap between noise and hearing. Based on the Southall et al. (2007) results, Lurton and DeRuiter (2011) modeled the potential impacts (PTS and behavioral reaction) of conventional echosounders on marine mammals. They estimated PTS onset at typical distances of 10m to 100m for the kinds of sources in the fisheries surveys considered here. They also emphasized that these effects would very likely only occur in the cone ensonified below the ship and that animal responses to the vessel at these extremely close ranges would very likely influence their probability of being exposed to these levels. For certain species (e.g., odontocete cetaceans and especially harbor porpoises), these ranges may be somewhat greater based on more recent data (Lucke et al. 2009; Finneran and Schlundt 2010), although they are likely still on the order of hundreds of meters for most fisheries acoustic sources. In addition, the behavioral responses that typically occur (described below) further reduce this already low likelihood that an animal may approach close enough for any type of hearing loss to occur.

The overall conclusion here is that the available information on hearing and potential auditory effects in marine mammals would suggest that the high frequency cetacean species would be the most likely to have temporary (not permanent) hearing losses from a vessel operating high frequency sonar sources, but that even for these species, individuals would have to either be very close to and also remain very close to vessels operating these sources for multiple exposures at relatively high levels. Given the moving nature of vessels in fisheries research surveys, the likelihood that animals may avoid the vessel to some extent based on either its physical presence or active acoustic sources, and the intermittent nature of many of these sources, the potential for TTS is probably low for high frequency cetaceans and very low to zero for other species.

Behavioral responses of marine mammals are extremely variable depending on a host of exposure factors, including exposure level, behavioral context and other factors. The most common type of behavioral response seen across studies is behavioral avoidance of areas around sound sources. These are typically the types of responses seen in species that do clearly respond, such as harbor porpoises, around temporary/mobile higher frequency sound sources in both the field (e.g., Culik et al. 2001; Johnston et al. 2002) and in the laboratory settings (e.g., Kastelein et al. 2000, 2005, 2008a and b). However, what appears to be more sustained avoidance of areas where high frequency sound sources have been deployed for long durations has also been documented in some odontocete cetaceans, particularly those like porpoises and beaked whales that seem to be particularly behaviorally sensitive (e.g., Olesiuk et al. 2002; Carretta et al. 2008; Southall et al. 2007). While low frequency cetaceans and pinnipeds have been observed to respond behaviorally to low- and mid-frequency sounds, there is little evidence of behavioral responses in these species to high frequency sound exposure (see e.g., Jacobs and Terhune 2002; Kastelein et al. 2006).

7.2.2.3 Active acoustic sources used by the SWFSC and their effect on marine mammals

A brief discussion of the general characteristics of high frequency acoustic sources associated with fisheries research activities is given below, followed by a qualitative assessment of how those sources may affect marine life. Marine mammals, as opposed to marine fish and sea turtles, are the focus of this assessment given their overlapping hearing capabilities (Figure 7.1) with the sounds produced by high frequency sound sources.

The high frequency transient sound sources operated by the Center are used for a wide variety of environmental and remote-object sensing in the marine environment. They include various echosounders (e.g., multibeam systems), scientific sonar systems, positional sonars (e.g., net sounders for determining trawl position), and environmental sensors (e.g., current profilers). The specific acoustic sources used in SWFSC active acoustic surveys, are described in Section 6.2. As a general categorization, however, the types of active sources employed in fisheries acoustic research and monitoring may be considered in two broad categories here, based largely on their respective operating frequency (e.g., within or outside the known audible range of marine species) and other output characteristics (e.g., signal duration, directivity). As described below, these operating characteristics result in differing potential for acoustic impacts on marine mammals and other protected species.

<u>Category 1 active acoustic sources</u>

Certain active fisheries acoustic sources (e.g., short range echosounders, acoustic Doppler current profilers) are distinguished by having very high output frequencies (>180 kHz) and generally short duration signals and highly directional beam patterns. Based on the frequency band of transmissions relative to the functional hearing capabilities of marine species, they are not expected to have any negative effect on marine life. They are thus not considered explicitly in the qualitative assessment below (or in the quantitative analysis conducted in Section 6.2). Additionally, passive listening sensors which are sometimes described as elements of fisheries acoustic systems that exist on many oceanographic research vessels have no potential impact on marine life because they are remotely and passively detecting sound rather than producing it.

These sources are determined to have essentially no probability of being detected by or resulting in any potential adverse impacts on marine species. This conclusion is based on the relative output frequencies (> 180 kHz) and the fact that this is above the known hearing capabilities of any marine species (as described above). Sounds that are above the functional hearing range of marine animals may be audible if sufficiently loud (e.g., see Møhl, 1968). However, the relative output levels of these sources and the levels that would likely be required for animals to detect them would be on the order of a few meters. The probability for injury or disturbance from these sources is essentially zero. In fact, NOAA does not regulate or require take assessments for acoustic sources with source frequencies at or above 180 kHz because they are above the functional hearing range of any known marine animal (including high frequency odontocete cetaceans, such as harbor porpoises).

<u>Category 2 active acoustic sources</u>

These acoustic sources, which are present on most SWFSC fishery research vessels, include a variety of single, dual, and multi-beam echosounders (many with a variety of modes), sources used to determine the orientation of trawl nets, and several current profilers with slightly lower output frequencies than Category 1 sources. Category 2 active acoustic sources have moderate to very high output frequencies (10 to 180 kHz), generally short ping durations, and are typically focused (highly directional) to serve their intended purpose of mapping specific objects, depths, or environmental features. A number of these sources, particularly those with relatively lower sound frequencies coupled with higher output levels can be operated in different output modes (e.g., energy can be distributed among multiple output beams) that may lessen the likelihood of perception by and potential impact on marine life.

Category 2 active acoustic sources are likely to be audible to some marine mammal species. Among the marine mammals, most of these sources are unlikely to be audible to whales and most pinnipeds, whereas they may be detected by odontocete cetaceans (and particularly high frequency specialists such as harbor porpoise). There is relatively little direct information about behavioral responses of marine mammals, including the odontocete cetaceans, but the responses that have been measured in a variety of species to audible sounds (see Nowacek et al. 2007; Southall et al. 2007 for reviews) suggest that the most likely behavioral responses (if any) would be short-term avoidance behavior of the active acoustic sources.

The potential for direct physical injury from these types of active sources is low, but there is a low probability of temporary changes in hearing (masking and even temporary threshold shift) from some of the more intense sources in this category. Recent measurements by Finneran and Schlundt (2010) of TTS in mid-frequency cetaceans from high frequency sound stimuli indicate a higher probability of TTS in marine mammals for sounds within their region of best sensitivity; the TTS onset values estimated by Southall et al. (2007) were calculated with values available at that time and were from lower frequency sources. Thus, there is a potential for TTS from some of the Category 2 active sources, particularly for mid- and high-frequency cetaceans. However, even given the more recent data, animals would have to be either very close (few hundreds of meters) and remain near sources for many repeated pings to receive overall exposures sufficient to cause TTS onset (Lucke et al. 2009; Finneran and Schlundt 2010). If behavioral responses typically include the temporary avoidance that might be expected (see above), the potential for auditory effects considered physiological damage (injury) is considered extremely low so as to be negligible in relation to realistic operations of these devices.

