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

Pacific Islands Fisheries Science Center

within the

Hawaiian Archipelago, Mariana Archipelago, American Samoan Archipelago, and Western and Central Pacific Research Areas

November 2015

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1.0 A 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 Pacific Islands Fisheries Science Center (PIFSC), National Marine Fisheries Service (NMFS). 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 from the shoreline [those waters 3-12 nautical miles offshore comprise territorial waters and those 12-to-200 nautical miles 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, National Oceanic and Atmospheric Administration (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.

The PIRO conducts fisheries research in the Hawaiian Archipelago Research Area (HARA), the Mariana Archipelago Research Area (MARA), the American Samoa Archipelago Research Area (ASARA) and the Western and Central Pacific Ocean. 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), the Tuna Conventions Act, the ESA, Migratory Bird Treaty Acts, the International Dolphin Conservation Program Act. Accomplishing the requirements of these statutes requires the close interaction of numerous entities in a sometimes complex fishery management process. In the Pacific Islands, the entities involved are a NMFS Regional Fisheries Science Center; NMFS Regional Office; NMFS Offices of Protected Resources, Sustainable Fisheries and Science and Technology; the Western Pacific Regional Fisheries Management Council; the Western and Central Pacific Fisheries Commission (WCPFC), the International Commission for the Conservation of Atlantic Tunas (ICCAT), and the Inter-American Tropical Tuna Commission (IATTC).

1.1 Fisheries Science Centers

Six Regional Fisheries Science Centers gather, direct, and coordinate the collection of scientific information needed to inform fisheries management decisions. Each Fisheries Science Center is a distinct entity and is the scientific focal point for a particular region (Figure 1.1). The Pacific Islands Fisheries Science Center (PIFSC) conducts research and provides fisheries and ecosystem scientific information to resource managers throughout the Western and Central Pacific Ocean (Figure 1.2). PIFSC provides scientific information to support the Western Pacific Fishery Management Council and Western Pacific Fisheries Information Network (WPacFIN) that compiles fisheries data from the territories of Guam and American Samoa, the Commonwealth of the Northern Mariana Islands, the State of Hawai‘i, and other domestic and international fisheries management organizations.