7.2.2.4 Acoustic summary

Based on current scientific understanding and knowledge of the kinds of sources used in field operations, many of the high frequency, directional, and transient active acoustic sources used in SWFSC fisheries research operations are unlikely to be audible to and thus have no adverse impacts on most marine mammals. Sources operating at lower output frequencies, higher output levels, more continuous types of operation and with less directed acoustic energy are more likely to be audible to and affect more marine species.

Among the marine mammals, the whales and pinnipeds are the least likely to detect and be affected by these sounds. The most likely taxa to hear and react would be the odontocete cetaceans (and especially the high frequency specialized and relatively behaviorally sensitive harbor porpoises), who have specialized echolocation systems and associated high frequency hearing and excellent temporal processing of short-duration signals. The current NMFS acoustic step-function threshold of (160 dB RMS received level, irrespective of sound frequency,) is applied in the quantitative assessment in section 6.2 because this is the current requirement. However, for many marine mammal species with reduced functional hearing at the higher frequencies produced by category 2 active sources (e.g., 40-180 kHz), based purely on their auditory abilities, the potential impacts are likely much less (or non-existent) than might be calculated in the quantitative assessment since these relevant factors are not taken into account.

For species that can detect sounds associated with high frequency active sources, based on the limited observational and experimental data on these and similar sound sources, the most likely impacts would be localized and temporary behavioral avoidance. These kinds of reactions, depending on their relative duration and severity, have been considered relatively low to moderately significant behavioral responses in the severity scaling assessment for marine mammals by Southall et al. (2007).

There is a low probability of some temporary hearing impacts and an even lower probability of direct physical harm for odontocete cetaceans to the loudest kinds of these high frequency sources over very localized areas (tens of meters) around the source. There is no published evidence for marine mammal stranding events as a function of high frequency active acoustic sources.

As a general conclusion, while some of the active acoustic sources used in SWFSC active acoustics during fisheries research surveys are likely to be detected by some marine species (particularly phocid pinnipeds and odontocete cetaceans), the potential for direct injury or hearing impairment is extremely low and the most likely responses involve temporary avoidance behavior. Consequently, and in a manner consistent with the current NMFS acoustic guidelines for defining Level B harassment of marine mammals from impulse noise sources, a quantitative framework was developed (Section 6.2) for assessing the potential impacts of SWFSC active acoustic sources used in fisheries research.

7.3 Surveys That May Take Marine Mammals by Level B Harassment

Current NMFS practice regarding exposure of marine mammals to sound is that cetaceans and pinnipeds exposed to impulsive sounds of 180 and 190 dB RMS or above, respectively, are considered to have been taken by Level A (i.e., injurious) harassment. Behavioral harassment (Level B) is considered to have occurred when marine mammals are exposed to sounds at or above 160 dB RMS or impulse sounds (e.g., impact pile driving) and 120 dB RMS for continuous noise (e.g., vibratory pile driving), but below injurious thresholds. For airborne noise, pinniped disturbance from haul-outs has been documented at 100 dB for pinnipeds in general, and at 90 dB for harbor seals. NMFS uses these levels as guidelines to estimate when harassment may occur.

Gear interactions causing mortality/serious injury on non-serious Level A harassment may occur in Center fisheries surveys described at 7.2; Level B harassment associated with use of active acoustics equipment may also occur in SWFSC fisheries surveys. These surveys are described at 1.6 and 7.2 and include the following. The SWFSC believes that the activities listed below: (1)

will have a negligible impact on the affected species or stocks of marine mammals (based on the likelihood that the activities will not affect annual rates of recruitment or survival); and (2) will not have an unmitigable adverse impact on the availability of the species or stock(s) for subsistence uses.

7.3.1 Surveys conducted in the CCE that may take marine mammals by Level B harassment using category 2 acoustic sources

Coastal Pelagic Species (CPS) Survey (aka. Sardine Survey). Level B harassment associated with use of active acoustics may occur.

Juvenile Salmon Surveys. Level B harassment associated with use of active acoustics may occur.

Juvenile Rockfish Surveys. Level B harassment associated with use of active acoustics may occur.

CalCOFI Survey - Winter. There have been no gear interactions associated with this survey; however, Level B harassment associated with use of active acoustics may occur.

CalCOFI Survey - Spring. There have been no gear interactions associated with this survey; however, Level B harassment associated with use of active acoustics may occur.

CalCOFI Survey - Summer. There have been no gear interactions associated with this survey; however, Level B harassment associated with use of active acoustics may occur.

CalCOFI Survey - Fall. There have been no gear interactions associated with this survey; however, Level B harassment associated with use of active acoustics may occur.

PaCOOS Central CA (MBARI). There have been no gear interactions associated with this survey; however, Level B harassment associated with use of active acoustics may occur.

PaCOOS Northern CA, Humboldt State University (HSU). There have been no gear interactions associated with this survey; however, Level B harassment associated with use of active acoustics may occur.

Highly Migratory Species (HMS) Surveys. Level B harassment associated with use of active acoustics may occur.

Thresher Shark Surveys. Level B harassment associated with use of active acoustics may occur.

Marine Mammal Ecosystem Surveys. There have been no gear interactions associated with this survey; however, Level B harassment associated with use of active acoustics may occur.

White Abalone Survey. There have been no gear interactions associated with this survey; however, Level B harassment associated with use of active acoustics may occur.

Collaborative Optical Acoustical Survey Technology (COAST) Survey. There have been no gear interactions associated with this survey; however, Level B harassment associated with use of active acoustics may occur.

Habitat Surveys. Level B harassment associated with use of active acoustics may occur.

Small boats. There have been no gear interactions associated with this survey; however, Level B harassment associated with use of active acoustics may occur.

7.3.2 Surveys conducted in the ETP that may take marine mammals by Level B harassment using category 2 acoustic sources

Marine Mammal Ecosystem Surveys. There have been no gear interactions associated with this survey; however, Level B harassment associated with use of active acoustics may occur.

Highly Migratory Species (HMS) Surveys. There have been no gear interactions associated with this survey; however, Level B harassment associated with use of active acoustics may occur.

7.3.3 Surveys conducted in the AMLR that may take marine mammals by Level B harassment using category 2 acoustic sources

Antarctic Survey. There have been no gear interactions associated with this survey; however, Level B harassment associated with use of active acoustics may occur.