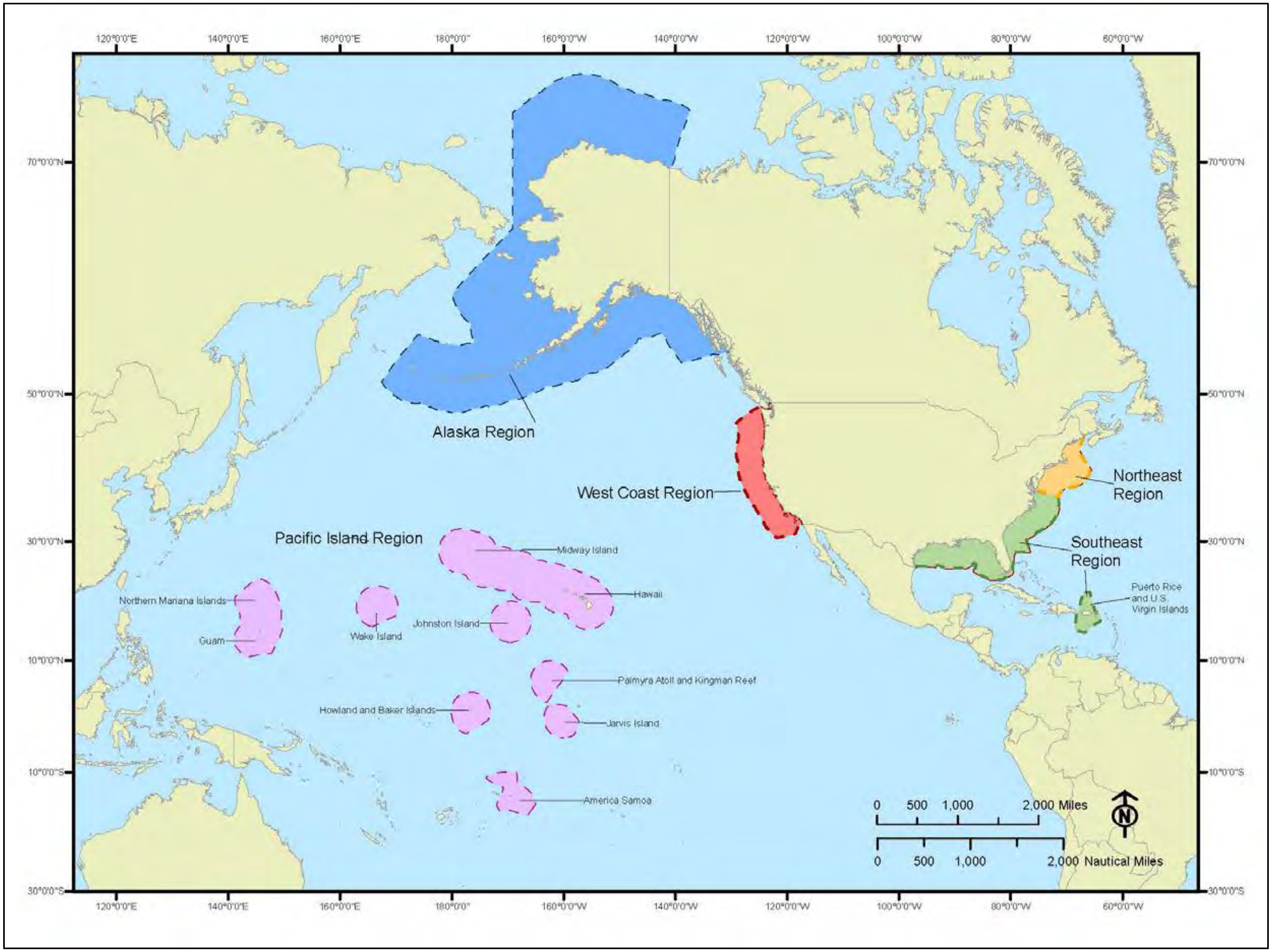


Figure 1.1 National Marine Fisheries Service Regions

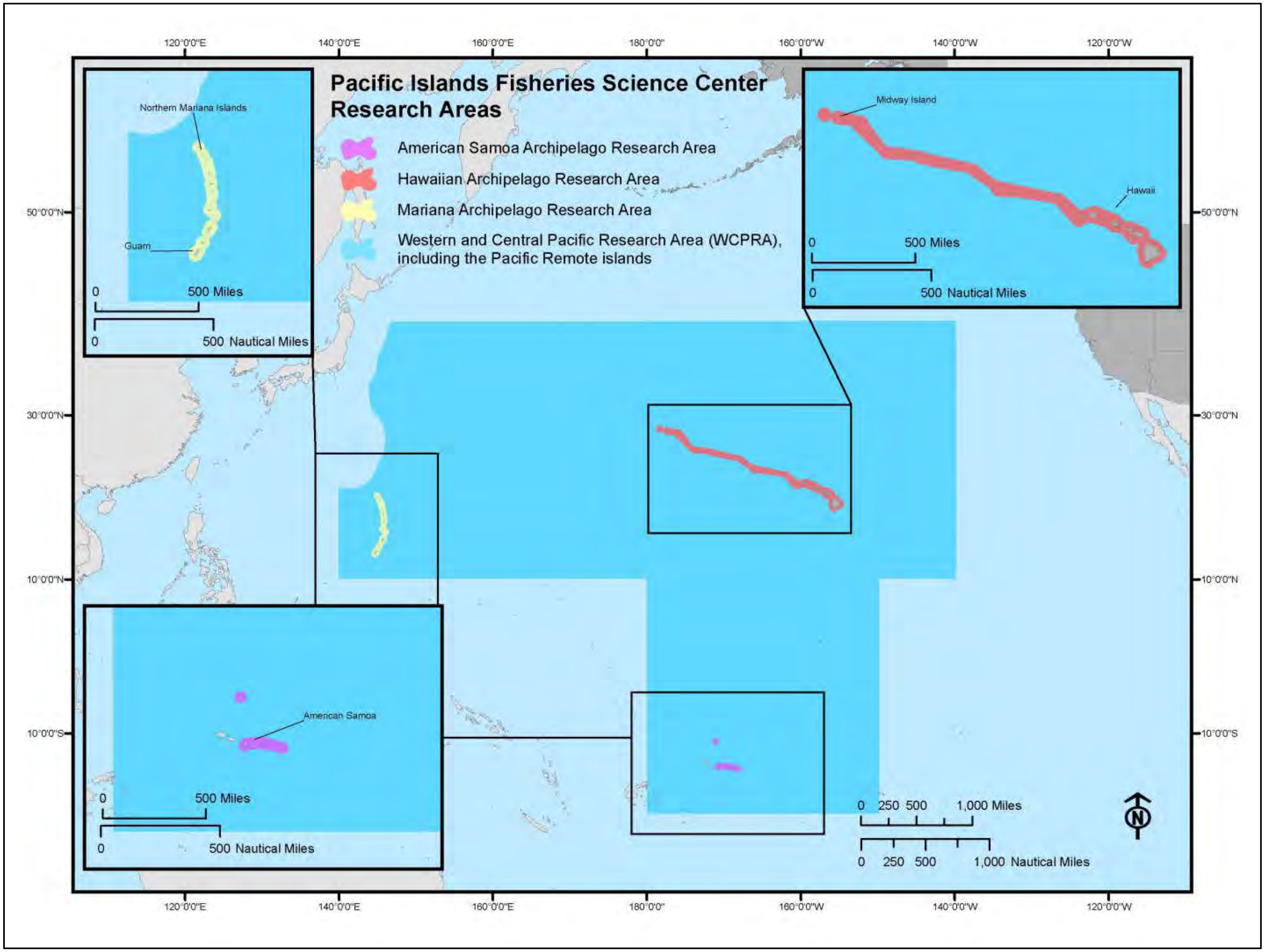


Figure 1.2 **PIFSC Research Areas**

1.2 Domestic and International Fisheries Management Organizations and Agreements

PIFSC conducts fisheries research utilized for management of an array of species inhabiting a vast geographic region. Fisheries management of these species involves numerous domestic and international organizations with complex interrelationships and overlapping jurisdictions. These organizations include: Fisheries Management Councils, International Fisheries Management Organizations and Commissions, International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean, South Pacific Tuna Treaty, South Pacific Regional Fisheries Management Organization, Convention on the Conservation and Management of High Seas Fisheries Resources in the North Pacific Ocean, Inter-American Convention for the Protection and Conservation of Sea Turtles, Inter-American Tropical Tuna Commission (IATTC). Many details of these areas of responsibility along with maps of these operational areas are presented and discussed in depth in Chapter 1 in the accompanying Draft Programmatic Environmental Assessment (Draft PEA) prepared for this application. To streamline review and to avoid redundancy, the reader is referred to that document for details.

1.3 Role of Fisheries Research in Federal and Regional Fisheries Management

PIFSC provides stock assessments and other scientific information to assist with the development of Fisheries Management Plans (FMPs) prepared by the Western Pacific Regional Fishery Management Council (WPRFMC), Pacific Fishery Management Council (PFMC), and other 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 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.

In addition to providing information to domestic fisheries management councils, PIFSC provides scientific advice to support numerous international fisheries councils, commissions, and conventions including the Western and Central Pacific Fisheries Commission, International Whaling Commission, and the Parties to the Agreement on the International Dolphin Conservation Program.

1.4 PIFSC Research Divisions

PIFSC is the research arm of NMFS in the Pacific Islands Region. PIFSC 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.

Effective May 3, 2015, PIFSC underwent a reorganization of its division structure to better represent the future research mission and more closely align with other NMFS offices. The new structure includes the Director’s Office, three research divisions (Ecosystem Sciences; Fisheries Research and Management; and Protected Species), and two administrative divisions (Operations, Management, and Information; and Science Operations). The former Coral Reef Ecosystem Division, Ecosystem and Oceanography Division, and Socioeconomics Program were combined to form the Ecosystem Sciences Division. The Director’s Office is responsible for overall scientific leadership and research direction, program management, and operational policy.

1.4.1 Ecosystem Sciences Division

The Ecosystem Sciences Division conducts multidisciplinary research, monitoring, and analysis of integrated environmental and living resource systems in coastal and offshore waters of the Pacific Ocean. Field research activities cover from near-shore island-associated ecosystems such as coral reefs, to open ocean ecosystems on the high seas. Research focus includes: oceanography, coral reef ecosystem assessment and monitoring, benthic habitat mapping, and marine debris research and removal. Analysis of the current structure and dynamics of marine environments, as well as examination of potential projections of future conditions such as those resulting from climate change impacts are assessed with use of numerical ecosystem models. Because humans are a key part of the ecosystem, the ESD includes research of the social and economic aspects of fishery and resource management decisions. The ESD also provides scientific and capacity building support to international organizations.

1.4.2 Fisheries Research and Monitoring Division

The Fisheries Research and Monitoring Division provides fisheries research and monitoring science to support fisheries management in the Pacific Islands Region. The Division's fisheries research activities include: investigations into target fish species' life history; production of assessments of population size and characteristics for target and non-target species; and research into methods to reduce bycatch of non-target species, including modifications to fishing gear and use of deterrent devices. The Division also monitors fishing activity in Federal fisheries via logbook and compiles reports of these data, as well as works with State of Hawai‘i and Pacific Territorial agencies to enhance their fisheries monitoring efforts. The Division provides information about and findings from its fisheries research and monitoring activities to a variety of stakeholders, including the Western Pacific Regional Fishery Management Council (Council) and Regional Fishery Management Organizations (RFMOs; conventions that govern catch of highly migratory species throughout the central and western Pacific), and participates in collaborations and fishing gear technology transfer with foreign nations and with non-governmental organizations.

1.4.3 Protected Species Division

The Protected Species Division conducts scientific investigations which serve as a basis for management decisions and actions to enhance the conservation and recovery of endangered Hawaiian monk seals, endangered and threatened sea turtles, whales, and dolphins. The Division is comprised of three programs: the Hawaiian monk seal Research Program, the Turtle Research Program, and the Cetacean Research Program. Research objectives for all three programs address species-specific topics designed to assess and monitor population trends, characterize biology and natural history, understand foraging ecology and movement patterns at sea, identify and investigate impediments to population growth, and build research capacities with other stakeholders. The Division also conducts community outreach and education activities to share information with stakeholders and promote the stewardship of protected species.

1.4.4 Science Operations Division

The Science Operations Division (SOD) provides the technical and logistical support necessary to carry out the PIFSC science mission in the field and the lab. SOD is composed of three complementary units: Program Coordination, Survey, and Technical Services. The Program Coordination unit is responsible for communicating science needs and plans in the Marine National Monuments of the Pacific. This includes working closely with our research and management partners located in Hawai‘i, Guam, American Samoa, and the Commonwealth of the Northern Mariana Islands. The Survey unit provides the hands-on operational and scientific support for field research using advanced sampling technologies while on ships and small boats. The Technical Services unit facilitates compliance of research activities with applicable environmental statutes and regulations, including NEPA and permits. Technical Services also facilitates document preparation for publication and maintains the research library facilities.

1.4.5 Operations, Management, and Information Division

The Operations, Management, and Information Division (OMID) provides support for strategic and annual operations planning; budget allocation and execution; FTE and human resources management (including EEO and diversity); administrative processes, data and information management information technology, e-mail and telecommunications systems; environmental compliance, safety and facilities management. Other functions include travel services, acquisition and grants, and all other administrative services in support of Center scientists.

1.5 PIFSC Fisheries and Ecosystem Research Activities

PIFSC conducts fisheries research that may incidentally take marine mammals. Detailed information describing the time of year projects are conducted, the regions of operations, the gear used, and methodological details of those fisheries research projects anticipated to be conducted for the foreseeable future is presented in Table 1.1. PIFSC is requesting rulemaking and subsequent Letters of Authorization for these proposed activities. Additional information and details are contained Appendix A. In general, all PIFSC surveys are set in an ecological context. That is, PIFSC conducts concurrent hydrographic, oceanographic, and meteorological sampling in addition to the marine resource surveys. PIFSC anticipates that these long-term surveys are likely to continue during the next five years or longer, although not necessarily every year.

Table 1.1 **Summary description of PIFSC fisheries and ecosystem research activities in the Pacific Islands Region**

Survey Name	Survey Description	General Area of Operation	Season, Frequency& Yearly Days at Sea (DAS)	Vessel Used	Gear Used	Gear Details	Total Number of Samples (Approximated)
Sampling Pelagic Stages of Insular Fish Species	Results of sampling inform life history and stock structure studies for pelagic larval and juvenile stage specimens of insular fish. Additional habitat information is also collected. Target species are snapper, grouper, and coral reef fish species within the 0-175 m depth range. Pelagic stages sampling is conducted both at midwater depths using a "Stauffer" modified Cobb trawl (Cobb trawl) or a 10-foot Isaacs-Kidd trawl, and at the surface using a 6-foot Isaacs-Kidd trawl. Surveys may occur every year in the HARA, but approximately once every three years in the MARA, ASARA, and WCPRA.	HARA MARA ASARA WCPRA 3-200 nautical miles (nm) from shore	Year-round HARA: up to 20 Days at Sea (DAS) MARA, ASARA, WCPRA: up to 30 DAS approximately once in research area every three years Midwater trawls are conducted at night, surface trawls are conducted day and night	NOAA Ship *Oscar Elton Sette* or equivalent vessel	Cobb trawl (midwater trawl) or Isaacs-Kidd 10-foot (ft) net (midwater trawl)	Tow speed: 2.5-3.5 knots (kts) Duration: 60-240 minutes (min) Depth: deployed at various depths during same tow to target fish at different water depths, usually to 250 meters (m)	40 tows per survey per year
					Isaacs-Kidd 6-ft net (surface trawl) Dip net (surface) Trawl mounted OES Netmind (midwater)	Tow speed: 2.5-3.5 kts Duration: 60 min Depth: Surface	40 tows per survey per year
Spawning Dynamics of Highly Migratory Species	Early life history studies provide larval stages for population genetic studies and include the characterization of habitat for early life stages of pelagic species. Egg and larval collections are taken in surface waters using a variety of plankton gear, primarily Isaac-Kidd 6-foot surface trawl, but also sometimes including 1-meter ring net and surface neuston net.	HARA MARA ASARA WCPRA 1-25 nm from shore	Year-round HARA: up to 25 DAS MARA, ASARA, WCPRA: up to 25 DAS approximately once in research area every three years Surface trawls are conducted day and night	*Oscar Elton Sette* or equivalent vessel, Small boats	Isaacs-Kidd 6-foot net (surface)	Tow speed: 2.5-3.5 kts Duration: 60 min Depth: Surface	140 tows per survey per year
					Neuston tows (surface) 1-m ring net (surface)	Tow Speed: 2.5-3.5 kts Duration: 30-60 min Depth: 0-3 m	140 tows per survey per year
Cetacean Ecology Assessment	Survey transects conducted in conjunction with cetacean visual and acoustic surveys within the Hawai'i EEZ to develop ecosystem models for cetaceans. Sampling includes active acoustics to determine relative biomass density of sound scattering layers; trawls to sample within the scattering layers; cetacean observations; surface and water column oceanographic measurements and water sample collection.	HARA MARA ASARA WCPRA	Variable timing, depending on ship availability, up to 180 DAS Usually conducted in non-winter months Midwater trawls are conducted at night, surface trawls are conducted day and night All other gear and instruments are conducted day and night	*Oscar Elton Sette*, NOAA Ship *Hi'ialakai,* Small boats, Contracted fishing vessels	Cobb trawl (midwater trawl)	Tow speed: 3 kts Duration: 60-240 min	180 tows total per year
					Small-mesh towed net (surface trawl)	Tow Speed: 2.5-3.5 kts Duration: 30-60 min	180 tows per research area
					Active acoustics (splitbeam Simrad EK60; trawl mounted OES Netmind)	38-200 kHz	Intermittent continuous during surveys
					ADCP (RD Instruments Ocean Surveyor 75)	75 kHz	Intermittent continuous during surveys
					CTD profiler	90 min	2 per day
					XBT	10 min duration. Profiles from surface to up to 1000n m depth	Maximum 5 per day
	<u>*Passive Acoustics Calibration*</u> - Transmit sound (synthetic pings, dolphin whistles or echolocation clicks, etc.) to passive acoustic recording devices for purposes of in-situ calibration, needed to understand detection distances and received level or frequency-dependent variation in the device performance.	HARA MARA ASARA WCPRA			Underwater sound playback system	Includes underwater projector and amplifier suspended from small boat or ship. Projection depth may vary from near surface to 100 m.	Intermittent