7.4 Collision and Strike

Commercial and Navy ship strikes of cetaceans can cause major wounds, which may lead to the death of the animal. An animal at the surface could be struck directly by a vessel, a surfacing animal could hit the bottom of a vessel, or an animal just below the surface could be cut by a vessel's propeller. The severity of injuries typically depends on the size and speed of the vessel (Knowlton and Kraus 2001; Laist et al. 2001; Vanderlaan and Taggart 2007).

Injuries and death to marine mammals resulting from ship collisions caused by vessels during SWFSC research are not likely to occur. The probability of vessel and marine mammal interactions occurring during Center operations is negligible due to the vessel's slow operational speed, which is typically 4 kts or less. Outside of operations, each vessel's cruising speed would be approximately 10 kts, which is generally below the speed at which studies have noted reported increases of marine mammal injury or death (Laist et al., 2001).

Even though the likelihood of a ship strike is very small, we reviewed the available literature to assess the possible impact of ship strike as it applies to SWFSC survey vessels. Williams and O'Hara (2009) summarized their modeling efforts to characterize ship strikes of large cetaceans in British Columbia. Their information on ship strikes was based on ship activity provided to them by the Canadian Coast Guard. Spatially-explicit statistical modeling and Geographic Information System visualization techniques identified areas of overlap between shipping activity and waters used by humpback, fin and killer whales. Areas of highest risk were far removed from areas with high concentrations of people, suggesting that many beach-cast carcasses could go undetected. With few exceptions, high-risk areas were found in geographic bottlenecks, such as narrow straits and passageways. Although not included in the geographic area of the Williams and O'Hara study, the SWFSC survey area is such an area where large numbers of cargo ships transit the area each year, yet evidence for ship collisions are rare. Williams and O'Hara (2009) state that their risk assessments illustrate where ship strikes are most likely to occur, but cannot estimate how many strikes might occur. Propeller wounds on live killer whales were common in their study region, and fatal collisions have been reported in B.C. for all three species.

In an analysis of the probability of lethal mortality of large whales at a given speed, results of a study using a logistic regression model showed that the greatest rate of change in the probability of a lethal injury to a large whale, as a function of vessel speed, occurs between vessel speeds of 8.6 and 15 knots (Vanderlaan and Taggart, 2007). Across this speed range, they found that the chances of a lethal injury decline from approximately 80% at 15 knots to approximately 20% at 8.6 knots. Notably, it is only at speeds below 11.8 knots that the chances of lethal injury drop below 50% and above 15 knots the chances asymptotically increase toward 100%. Vessels associated with the SWFSC survey project will not be traveling at speeds that could be lethal to large whales, including killer whales. Vessels associated with this project when conducting scientific research will be travelling <4 kts and at 10 kts during transit. Considering this slow speed and the continual bridge watches/observation for marine mammals during all ship operations, the SWFSC believes that the vessels will be able to change course if any marine mammal is sighted in the line of vessel movement and avoid a strike. Even under the remote chance that a strike occurs by a Center vessel it is unlikely to result in mortality.

Jensen and Silber (2003) summarized large whale ship strikes world-wide from 1975 to 2003 and found that most collisions occurred in the open ocean involving large vessels. Commercial fishing vessels were responsible for four of 134 records (3%), and one collision (0.75%) was reported for a research boat, pilot boat, whale catcher boat, and dredge boat.

There is a potential for vessels to strike cetaceans while traveling at slow speeds. For example, a NOAA contracted survey vessel traveling at low speed while conducting multi-beam mapping surveys off the central California coast struck and killed a female blue whale in October 2009. Pace and Silber (2005) found that the probability of death or serious injury increased rapidly with increasing vessel speed. Specifically, the predicted probability of serious injury or death increased from 45% to 75% as vessel speed increased from 10 to 14 kts, and exceeded 90 percent at 17 kts. Higher speeds during collisions result in greater force of impact, but higher speeds also appear to increase the chance of severe injuries or death by pulling whales toward the vessel. Computer simulation modeling showed that hydrodynamic forces pulling whales toward the vessel hull increase with increasing speed (Clyne 1999; Knowlton et al. 1995). In the case of the Center's vessels, we anticipate that vessel collisions with marine mammals are unlikely, unpredictable events for which there are no preventive measures. That said, although these surveys have the potential for vessel collision, we anticipate no adverse effects on annual rates of recruitment or survival of the affected marine mammal species or stocks because of the slow speed of the vessels, the move on rule, and visual monitoring.

7.5 Conclusions Regarding Impacts of SWFSC Fisheries Research Activities on Marine Mammal Species and Stocks

As outlined in this and previous sections, there are several SWFSC fisheries research activities that have the potential to cause Level B harassment, Level A harassment (injury), and serious injury or mortality of marine mammals in the CCE, ETP and AMLR study areas. However, because of the low level of historical interactions relative to the abundance of affected populations, as well as the low level of predicted future takes associated with SWFSC surveys, the SWFSC believes its activities will not affect annual rates of recruitment or survival or the health and condition of the species or stock of the requested species.

- As discussed earlier in this Section, the requested annual takes associated with entanglement or hooking in SWFSC fisheries research surveys over the period 2013-2018 do not exceed any stock's PBR, and for most affected stocks the SWFSC take request is only a small fraction of PBR.

- In the AMLR study area, SWFSC expects due to the density of pinnipeds hauled out on ice in the southern hemisphere winter some animals will experience Level B harassment when the survey vessel passes during the course of conducting research operations. However, these events are expected to be infrequent and ephemeral. Further, cited studies on pinniped disturbance do not indicate that impacts would be of the magnitude are likely to result in population-level impacts.

- In the CCE, ETP and AMLR, SWFSC surveys use a variety of active acoustic systems. These are expected to result in Level B harassment for marine mammals in close proximity to the survey vessel and its active acoustic systems. However, as noted previously in this section exposure to active acoustics used on SWFSC fisheries research surveys is not expected to result in injury to animals and behavioral disturbance is expected to be relatively short lived and not result in population level impacts.

Based on this information the SWFSC believes that its activities: (1) will have a negligible impact on the affected species or stocks of marine mammals (based on the likelihood that the activities will not affect annual rates of recruitment or survival); and (2) will not have an unmitigable adverse impact on the availability of the species or stock(s) for subsistence uses.

8. THE ANTICIPATED IMPACT OF THE ACTIVITY ON THE AVAILABILITY OF THE SPECIES OR STOCKS OF MARINE MAMMALS FOR SUBSISTENCE USE.

The proposed activity will take place in the California Current Ecosystem, the Eastern Tropical Pacific, and the Antarctic. There are no relevant subsistence uses of marine mammals implicated by this action in these areas.

9. THE ANTICIPATED IMPACT OF THE ACTIVITY ON THE HABITAT OF THE MARINE MAMMAL POPULATIONS AND THE LIKELIHOOD OF RESTORATION OF THE AFFECTED HABITAT.

9.1 Changes in Food Availability

Prey of marine mammals varies by species, season, and location and, for some, is not well documented. SWFSC fisheries research removals of commonly utilized species are few in number and small in size and typically do not include the size and age of fish taken in commercial fisheries or consumed by marine mammals. Research takes are distributed over a wide area because of the random sampling design covering large sample areas. Fish removals by research are unlikely to affect the spatial concentrations and availability of prey for these species.

There is some overlap in prey of marine mammals in the CCE and the species sampled and removed during SWFSC research surveys. The removal by SWFSC fisheries research, regardless of season and location is, however, trivial relative to that taken through commercial and sport fisheries. Sardines are sampled during research surveys to determine fecundity and only a kilogram or less is needed on any one tow to determine female fecundity. The total annual removal of sardine in the CCE, whether targeted or caught incidentally in other research surveys, is approximately 1000 kg. Similarly SWFSC removal of anchovy, jack mackerel, and other fish that are consumed by marine mammals is a very small amount. Also, SWFSC fisheries research surveys catch very short (a few cm) juvenile rockfish that are not known to be prey of marine mammals in the CCE. Thus, SWFSC fish sampling during research surveys in the CCE is unlikely to effect changes in prey type, distribution, or quantity available to any marine mammals. The resulting impact of the catch level on prey resources would, therefore, be negligible.

Table 9.1 shows the average SWFSC research catch of target species in the CCE over the past five years compared to the allowable biological catch (ABC) or other metric for commercial harvests of these species. Only species that have been taken in quantities over 100 kg per year are shown. In all cases for which there are fishing metrics for comparison, the SWFSC research catch represents much less than 0.1% of the ABC or other metric for the target species. For all target species in the CCE, mortality from SWFSC research surveys is considered minor on the population level.

The lack of impact of fisheries research takes is especially true for pinnipeds in the CCE. With pinniped populations increasing and ranges expanding in the Pacific Northwest, food availability does not appear to be a limiting factor (Baraff and Loughlin 2000). All the pinnipeds that occur within the CCE are opportunistic predators that consume a wide assortment of fish and squid, including managed species such as rockfish, hake, anchovy, sardine, herring, and squid (summarized in Baraff and Loughlin 2000). Given the comparatively low catch rate by SWFSC and broad prey base of pinnipeds in the area, the potential for impacts on prey availability is negligible.

Finally, in the CCE SWFSC research activities overlap with areas that have been identified as Essential Fish Habitat (EFH) for several Fishery Management Plans, including the Coastal Pelagic Species, Highly Migratory Species and Groundfish Fishery Management Plans. However, the proposed research is expected to result in impacts that are no more than minimal and temporary in nature to EFH. Mortality from captures in surveys is a potential impact, but as noted previously past levels of catch in SWFSC research surveys are very small and considered negligible to their respective populations. For species that are targeted by commercial fisheries, mortality due to research surveys is much less than one percent of commercial harvest and is considered to have negligible adverse effects for all species. Further, these gears are deployed in pelagic habitats, which due to their physical characteristics, are not affected in the same way benthic habitats are when they are contacted by fishing and research gears. For these reasons SWFSC research will have effects that are minimal and temporary in nature on any areas identified as EFH for federally managed species.

Table 9.1. Relative size of SWFSC research catch in California Current Ecosystem compared to commercial allowable biological catch (ABC). Only target species taken in excess of 100 kg per year are shown.

Species	Stock Status	Average SWFSC Research Catch per year (kg) (2007-2011 data)	ABC Commercial Catch Reference Value (kg)	Average SWFSC Research Catch, Compared to ABC Reference Value (percentage)
Blue shark	Not overfished	900	N/A	N/A
Common Mola	Monitored	1,135	N/A	N/A
Common thresher shark	Not overfished	2,200	N/A	N/A
Jack mackerel	Monitored	392	31,000,000	0.0003%
Jacksmelt	Monitored	330	N/A	N/A
North Pacific albacore tuna	Not overfished	1,589	405,000,000	0.0039%
Northern anchovy	Monitored	1,201	34,750,000	0.0003%
Pacific hake (whiting)	Not overfished	1,045	2 million metric tons (mt) (2011 spawning biomass)	<0.0001%
Pacific mackerel	Not overfished	7,534	42,375,000	0.0178%
Pacific sardine	Not overfished	1,564	84,681,000	0.0019%
Shortbelly rockfish	Not overfished	412	23,500,000	<0.0001%
Shortfin mako shark	Not overfished	2,500	N/A	N/A
Spiny dogfish	Not overfished	189	1,584,000	0.0001%
Yellowtail rockfish	Not overfished	117	4,320,000	<0.0001%

SWFSC research activities remove very small quantities of fish from the ETP, primarily larval and juvenile size classes caught in plankton nets. Overall catch of fish is only about 1 kg per year which is negligible for all species in the ETP.

SWFSC AMLR surveys in the Antarctic monitor Antarctic krill and remove a small amount of post-larval and adult krill during sampling with trawl nets in order to estimate krill biomass around the South Shetland Islands and South Orkney Islands. The amount of krill biomass removed is an insignificant amount compared to the amount of Antarctic krill available. Krill is consumed by numerous marine mammals including southern fur seals, balaenopterid whales, and others. Therefore the small amount of krill removed by SWFSC will not cause changes in prey distribution or availability to marine mammals and the impact of the removal is negligible to none. The SWFSC also conducts periodic bottom trawl surveys in the South Orkney Islands area to monitor the recovery of several finfish that were overfished in the 1970s and 1980s. These surveys are only conducted every two or three years as funds and charter vessels become available. During the last research survey, conducted during the 2008-2009 season, only nine species were harvested in totals greater than 100 kg (Table 9.2). Although no commercial fisheries metrics have been determined for these species for many years, given the very small catches of all species and the periodic frequency of the finfish survey, the effects of SWFSC research mortality on fish species in the Antarctic can be considered negligible.

The overall effects of SWFSC research activities on fish populations found in the CCE, ETP, and AMLR are minor since they are of negligible magnitude and intensity, short-term in duration, of localized geographic extent, and are unlikely to result in measurable population change.

Table 9.2. SWFSC research catch in the Antarctic research area during bottom trawl surveys. No information is available on current stock size or status for any species. Data from Van Cise (2009).

Species	SWFSC Research Catch per survey (kg) (2008-2009 data)
Blackfin icefish	1,920
Mackerel icefish	575
Ocellated icefish	618
Humped rockcod	2,628
Grey rockcod	505
Black rockcod	110
South Georgia icefish	656

9.2 Changes in Physical Habitat

Physical impacts to seafloor habitat would be principally limited to the AMLR, which is the only SWFSC research area where bottom-contact trawl equipment is used during the course of research surveys (see Table 1.1). Such surveys would occur once every three years and have historically involved 75 bottom trawl hauls per survey.