Survey Name	Survey Description	General Area of Operation	Season, Frequency& Yearly Days at Sea (DAS)	Vessel Used	Gear Used	Gear Details	Total Number of Samples (Approximated)
	Stationary Passive Acoustic Recording - Placement of long-term acoustic listening devices for the purposes of recording cetacean occurrence and distribution, ambient and anthropogenic noise levels, and presence of other natural sounds. Recorders are typically deployed and retrieved once or twice per year at each monitoring location.	HARA MARA ASARA WCPRA			HARP, EAR, or similar device	Deployed in seafloor package or mooring configuration consisting of recorder, acoustic releases, anchor and flotation	Up to tenlong-term monitoring sites
	Passive Acoustic Monitoring - Deployment of passive acoustic monitoring devices in conjunction with other sampling measures, such as on fishing gear or free-floating.	HARA MARA ASARA WCPRA			Miniature HARPs or similar platforms	Autonomous recorder package modified for attachment to longline gear, oceanographic mooring, or free-floating. Various configurations may have surface buoys with recorder up to 1000 ft below, or may have smaller form factor with entire package not exceeding 1m length.	Continuous
	Passive Acoustic or Oceanographic Gliders - Autonomous underwater vehicles used for sub-surface profiling and other sampling over broad areas and long time periods. Passive acoustic device integrated into the vehicle provide measure of cetacean occurrence and background noise. CTD, pH, fluorometer, and other sensors provide oceanographic measures over several months duration.	HARA MARA ASARA WCPRA			Seaglider; WaveGlider; or similar platform	Autonomous underwater vehicle. Buoyancy driven glider profile from surface to pilot-controlled depth (up to 1000 m), Inertial vehicles driven by wave-action have surface float with solar panels and communication antennas with sub-surface sled carrying sensors 5-20 m below surface.	Continuous
Marine Debris Research and Removal	Surface and midwater plankton tows to quantify floating microplastic in seawater	HARA MARA ASARA WCPRA	Annually, or on an as-needed basis, up to 30 DAS Surface trawls are conducted day and night UAS are conducted during the day or night In-water and beach activities are conducted during the day	*Oscar Elton Sette, Hi'ialakai,* or equivalent vessel Small boats	Neuston, or similar, plankton nets surface towed alongside ship and/or small boats	Tow Speed: varied Duration: < 1 hour	Up to 250 tows per survey per year
	The use of UAS platforms can aid in CRED's efficiency during survey and removal operations by directing efforts to high density areas	HARA			UASs (e.g., NOAA PUMA or NASAIkhana systems, hexacopter)	Deployed from shore, small boat, or ship. Operate along shoreline or over water around atoll.	Less than 20 operations per island or atoll per year
	Adding more frequent marine debris research and removal activities to other research areas.	MARA WCPRA	Additional 30 DAS		Same as above	Same as above	Same as above
	Collection and sieving of mesoplastics from beach sand located between the low and high tide lines. Plastics are removed for sampling and further study.	HARA			Sieves	Sieving of mesoplastics (> 500 microns in size) from sand.	100 samples per atoll
Coral Reef Benthic Habitat Mapping	Produces comprehensive digital maps of coral reef ecosystems using multibeam sonar surveys and optical validation data collected using towed vehicles and AUVs.	HARA MARA ASARA WCPRA	Year-round 30 DAS Day and night	*Oscar Elton Sette, Hi'ialakai,* or equivalent vessel Small boats	Active acoustics (will vary by vessel): Multibeam Simrad EM3002 D and EM300, multibeam Reson 8101 ER, Imagenex 837 DeltaT, split-beam Simrad EK60	18-300 kilohertz (kHz)	Continuous

Survey Name	Survey Description	General Area of Operation	Season, Frequency& Yearly Days at Sea (DAS)	Vessel Used	Gear Used	Gear Details	Total Number of Samples (Approximated)
Deep Coral and Sponge Research	Research includes opportunistic surveys on distribution, life history, ecology, abundance, and size structure of deep corals and sponges using ROV, divers, and submersibles. Besides visual surveys, sampling protocols include collection of coral and sponges for genetic, growth and reproductive work and an array of data loggers (temperature, currents, particulate load) placed on the bottom for recovery in future years.	HARA MARA ASARA WCPRA	Opportunistically Year-round, 50 DAS Day and night	NOAA Ship *Okeanos Explorer*, *Oscar Elton Sette*, *Hi'ialakai,* *Ka'imikai-o-Kanaloa,* or equivalent vessel	Remotely Operated Vehicle (ROV), divers, submersibles, Autonomous Underwater Vehicle (AUV), landers, instrument packages, Ship-based multibeam (SeaBeam 3012 multibeam, Kongsberg EM-302 30 kHz, EK-60 18kHz, Knudsen 3260 sub-bottom profiler 3.5 kHz)	ROVs include the Super Phantom S2 ROV system operated by the Undersea Vehicles Program at the University of North Carolina at Wilmington. Subs include Pices V and Pices IV and similar Human occupied vehicles (HOV) AUV includes Seabed and other unmanned systems Hull-mounted 3.5-30 kHz multibeam	HARA: 200 MARA: 200 ASARA: 200 WCPRA: 200 DNA specimens N=100, mean weight (wt) = 10 grams (g) Voucher specimens N=60 wt = 10-500 g Paleo-specimens N=40, wt=500-2000 g
Insular Fish Life History Survey and Studies	Provide size ranges of deepwater eteline snappers, groupers, and large carangids to determine sex-specific length-at-age growth curves, longevity estimates, length and age at 50% reproductive maturity within the Bottomfish Management Unit Species (BMUS) in Hawai'i and the other Pacific Islands regions. Specimens are collected in the field and sampled at markets.	HARA: (0.2 -5 nm from shore) every year. MARA ASARA WCPRA	HARA: July-September, up to 15 DAS/yr. Other areas: Year-round, up to 30 DAS for each research area once every three years Day and night	*Oscar Elton Sette* or equivalent vessel, Contracted fishing vessels, Small boats	Hook-and-line	Hand line, electric or hydraulic reel: Each operation involves 1-3 lines with.4-6 hooks per line; soaked 1-30 min. Squid bait on circle hooks (typically 10/0 to 12/0).	HARA: 350 operations per year Other areas: 240 operations per year for each research area
Pacific Reef Assessment and Monitoring Program (RAMP)	Ecosystem surveys that include rapid ecological assessments; towed-diver surveys; coral disease, invertebrates, fish, and algae surveys; and oceanographic characterization of coral reef ecosystems. Surveys also include training to conduct surveys which occur between 0-3nm from shore, year-round, using small boats, SCUBA or closed circuit rebreathers (CCR) diver surveys, sampling, and deployment of various equipment. Samples and specimens collected in the field would be analyzed in the laboratory.	HARA MARA ASARA WCPRA; 0-20 nm from shore	Year-round; annual (each research area is surveyed triennially) 30-120 DAS depending on which area is surveyed In-water activities with divers are conducted during the day, all other activities are conducted day and night	*Oscar Elton Sette*, *Hi'ialakai*, Small boats	Hand gear used by SCUBA and free divers	Spear gun, slurp gun (a clear plastic tube designed to catch small fish by sliding a plunger backwards out of the tube), hand net, including small boat operations with SCUBA Hammer, chisel, bone cutter, shears, scissors, clippers, scraping, syringe, core-punch, hand snipping Temporary transect line, surface marker buoy, 1 m long plastic spacer pole with camera	MARA: Ad hoc fish collections from 2009, less than 20 specimens. Up to 500 samples per year including corals, coral products, algae and algal products, and sessile invertebrates (size range from fragments to entire individuals/colonies, although the smallest possible sample will be taken - typically only a few centimeters (cm) in diameter but perhaps occasionally larger X transects per year with 30 pole contacts on the substrate for each photo-transect site
					Pneumatic/hydraulic drill for coral coring	Approximately 4 cm diameter and ≤ 100 cm long masonry drill bit used to extract a 2.5 x 5-70 cm coral sample	30 coral cores per year
					Active acoustics: will vary by vessel (Multi-beam: Reson8101 ER; split-beam: Simrad EK60)	38-200 kHz	Continuous
					Bioerosion monitoring units (BMUs)	1 x 2 x 5 cm pieces of relic calcium carbonate, placed next to the reef and deployed at 0-40 m	Up to 500 deployments per year Deployed for approximately 1-3 years
					Autonomous reef monitoring structures (ARMS)	36 x 46 x 20 cm structure placed on pavement or rubble (secured to bottom by stainless steel stakes and weights) in proximity to coral reef structures	150 deployments for a duration of typically1-3 years each