Fishing gear that contacts the seafloor can physically damage seafloor habitat. Physical damage may include furrowing and smoothing of the seafloor as well as the displacement of rocks and boulders, and such damage can increase with multiple contacts in the same area (Morgan and Chuenpagdee 2003; Stevenson et al. 2004). Other survey equipment that contacts the seafloor, such as sensors and samplers, could cause localized physical damage to benthic habitats; but the effects of such equipment on benthic habitat would be limited to a very small area because this equipment is not usually dragged along the seafloor.

In general, physical damage to the seafloor recovers within 18 months through the action of water currents and natural sedimentation, with the exception of rocks and boulders which may be permanently displaced (Stevenson et al. 2004). Silt, sand, clay, and gravel are abundant at particular sites within each research area. With the exception of rock and boulder displacement, any physical impacts to benthic habitat resulting from SWFSC survey activities would be expected to recover within 18 months.

Bottom-contact fishing gear can also increase turbidity and alter the chemical composition of water near the seafloor. However, these effects would be short-term, minor in magnitude, and limited in areal extent.

The area of benthic habitat affected by SWFSC research each year would be a very small fraction of the total of the research areas. Considering the small area affected and the limited magnitude of the physical effects, the overall effects of surveys on benthic habitat in each of the SWFSC research areas would be minor.

10. ANTICIPATED IMPACT OF LOSS OR MODIFICATION OF THE HABITAT ON MARINE MAMMAL POPULATIONS

As stated in response to Question 9 above, the proposed activities are not anticipated to result in impacts to marine mammal habitats or to the food resources on which they depend. Therefore, we do not expect any long-term adverse impacts to marine mammals resulting from loss of or modification to marine mammal habitats as a result of the proposed activities.

11. THE AVAILABILITY AND FEASIBILITY (ECONOMIC AND TECHNOLOGICAL) OF EQUIPMENT, METHODS, AND MANNER OF CONDUCTING SUCH ACTIVITY OR OTHER MEANS OF EFFECTING THE LEAST PRATICABLE ADVERSE IMPACT UPON THE AFFECTED SPECIES OR STOCKS, THEIR HABITAT, AND ON THEIR AVAILABILITY FOR SUBSISTENCE USES, PAYING PARTICULAR ATTENTION TO ROOKERIES, MATING GROUNDS, AND AREAS OF SIMILAR SIGNIFICANCE

Over the past five years, the SWFSC has invested significant time and effort in identifying technologies, practices and equipment to minimize the impact of the proposed activities on marine mammal species and stocks and their habitat. These efforts have resulted in the consideration of several mitigation measures, most of which SWFSC has determined to be feasible and has implemented during 2009 and 2010 as a standard part of sampling protocols (Hewitt 2009). These measures include the “move-on rule,” protected species visual watches and use of acoustic pingers on trawl gear, as well as current implementation of a marine mammal excluder device in Nordic 264 trawls and planned design and implementation of this device in modified Cobb trawls.

In addition, SWFSC is conducting an evaluation of oceanographic conditions and other factors that might contribute to interactions in order to avoid those conditions to minimize future takes. SWFSC staff have been using predictive machine-learning methods (classification trees) for various applications, including a recently published paper (Carretta and Barlow 2011) examining bycatch rates of cetaceans and pinnipeds in a commercial swordfish and thresher shark drift gillnet fishery in relation to the use of acoustic pingers. Using similar methods, the SWFSC plans to examine research trawl data for any link between trawl variables and observed marine mammal bycatch. SWFSC staff are currently reviewing historical fisheries research data to determine whether sufficient data exist for such an analysis. Some of the variables SWFSC is currently considering for this analysis are: moon phase, sky cover, pinger presence, trawl speed, vessel sonar use during trawl, use of deck lights, etc. SWFSC is exploring patterns in past marine mammal bycatch in its fisheries research surveys to better understand what factors might increase the likelihood of take. If take patterns emerge, the SWFSC will focus future research on reducing or eliminating high-risk factors in ways that enable scientifically important surveys to continue with minimized environmental impact.

11.1 Trawl Surveys

11.1.1 Monitoring methods

If marine mammal observers are not present and already conducting watches, marine mammal watches will be initiated 30 minutes prior to arrival on station to determine if these species are near the proposed trawl set location. When observers are not present the Officer on Deck (OOD), Chief Scientist (CS), and crew standing watch will visually scan for marine mammals during all daytime operations. Marine mammal watches will be conducted using any binocular or monocular sighting instrument, with a means to estimate distance to infringing protected species during daytime, and the best available means of observation during nighttime observations. This typically occurs during transit leading up to arrival at the sampling station because of another mitigation measure intended to reduce the risk of attracting curious marine mammals, immediate deployment of trawl gear upon arriving at station. However, in some cases it may be necessary to conduct a bongo plankton tow prior to deploying trawl gear. In these cases, the visual watch will continue until trawl gear is ready to be deployed.

11.1.2 Operational procedures

"Move-On" Rule. If marine mammals or other protected species are sighted within 1 nm of the planned set location in the 30 minutes before setting the gear, the vessel will transit to a different section of the sampling area to maintain a minimum set distance of 1 nm. If, after moving on, protected species remain within the 1 nm exclusion zone, the CS or watch leader may decide to move again or to skip the station. However, SWFSC acknowledges that the effectiveness of visual monitoring may be limited depending on weather and lighting conditions, and it may not always be possible to conduct visual observations out to 1nm. CS or watch leader will determine the best strategy to avoid potential takes of marine mammals based on the species encountered, their numbers and behavior, position and vector relative to the vessel, and other factors. For instance, a whale transiting through the area off in the distance might only require a short move from the designated station while a pod of dolphins gathered around the vessel may require a longer move from the station or possibly cancellation if they follow the vessel. In any case, no gear will be deployed if marine mammals or other protected species have been sighted within 1 nm of the planned set location during the 30-minute watch period.

In many cases, trawl operations will be the first activity undertaken upon arrival at a new station, in order to reduce the opportunity to attract marine mammals to the vessel. However, in some cases it will be necessary to conduct plankton tows prior to deploying trawl gear in order to avoid trawling through extremely high densities of jellies and similar taxa that are numerous enough to severely damage trawl gear.

Once the trawl net is in the water, the OOD, CS, and/or crew standing watch will continue to monitor the waters around the vessel and maintain a lookout for marine mammal presence as far away as environmental conditions allow. If marine mammals are sighted before the gear is fully retrieved, the most appropriate response to avoid incidental take will be determined by the professional judgment of the CS, watch leader, OOD and other experienced crew as necessary. This judgment will be based on his/her past experience operating gears around marine mammals and SWFSC training sessions that will facilitate dissemination of Chief Scientist / Captain expertise operating in these situations (e.g., factors that contribute to marine mammal gear interactions and those that aid in successfully avoiding these events). These judgments take into consideration the species, numbers, and behavior of the animals, the status of the trawl net operation (net opening, depth, and distance from the stern), the time it would take to retrieve the net, and safety considerations for changing speed or course.

If trawling operations have been suspended because of the presence of protected species, the vessel will resume trawl operations (when practicable) only when these taxa have not been sighted within 1 nm of the planned set location. This decision is at the discretion of the officer on watch and is dependent on the situation.

Care will be taken when emptying the trawl to avoid damage to protected species that may be caught in the gear but are not visible upon retrieval. The gear will be emptied as quickly as possible after retrieval in order to determine whether or not protected species are present.

11.1.3 Tow duration

Standard tow durations of not more than 30 minutes at the target depth have been implemented, excluding deployment and retrieval time (which may require an additional 30 minutes depending on depth), to reduce the likelihood of attracting and incidentally taking marine mammals and other protected species. These short tow durations decrease the opportunity for curious marine mammals to find the vessel and investigate.

Trawl tow distances are less than 3nm, which should reduce the likelihood of attracting and incidentally taking marine mammals. Typical tow distances are 1-2 nm, depending on the survey and trawl speed.

11.1.4 Marine mammal excluder devices

Whenever possible, trawl nets will be fitted with marine mammal excluder devices (see Appendix A for detailed description) to allow marine mammals caught during trawling operations an opportunity to escape. These devices enable target species to pass through a grid or mesh barrier and into the codend while preventing the passage of marine mammals, which are ejected out through an escape opening or swim back out of the mouth of the net.

Two types of trawls are used in SWFSC surveys: the Nordic 264 and the Modified Cobb trawl. Currently, all Nordic 264 nets are outfitted with excluder devices developed for the SWFSC (Appendix A). Most marine mammals caught during SWFSC operations have been caught in surveys using this type of net before the excluder devices were installed.

Modified Cobb trawls are considerably smaller than Nordic rope trawls, are fished at slower speeds, and have a different shape and functionality than the Nordic 264. Due to the smaller size of the modified Cobb, this gear does not yet have marine mammal excluder devices but research and design work are currently being performed to develop effective excluders that will not appreciably affect the catchability of the net and therefore maintain continuity of the fisheries research data set. Successful development and implementation of excluder devices for Modified Cobb trawls is expected to occur within the 5 year timeframe of this EA and is therefore included as part of the Preferred Alternative.

A reduction in target salmon catch rates is an issue that has arisen from preliminary analyses conducted by NWFSC when the MMED is used in Nordic 264 gear. Although NWFSC sample sizes are small, the preliminary results have cast some doubt as to whether the MMED would be suitable for surveys with a primary objective of estimating abundance (whether they use the Nordic 264 or the Modified Cobb gears). If data collected by NWFSC and SWFSC during testing of the MMED in Modified Cobb trawl gear continues to indicate reduce catch rates SWFSC would expect to continue testing to explore whether it is possible to calculate reliable conversion factors to equate catches when using the MMED to surveys when it was not. If this is not possible, then implementation of the MMED in these surveys may also not be possible without compromising one of their primary objectives.

11.1.5 Acoustic pinger devices

Pingers will be deployed during all trawl operations and all types of trawl nets. Two to four pingers will be placed along the footrope and/or headrope to discourage marine mammal interactions.

Acoustic pingers are underwater sound emitting devices that decrease the probability of entanglement or unintended capture of marine mammals (see Appendix A). Acoustic pingers have been shown to effectively deter several species of small cetaceans from becoming entangled in gillnets and driftnets (e.g., no observed catches of beaked whales after pingers implemented reported in Carretta and Barlow 2011; 50% reduction in common dolphin entanglement reported in Cameron and Barlow 2003; 60% reduction in harbor porpoise bycatch reported in Palka et al. 2008). While their effectiveness has not been tested on trawls, pingers are believed to represent a mitigation measure worth pursuing given their effectiveness in other gears.

Pingers are manufactured by STM Products, model DDD-03H. Pingers remain operational at depths between 10 meters (m) and 200 m. Tones range from 100 microseconds to seconds in duration, with variable frequency of 5-500 kilohertz (kHz). Maximum sound pressure level of 176 decibels (dB) root mean squared referenced to 1 micropascal at 1 m at 30-80 kHz.

11.1.6 Gear maintenance

The vessel's crew will clean trawl nets prior to deployment to remove prey items that might attract marine mammals. Catch volumes are typically small, with every attempt made to collect all organisms caught in the trawl.

11.1.7 Speed limits and course alterations

The vessel's speed during active sampling will rarely exceed 5 knots. Typical speeds during trawling are 2-4 knots. Transit speeds vary from 6-14 knots, but average 10 knots.

As noted above, if marine mammals are sighted within 30 minutes prior to deployment of the trawl net, the vessel will be moved away from the animals to a new station.

At any time during a survey or in transit, any crew member standing watch or dedicated marine mammal observer that sights marine mammals that may intersect with the vessel course will immediately communicate their presence to the bridge for appropriate course alteration or speed reduction as possible to avoid incidental collisions.

11.2 Longline Gear

11.2.1 Visual surveillance by OOD, CS, and crew

Longline surveys are conducted aboard smaller vessels and with fewer crew than trawl surveys but the pre-set monitoring procedures for longline gear are the same as described for trawling gear. No longline sets are made if marine mammals or other protected species have been seen within 1nm of the planned set location during the past 30 minutes, the move-on rule is implemented if these taxa are present, and the CS, watch leader, and OOD uses professional judgment to minimize the risk to protected species from potential gear interactions.

The only exception is when California sea lions are sighted during the watch period prior to setting longline gear. For this species only, longline gear may be set if a group of 5 or fewer animals is sighted within 1 nm of the planned set location; when groups of more than 5 sea lions are sighted within 1 nm deployment of gear would be suspended. This exception has been defined considering the rarity of past interactions between this gear and CA sea lions and in order to make this mitigation measure practicable to implement. Without it, given the density of CA sea lions in the areas where longline surveys are conducted, SWFSC believes implementing the move-on rule for a single animal would preclude sampling in some areas and introduce significant bias into survey results. Groups of 5 California sea lions or greater is believed to represent a trigger for the move-on rule that would allow sampling in areas where target species can be caught without increasing the number of interactions between marine mammals and research longline gear.

11.2.2 Operational procedures

SWFSC longline sets are conducted with drifting pelagic or anchored gear marked at both ends with buoys (Appendix A). Typical soak times are 2-4 hours, but may be as long as 8 hours when targeting swordfish (measured from the time the last hook is in the water to when the first hook is brought out of the water).