Survey Name	Survey Description	General Area of Operation	Season, Frequency& Yearly Days at Sea (DAS)	Vessel Used	Gear Used	Gear Details	Total Number of Samples (Approximated)
					Sea Bird Electronics SBE56 temperature recorders	Instrument and mounting brackets are 10 x 5 x 30 cm, anchored to a dead portion of the reef with two coated 3lb dive weights and cable ties, typically deployed at 5-25 m, but may reach 30 m	Typically deployed for 1-3 years
					ADCP	Nortek Aquadopp Sideseeing Profiler, 2 MHz down to 30m	Continuous during transects
					Conductivity, temperature, depth (CTD) profiler (shallow-water and deep-water)	Shallow-water CTDs will be conducted from small boats to a depth of 30 meters Deep-water CTDs will be conducted from larger vessels to a maximum depth of 500 m.	Hundreds to thousands of casts per year for each CTD
					Baited remote underwater video system (BRUVS)	35 kg system weight with 1 kilogram (kg) of bait Deployed down to100 m to the seafloor	Up to 600 deployments per year Deployed for approximately 1 hour
					Calcification acidification units (CAUs)	Each CAU consists of 2 PVC plates (10 x 10cm) separated by a 1 cm spacer and mounted on a stainless steel rod which is installed by divers into the bottom (avoiding corals) down to 30 m	Up to 500 deployments per year Deployed for approximately 1-3 years
					EARs	Deployed by use of ~ 70 lb anchors guided into place by divers	25 EARs per year, typically deployed for 1-3 years
					Water samplers (PUCs, RAS, and hand collecting devices)		30 water samplers per year, deployed 1-7 days
					Carbonate Sensing Instruments [SEAFET (pH), SAMI (pH), SAMI (pCO_2)]	These CTD sized instruments are anchored to a dead portion of the reef with coated weights and cable ties, typically deployed at 5030 m deep	150 deployments per year, deployed for approximately 1-3 years
					Unmanned aerial systems (UASs) (e.g., NOAA PUMA or NASA Ikhana systems, hexacopter)	UASs would be used to collect coral reef ecosystem mapping & monitoring data. Initially testing and field trials would be conducted using multispectral, hyperspectral, or IR sensors. Surveys would be conducted around the MHI. Deployed from shore, small boat, or ship. Operate along shoreline or over water around atoll.	Less than 20 operations per island or atoll per year
					Emily Unmanned Surface Vehicles (USV) will be used to conduct nearshore sampling of surface and bottom variables, as well as ambient atmospheric conditions near the USV.		
					SCUBA and free divers	Visual fish identification and abundance surveys, benthic photo-transect	None
Surface Night-Light Sampling	Conducted opportunistically for decades aboard PIFSC research vessels. Sampling goals: collect larval or juvenile stages of pelagic or reef fish species that accumulate within surface slicks during daylight hours and those attracted to surface and submerged lights from research vessels at night.	HARA; primarily 1-25 nm from shore; adjacent to the Kona coast, but also out to 200 nm and beyond in the WCPRA	Year-round Up to 30 DAS Along with scheduled NOAA research cruises or opportunistically aboard other vessels. Night	*Oscar Elton Sette* or equivalent fisheries research vessel, or other vessels.	Net (dip)	Scoop nets (0.5 m diameter sometimes attached to 3-4 m long poles) used while vessel is drifting	30 night-light operations on all vessels combined. Total catch (all species) ≤ 1500 specimens of larval or juvenile fish per year

Survey Name	Survey Description	General Area of Operation	Season, Frequency& Yearly Days at Sea (DAS)	Vessel Used	Gear Used	Gear Details	Total Number of Samples (Approximated)
Pelagic Troll and Handline Sampling	Surveys would be conducted to collect life history and molecular samples from pelagic species. Other target species would be tagged-and-released. Different tags would used depending upon the species and study, but could include: passive, archival, ultrasonic, and satellite tags.	HARA, MARA, ASARA, 0 to 24 nm from shore (excluding any special resource areas)	Variable, up to 14 DAS Day and night	NOAA research vessels or the equivalent, or contracted fishing vessels.	Pelagic troll and handline (hook and line) fishing.	Troll fishing with up to 4 troll lines each with 1-2 baited hooks or 1-2 hook trolling lures at 4-10 kts. Pelagic handline (hook-and-line) fishing at 10-100 m midwater depths, with hand, electric, or hydraulic reels. Up to 4 lines. Each line is baited with 4 hooks.	A total of up to 2 operations of any of these gear types per DAS, totaling 28 operations (all types combined) for the survey.
Insular fish Abundance Estimation Comparison Surveys	Comparison of fishery-independent methods to survey bottomfish assemblages in the Main Hawaiian Islands: coordinated research between PIFSC EOD and FRMD, State of Hawai‘i Department of Land and Natural Resources, University of Hawai‘i at Manoa, University of Miami. Day and night surveys are used to develop fishery-independent methods to assess stocks of economically important insular fish. Methods include: active acoustics, stereo baited underwater video camera systems (BotCam, MOUSS, BRUVS), autonomous underwater vehicle (AUV) equipped with stereo video cameras, towed optical assessment device (TOAD), and hook-and-line fishing .	HARA MARA ASARA WCPRA	Variable, up to 30 DAS per research area per year, HARA surveyed annually, , ASARA, WCPRA surveyed every 3 years Sampling occurs day and night.	*Oscar Elton Sette, Hi‘ialakai*, or equivalent research vessel, and contracted fishing vessels	Hook-and-line	Hand, electric, hydraulic reels. Each vessel fishes 2 lines. Each line is baited with 4-6 hooks. 1-30 minutes per fishing operation.	HARA: 7,680 operations per year MARA: 1.920 every 3rd year (average) 640 operations per year) ASARA: 1,920 every 3rd year (average e 640 per year) WCPRA: 1,920 every 3rd year (average 640 per year)
					Active acoustics (split-beam): Simrad EK60	Hull mounted: 38-200 kHz	Intermittent continuous during surveys
					Underwater stereo-video camera systems (e.g., BotCam, BRUVS, MOUSS)	Deployed from ship or small boat on line Duration of camera drop: ≤30 min	HARA: 7,680 drops per year MARA: 1.920 every 3rd year (average 640 per year) ASARA: 1,920 every 3rd yr (average 640 per year) WCPRA: 1,920 every 3rd year (average 640 per year)
					AUV	Speed: 5 kts Duration: 3 hrs	HARA: 480 deployments per year MARA: 80 every 3rd year (average 27 per year) ASARA: 80 every 3rd year (average 27 per year) WCPRA: 80 every 3rd year (average27 per year)
					ROV	Duration: 1 hr	HARA: 480deployments per year MARA: 80 every 3rd year (average 27 per year) ASARA: 80 every 3rd year (average 27 per year) WCPRA: 80 every 3rd year (average 27 per year)
					TOAD	Tow speed: 6 kts Duration: 1 hr	HARA: 480 per year MARA: 80 every 3rd year (average 27 per year) ASARA: 80 every 3rd year (average27 per year) WCPRA: 80 every 3rd year (average27 per year)