SWFSC longline protocols specifically prohibit chumming (releasing additional bait to attract target species to the gear). However, spent bait may be discarded during gear retrieval while gear is still in the water. In the experience of SWFSC, this practice increases survey efficiency and has not resulted in interactions with marine mammals. Scientist observations indicate pinnipeds do not gather immediately aft of the survey vessel as a result of discarding spent bait. However, if protected species interactions with longline gear increase or if SWFSC staff observe that this practices is contributing to protected species interactions it will revisit this practice and consider the need to retain spent bait until no gear remains in the water.

If protected species are detected while longline gear is in the water, the CS, watch leader and OOD exercise similar judgments and discretion to avoid incidental take of these taxa with longline gear as described for trawl gear. The species, number, and behavior of the marine mammals are considered along with the status of the ship and gear, weather and sea conditions, and crew safety factors. The CS, watch leader and OOD will use professional judgment and discretion to minimize risk of potentially adverse interactions with protected species during all aspects of longline survey activities.

If protected species are detected during setting operations and are considered to be at risk, immediate retrieval or halting the setting operations may be warranted. If setting operations have been halted due to the presence of protected species, resumption of setting will not begin until they have not been observed within 1 nm of the set location.

If marine mammals are detected during retrieval operations and are considered to be at risk, haul-back may be postponed until the CS, watch leader or OOD determines that it is safe to proceed. SWFSC anticipates that additional information on practices to avoid marine mammal – longline gear interactions can be gleaned from protected species training sessions and more systematic data collection standards being implemented by SWFSC.

11.3 AMLR Bottom Trawl Surveys

The SWFSC has no historical interactions with marine mammals in bottom trawl gear used in the Scotia Sea Antarctic ecosystem. Researchers conduct visual and acoustic surveys prior to deploying bottom trawl gear to assess the bathymetry and whether marine mammals are present in the area. These visual and acoustic surveys have resulted in very few detections of marine mammals during trawling operations, possibly because there is infrequent spatial-temporal overlap between bottom trawl surveys and significant densities of protected species. This may help to explain the absence of marine mammal interactions with this gear during past AMLR surveys. Visual and acoustic monitoring will continue as a regular part of future bottom trawl surveys in the AMLR study area, and if detections increase at some point in the future that may indicate a higher potential for marine mammal interactions.

11.4 Deep-set Buoy Gear Surveys

SWFSC does not anticipate deep-set buoy surveys to results in any marine mammal takes, and these surveys have resulted in no past takes. While no formal mitigation measures have been implemented, it should be noted the gear is specifically designed to minimize risk of protected species interactions. For example, minimal visual and/or sensory attractants to the gear in the upper water column (e.g., no surface chumming or offal discharge, no visual cues from multiple hooks that are sinking to depth slowly) SWFSC believes minimizes hooking and entanglement risk. In addition, this gear features a single weighted monofilament line with virtually no slack or sag that is expected to minimize entanglement risk.

11.5 Sablefish Life History Surveys

These surveys have not historically taken marine mammals, and SWFSC does not anticipate that they will in the future. As such, no formal mitigation measures have been implemented for this survey/gear. However, factors that minimize future take likelihood include this survey's extremely small scale and low level of effort (approximately 200 hooks per month). In addition, because this gear fishes at the bottom it poses a significantly reduced risk of hooking and entanglement relative to surface gears.

11.6 Plankton Nets, Oceanographic Sampling Devices, Video Camera and ROV Deployments

The SWFSC deploys a wide variety of gear to sample the marine environment during all of their research cruises. These types of gear are not considered to pose any risk to protected species and are therefore not subject to specific mitigation measures. However, the OOD and crew monitor for any unusual circumstances that may arise at a sampling site and use their professional judgment and discretion to avoid any potential risks to protected species during deployment of all research equipment.

11.7 Handling Procedures for Incidentally Captured Individuals

The SWFSC is implementing a number of handling, data collection and reporting protocols to minimize potential harm to protected species that are incidentally taken during the course of fisheries research activities. In general, protocols have already been prepared for use on commercial fishing vessels. Because many parallels exist between commercial fishing operations and SWFSC fisheries research, SWFSC is adopting these protocols for use on its surveys on NOAA and charter vessels. In addition to the benefits implementing these protocols are believed to have on the animals through increased post-release survival, SWFSC believes adopting these protocols for data collection will also increase the information on which "serious injury" determinations are based and improve scientific knowledge about protected species that interact with fisheries research gears and the factors that contribute to these interactions.

Protected Species Handling

In general, following a "common sense" approach to handling protected species will present the best chance of minimizing injury to the animal and of decreasing risks to scientists, officers and crew. There are inherent safety concerns associated with handling/disentangling protected species, so using judgment and ensuring human safety is paramount.

SWFSC researchers will be provided with the PIFSC guide to "Identification, Handling and Release of Protected Species" (Appendix B.1) for more specific guidance on protected species handling. In addition to including this guide, Appendix B.1 contains data forms SWFSC will use for protected species interactions. The guide demonstrates how to identify different species, bring an individual aboard a vessel, assess the level of consciousness, remove fishing gear, return an individual to water and log activities pertaining to the interaction. The handling guide for marine mammals demonstrates how to handle, disentangle, and also record interaction activities for small whales and dolphin encounters.

For longline surveys, SWFSC will record interaction information on either the Marine Mammal Biological Data Form prepared by the Pacific Islands Regional Office Longline Observer Program (Appendix B.2). To aid in serious injury determinations and comply with the current NMFS Serious Injury Guidelines, researchers will also answer a series of supplemental questions on the details of marine mammal interactions. Forms and supplemental questions are provided in (Appendix B.3). For trawl surveys, the SWFSC will follow the same protocol as mentioned above for longline surveys.

Finally, for any marine mammals that are killed during fisheries research activitites, scientists will collect data and samples pursuant to the SWFSC MMPA and ESA research and salvage permit and to the "Detailed Sampling Protocol for Marine Mammal and Sea Turtle Incidental Takes on SWFSC Research Cruises" (Appendix B.4). Although SWFSC is taking several significant measures to avoid incidentally killing marine mammals during the course of its fisheries research it also recognizes the scientific value of collecting samples from these animals to learn more about wild marine mammal populations.

12. WHERE THE PROPOSED ACTIVITY WOULD TAKE PLACE IN OR NEAR A TRADITIONAL ARCTIC SUBSISTENCE HUNTING AREA AND/OR MAY AFFECT THE AVAILABILITY OF A SPECIES OR STOCK OF MARINE MAMMAL FOR ARCTIC SUBSISTENCE USE, THE APPLICANT MUST SUBMIT EITHER A "PLAN OF COOPERATION (POC)" OR INFORMATION THAT IDENTIFIES WHAT MEASURES HAVE BEEN TAKEN AN/OR WILL BE TAKEN TO MINIMIZE ANY ADVERSE EFFECTS ON THE AVAILABILITY OF MARINE MAMMALS FOR SUBSISTENCE USE.