Survey Name	Survey Description	General Area of Operation	Season, Frequency& Yearly Days at Sea (DAS)	Vessel Used	Gear Used	Gear Details	Total Number of Samples (Approximated)
Kona Integrated Ecosystem Assessment Cruise	Survey transects conducted off the Kona coast and Kohala Shelf area to develop ecosystem models for coral reefs, socioeconomic indicators, circulation patterns, larval fish transport and settlement. Sampling includes active acoustics to determine relative biomass density of sound scattering layers; trawls to sample within the scattering layers; cetacean observations; surface and water column oceanographic measurements and water sample collection.	HARA; 2-10 nm from shore	Variable timing, depending on ship availability, up to 10 DAS Day and night	*Oscar Elton Sette*, or equivalent vessel	Cobb trawl (midwater trawl)	Tow speed: 3 kts Duration: 60-240 min	15-20 tows/yr
					Hook-and-line	Electric or hydraulic reel: Each operation involves 1-3 lines, with squid lures, soaked 10-60 min at depths between 200m to 600m.	No more than 50 hours of effort. Approximately 10 mesopelagic squid caught per yr
					Small-mesh towed net (surface trawl)	Tow speed: 2.5-3.5 kts Duration: 30-60 min	
					Active acoustics Simrad split-beam EK60, trawl mounted OES Netmind, Didson 303	38-240 kHz Didson 303 is usually operated between 400m and 700m depth.	Intermittent, continuous during surveys Up to 12 Didson casts for up to 120 minutes per survey.
					Acoustic Doppler Current Profiler (RD Instruments Ocean Surveyor 75)	75 kHz	Intermittent, continuous during surveys
					CTD	45-90 min/cast	50 casts per year, alternating with Oceanography Cruise
Barbless Hook Donation	Donations of barbless circle hooks are made primarily at shore-based fishing tournaments or other outreach events to encourage replacement of barbed hooks in normal (legal) use. PIFSC has no control over the use of the hooks after the donation.	HARA	Year-round, 0 DAS	None	Barbless circle hooks	Hooks have the barbs crimped flat (barbs effectively removed)	Up to 35 events (days of donating hooks) per year. Up to 35,000 hooks donated per year
Gear and Instrument Development and Field Trials	Field trials to test the functionality of the gear prior to the field season, or to test new gear or instruments described elsewhere in this table, but outside the geographic scope specified for other surveys.	HARA (primarily in the waters south of Pearl Harbor on the Island of Oahu)	Year-round Up to 15 DAS Day and night	*Oscar Elton Sette*, *Hi'ialakai*, or equivalent vessel Small boats	Nets, lines, instruments Calibration of Simrad EK60	38-200 kHz	Intermittent for 24-48 hrs
Sampling of Juvenile-stage Bottomfish via Settlement Traps	Sampling activity to capture juvenile recruits of eteline snappers and grouper that have recently transitioned from the pelagic to demersal habitat. The specimens will provide estimates of birthdate, pelagic duration, settlement date, and pre-and post-recruitment growth rates derived from the analysis of otoliths. The target species include Deep-7 bottomfish and the settlement habitats these stages are associated with.	Main Hawaiian Islands; 0.2-5 nm from shore	July-September Up to 25 DAS Day and night	*Oscar Elton Sette,* or equivalent vessel, Small boats	Trap (settlement)	Cylindrical with dimensions up to 3 m long and 2 m diameter. Frame composed of semi-rigid plastic mesh of up to 5 cm mesh size. Folded plastic of up to 10 cm mesh is stuffed inside as settlement habitat, and cylinder ends are then pinched shut. Traps are clipped throughout the water column onto a vertical line anchored on bottom at up to 400 m, supported by a surface float.	10 traps per line set; up to 4 line sets soaked per day, from overnight up to 3 days. Up to 100 lines of traps set per yr. Catch of 2500 juvenile stage bottomfish per year
Mariana Resource Survey	Sampling activity to quantify baseline bottomfish and reef fish resources in the Mariana Archipelago Research Area. Various artificial habitat designs, Cobb trawl and IK trawls will be developed, enclosed in mesh used to retain captures, and evaluated collect pelagic-stage specimens of	MARA 0-25 nmi from shore	May - August Up to 102 DAS (once every three years) Midwater trawls are	*Oscar Elton Sette*	Large-mesh Cobb midwater trawl Isaacs-Kidd midwater trawl	Tow speed: 3 kts Duration: 60-240 min trawls; 2 tows per night Depth(s): deployed at various depths during same tow to target fish at different water depths, usually between 100 m and 200m	15-20 tows per survey per year

Survey Name	Survey Description	General Area of Operation	Season, Frequency& Yearly Days at Sea (DAS)	Vessel Used	Gear Used	Gear Details	Total Number of Samples (Approximated)
	reef fish and bottomfish species. Large fish traps (1m x 1m x2m) deployed along or perpendicular to determine bottom contour overnight to access adult reef and bottomfish composition relative to hook-and-line fishing. Traps will be primarily set in mesophotic habitats (50-200 m depths) and in the quality of each habitat for recent recruits. deep-slope bottomfish habitats (200-500m depths).		conducted at night, surface trawls are conducted day and night In-water activities are conducted during the day All others are day and night		Small-mesh surface trawl nets (Isaacs-Kidd, neuston, ring, bongo nets)	Tow speed: 3 kts Duration: up to 60 min. Depth: 0-200 m	15-20 tows (any combination of the nets described)
					Traps (Kona crab, enclosure)	Kona crab traps are nylon, with meshing spaced 2 1/2 inches apart attached to a wire ring with squid or fish bait set in the middle. Up to ten nets can be tied together with a buoy on the end net for retrieval. They are left for approximately 20 min. Enclosure traps are Fathoms Plus shellfish "lobster" traps or similar. These traps are dome-shaped, single-chambered, two entrance cones (with dimensions of 980 millimeter (mm) x 770mm x 295mm, with inside mesh dimensions of 45mm x 45mm). The traps are weighted and baited with the remains of life history samples from trolling and bottomfishing operations, and attached to two surface floats. Two strings of six traps each would be deployed at night on sand, rubble and pavement (i.e. not coral) substrate, and retrieved the next morning. Up to 20 traps per string, separated by 20 fathoms of ground line; two depths 10-35 fathoms. Up to 2 strings per DAS. Trap dimensions up to 1m high, 1 m wide, and 2 m long. Traps have outer mesh covering from 0.5-3.0 inch mesh and 1-2 funnel entrances. Trap is baited with fish using an inside baiter. Trap door swings open to retrieve catch and baiter.	25 gear sets per cruise Up to 400 strings set per year
					Simrad split-beam EK60, OES Netmind	38-200 kHz	Intermittent, continuous during surveys
				Small Boats	Hook-and-line	Electric or hydraulic reel: each operation involves 1-3 lines, with squid lures, soaked 10-60 min at depths between 200 m to 600 m.	1000 sets persurvey
					Divers (spear)	Speargun	1000 reef fish
Pelagic Longline, Troll, and Handline Gear Trials	Investigate effectiveness of various types of hooks, hook guards, gear configurations, or other modified fishing practices for reducing the bycatch of non-target species and retaining or increasing target catch. Data collected on catch efficacy, fish size, species selectivity, and survival upon haul-back Investigate the vertical distribution of pelagic species catch and capture time with time-depth recorders (TDRs) and hook-timers. Investigate behavior of catch and bycatch in relation to fishing operations using cameras, hydrophones, or other sensors. Catch may be tagged and released and specimens may be kept for genetic, physiological, and ecological studies. Troll and handline fishing for pelagic species may also be investigated, with tag and release of catch and collection of specimens.	Longline fishing would occur outside of: (1) all longline exclusions zones in the Hawai'i EEZ; (2) the Insular False Killer Whale range, and (3) all special resource areas. Longline fishing would occur up to approximately 500 nm from the shores of the Hawai'i Archipelago.	21 DAS Day and night	*Oscar Elton Sette,* Contracted longline fishing vessels	Pelagic longline	Gear as required by regulations in each area (See Appendix A). Soak time: 600-1800 min	Up to 21 longline operations per year

Survey Name	Survey Description	General Area of Operation	Season, Frequency& Yearly Days at Sea (DAS)	Vessel Used	Gear Used	Gear Details	Total Number of Samples (Approximated)
		25 to 500 nm from shore (excluding any special resource areas)			Trolling, and handline (hook-and-line)	Troll fishing with up to 4 troll lines each with 1-2 baited hooks or 1-2 hook troll lures at 4-10 kts Pelagic handline (hook-and-line) fishing at 10-100 m midwater depths, with hand, electric, or hydraulic reels. Up to 4 lines. Each line is baited with 4 hooks. Up to 4 hrs per troll or handline operation	Up to 21 troll or handline (combined) operations per year
Pelagic Oceanographic Cruise	Investigate physical (e.g., fronts) and biological features that define the habitats for important commercial and protected species of the North Pacific Ocean, especially tuna and billfishes, which are targeted by longline fishers. Sampling includes active acoustics to determine relative biomass density of sound scattering layers; trawls to sample within the scattering layers; surface and water column oceanographic measurements and water sample collection.	Pacific Ocean; Western and Central tropical and subtropical Pacific 25-1000 nm from shore in any direction	Annual (season variable) Up to 30 DAS Midwater trawls are conducted at night, surface trawls are conducted day and night All other activities are conducted day and night	*Oscar Elton Sette*, or equivalent vessel	Large-mesh Cobb midwater trawl	Tow speed: 3 kts Duration: 60-240 min	20 tows per year, alternating with Kona IEA cruise 4 liters of micronekton per tow
					Plankton drop net (stationary surface sampling)	1 meter diameter plankton drop net would be deployed down to 100 m	20 drops per year (collections would be less than one liter of plankton)
					Small-mesh surface and midwater trawl nets (Isaacs-Kidd, neuston, ring, bongo nets)	Duration: up to 60 min Depth: 0-200 m	15-20 tows (any combination of the nets described) <1 liter of organisms per tow
					Active acoustics: split-beam and multi-beam: Reson8101 ER; Deep water: Simrad EK60; trawl mounted OES Netmind	38-200 kHz	Intermittent, continuous during surveys
					ADCP (RD Instruments Ocean Surveyor 75)	75 kHz	Intermittent, continuous during surveys
					CTD profiler	45-90 min cast duration	60 casts per year, alternating with Kona IEA cruise# of 60 tows/yr
Lagoon Ecosystem Characterization	Measure the abundance and distribution of reef fish (including juvenile bumphead parrotfish) in any of the lagoons in the WCPRA over a two-week-long period by employing standardized transect and photo-quadrant techniques using SCUBA and snorkeling gear. A collection net may also be used to non-lethally sample fish species inhabiting the lagoon to determine genetic identity. Hook-and–line and spear may also be used to lethally collect specimens.	WCPRA	Up to 14 DAS Conducted during the day	Small boats	Divers with hand net or speargun	SCUBA, snorkel, 12-inch diameter small mesh hand net	10 dives per survey 10 fin clips collected for genetic analyses
					Hook-and-line	Standard rod and reel using lures or fish bait from shoreline or small boat	1-30 minute casts 60 casts per survey

2.0 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 PIFSC surveys conducted on NOAA, University of Hawaiʻi, and chartered vessels. These surveys are likely to continue during the next five years, although not necessarily every year.

The Pacific Islands Region (PIR) is a vast geographic area, several times the size of the continental U.S. Consequently, it is impossible to carry out all of the research surveys in all of the research areas every year. As a result, research surveys are generally focused on one research area every year and that research area is visited every second, third, or fourth year. Over the course of five years, this research cycle could be presented as HARA-ASARA-MARA-WCPRA-HARA. This cycle inherently includes some overlap of any one research area (e.g., Wake Atoll in the WCPRA is usually visited when the ship is transiting to MARA because it is on the way and makes for the most cost-efficient model). Furthermore, a specific survey may be prioritized every year, for several years in a row, in one research area because of a defined management need. Because the ships and headquarters for PIFSC are based in Hawaiʻi, the HARA is visited more frequently than the other research areas. In addition, for any particular year only some of the surveys are funded and carried out. The sum of all the proposed Days-at-Sea (DAS) for the all the surveys listed in Table 1.1 is over 700 days. The projected DAS numbers in the table represent a best case scenario and are often carried out in fewer days. Furthermore, many of these surveys are overlapping (e.g., RAMP and Benthic Habitat Mapping can occur at the same time on the same ship), are specific to one research area (e.g., Mariana Resource Survey) and therefore carried out every third year, alternate with another survey (e.g., Kona IEA and Pelagic Oceanographic Survey), can occur independent of the NOAA white ships (e.g., small boat-based surveys that launch from land), and every survey is subject to available funding. In recent years the DAS was funded at approximately 150 DAS for the *Oscar Elton Sette* and 130 DAS for the *Hiʻialakai*. These DAS numbers include transit times and gear testing, which are not days in which research surveys are usually conducted.