Not applicable. The proposed activity will take place in the California Current Ecosystem, the Eastern Tropical Pacific, and the Antarctic, and no activities will take place in or near a traditional Arctic subsistence hunting area. There are no relevant subsistence uses of marine mammals implicated by this action.

13. MONITORING AND REPORTING PLAN

13.1 Monitoring

Marine mammal watches are now a standard part of conducting fisheries research activities, particularly those that use gears (e.g., longlines and mid-water trawls) that are known to interact with marine mammals or that we believe have a reasonable likelihood of doing so in the future. Marine mammal watches are conducted in two ways. First, watches are conducted by watch-standers (those navigating the vessel and other crew) at all times when the vessel is being operated. The primary focus for this type of watch is to avoid striking marine mammals and to generally avoid navigational hazards. At present, these watch-standers do not record or report to the scientific party data on marine mammal sightings except when gear is being deployed or retrieved. In most cases, watches in the first category are not done by dedicated staff; these personnel may have other duties associated with navigation and other vessel operations.

Second, marine mammal watches and monitoring occur for 30 minutes prior to deployment of gear, and they continue until gear is brought back on board, for longlines and mid-water trawl gear. Watches in this category are done by dedicated scientists with no other responsibilities during the watch period. If marine mammals are sighted within 1 nm of the planned set location then the sampling station is either moved or canceled. Watch-standers record the estimated species and number of animals present and their behaviors. This information can be valuable in understanding whether some species may be attracted to vessels or gears.

13.2 Reporting

As is normally the case, SWFSC will coordinate with the local Southwest Regional Stranding Coordinator and the NMFS Stranding Coordinator for any unusual marine mammal behavior and any stranding, beached live/dead, or floating marine mammals that are encountered during field research activities. In addition, Cruise Leaders provide reports to SWFSC leadership and to the Office of Protected Resources by event, survey leg and cruise. As a result, when marine mammals interact with the gear, whether killed or released alive, a report provided by the Cruise Leader will fully describe any observations of the animals, the context (vessel and conditions), decisions made and rationale for decisions made in vessel and gear handling. The circumstances of these events are critical in enabling SWFSC and the Office of Protected Resources to better evaluate the conditions under which takes are most likely occur. We believe in the long term this will allow us to avoid some of these situations in the future.

NOAA Fisheries has established a formal incidental take reporting system, the Protected Species Incidental Take (PSIT) database, requiring that incidental takes of protected species be reported within 48 hours of the occurrence. The PSIT generates automated messages to agency leadership and other relevant staff and alerts them to the event and that updated information describing the circumstances of the event have been inputted into the database. The PSIT and Chief Scientist reports represent not only a valuable real-time reporting and information dissemination tools, but also serve as an archive of information that could be mined at later points in time to study why takes occur, by species, gear, etc. Ultimately, SWFSC would hope that a single reporting tool capable of disseminating and archiving all relevant details of protected species interactions during fisheries research activities could be developed and implemented. Until that time, SWFSC will both input data into the PSIT database and submit detailed event reports.

A final and equally important component of reporting being implemented by SWFSC will facilitate serious injury (SI) determinations for marine mammals that are released alive. As discussed in Section 11, SWFSC is requiring that scientists complete data forms (already developed and used by commercial fisheries observer programs) and address supplemental questions, both of which have been developed to aid in SI determinations. SWFSC understands the critical need to provide scientists who make serious injury determinations with as much relevant information as possible about marine mammal interactions to inform their decisions.

14. COORDINATING RESEARCH TO REDUCE AND EVALUATE INCIDENTAL TAKE

NOAA Fisheries and the SWFSC provide a significant amount of funding and support to marine research. Specifically, NOAA Fisheries provides significant funding annually to universities, research institutions, Federal laboratories, private companies, and independent researchers around the world to study marine mammals. The SWFSC actively participates on Take Reduction Teams and in Take Reduction Planning, and it conducts a variety of studies, convenes workshops and engages in other activities aimed at developing effective bycatch reduction technologies, gears and practices. For example, the studies conducted by staff in the SWFSC Protected Resources Division have led to use of pingers in commercial fisheries to reduce beaked whale bycatch, development of alternative gears to reduce vaquita bycatch in Mexican shrimp fisheries, refinement of cetacean-habitat models to reduce ship strikes on the U.S. West Coast, and advances in circle hook technology to reduce protected species bycatch in South American longline fisheries. In addition, we have convened a number of expert workshops to address global bycatch issues, including in the purse-seine fishery for tuna in the eastern tropical Pacific and in West African nations to reduce bycatch.

Notably, in 2008, the SWFSC convened a workshop to evaluate and recommend mitigation measures in response to the sharp increase in marine mammal takes that it experienced in fisheries research activities earlier that year. In addition, oceanographic conditions of the time and location of interactions were evaluated to determine whether the events coincided with predictable oceanographic features. Workshop participants included SWFSC fisheries researchers and experts in bycatch reduction from the Protected Resources Division. As a result of this workshop, the SWFSC implemented a number of mitigation measures in 2009 and 2010 in fisheries research activities that use longline and trawl gears. Those include use of marine mammal watches, acoustic pingers, a marine mammal excluder device and others. The SWFSC will continue to foster this research to further reduce takes of protected species in both its operations and in commercial fisheries to the lowest practicable levels.

The SWFSC has a keen awareness that an increase in fisheries research effort is expected to result in more marine mammal takes over time. For this reason and because of resource limitations, the SWFSC maximizes efficient use of the charter and NOAA ship time it can attain. We also engage in operational plans with the Northwest and Pacific Islands Fisheries Science Centers in order to clearly delineate our respective research responsibilities and to ensure we avoid research gaps and duplication of effort between Centers. In short, the SWFSC is on the water conducting fisheries research activities no more often than is necessary to fulfill its responsibilities to provide scientific advice to the Southwest Regional Office, the Pacific Fisheries Management Council, and other relevant domestic and international management bodies.

Finally, as referenced in several earlier sections, SWFSC plans to implement an adaptive management approach to evaluating its actual takes on an annual basis and continuing to revisit its mitigation measures in light of take events to ensure they are appropriate. In consultation with Office of Protected Resources, if actual takes exceed those estimated in Section 6 of this application SWFSC may deem it necessary to change its current mitigation strategy to improve efficacy or to implement additional measures to reduce take levels.

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APPENDIX A – SWFSC Research Gear and Vessel Descriptions

APPENDIX B – Data collection forms, protocols and supplemental questions to facilitate serious injury determination