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 during the five year period requested depend on competitive grant processes and congressional funding levels for PIFSC, 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 in a particular research area because of the vast geographic size of the region 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

PIFSC scientists conduct fishery-independent research onboard NOAA owned and operated vessels or on chartered vessels in four geographic research areas. The Hawaiian Archipelago Research Area (HARA), the Mariana Archipelago Research Area (MARA), and the American Samoa Archipelago Research Area (ASARA) extend approximately 24 nm from the baseline of the respective archipelagos (i.e., to approximately the outer limit of the contiguous zone). The fourth research area, the Central and Western Pacific Ocean, including the Pacific Remote Island Areas, Research Area (WCPRA), includes the remainder of the archipelagic US EEZs, the Central and Western Pacific Ocean between the archipelagos, and the waters around the Pacific remote islands. In general, each research area is visited once every three years depending upon funding, logistics, priorities, and geographic efficiencies during ship transit (see above). Figure 1.2 shows the latitude and longitude boundaries of these research areas. Additional descriptive material concerning the geology, oceanography, and physical and metrological structure influencing species distribution within each of these research areas can be found in chapter 3 of the Draft PEA accompanying this application.

2.2.1 Hawaiian Archipelago Research Area

The HARA includes waters surrounding the Hawaiian Islands to a seaward extent of approximately 24 nm. PIFSC conducts research surveys in the HARA, primarily inside the Insular Pacific-Hawaiian LME boundary (Figure 2.1). The Insular Pacific-Hawaiian LME has a surface area of approximately one million km², extending 1,500 miles from the main Hawaiian Islands to the outer northwest islands, including a range of islands, atolls, islets, reefs and banks (WPRFMC 2009a). This area contains about 1 percent of the coral reefs and sea mounts in the world and four major estuaries (Aquarone and Adams 2008).

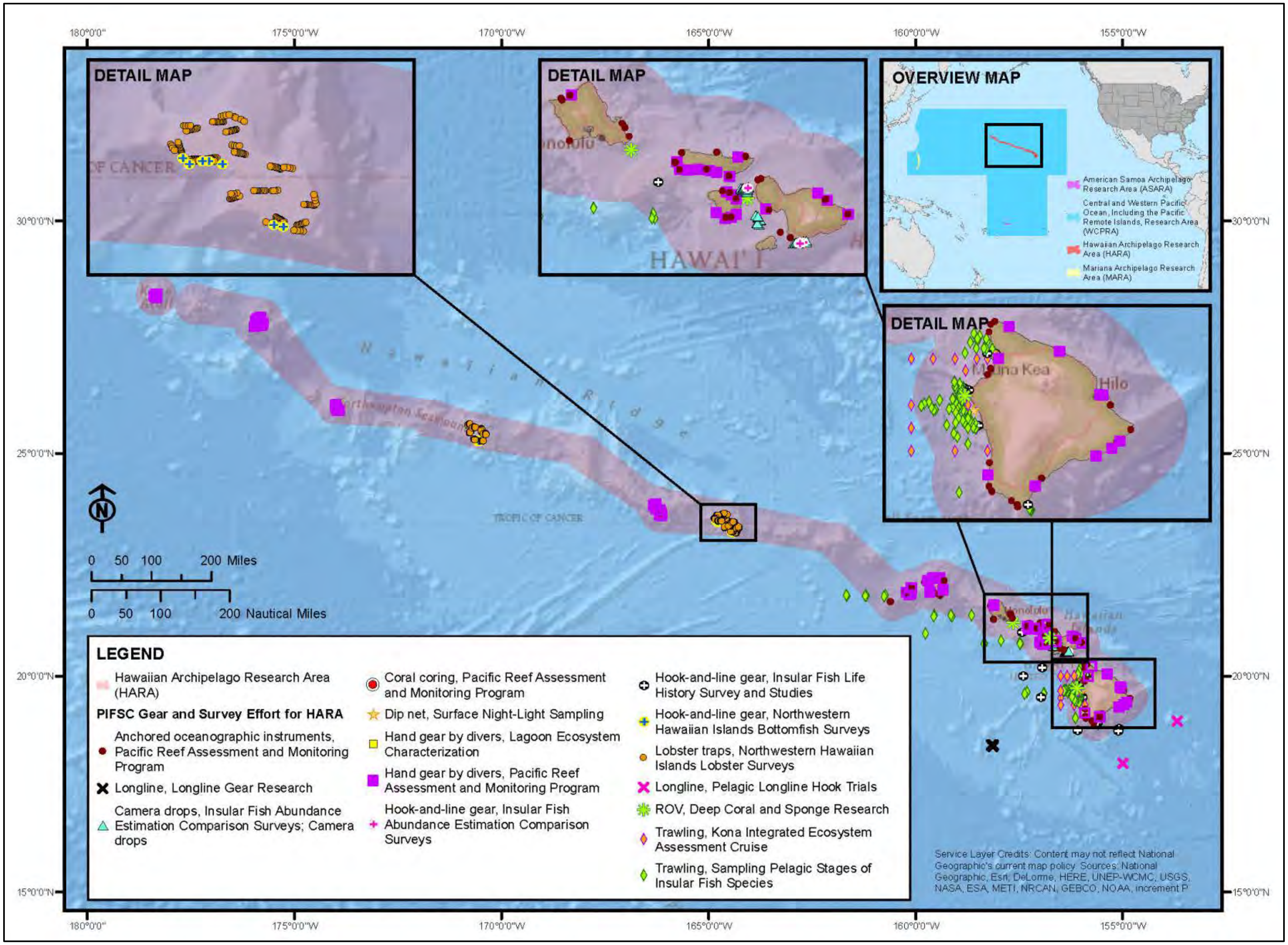


Figure 2.1 Hawaiian Archipelago Research Area showing representative locations of past fisheries and ecosystem research activities

2.2.2 Mariana Archipelago Research Area

The MARA includes waters surrounding the Commonwealth of the Northern Mariana Islands (CNMI) and the Territory of Guam to a seaward extent of approximately 24 nm. The Mariana Islands cover approximately 396 square miles. They are composed of 15 volcanic islands that are part of a submerged mountain chain that spans from Guam to Japan. Politically, the islands are split into the Territory of Guam and the CNMI, but are combined for the purposes of defining the MARA and representative of research effort in the region. The islands are oriented along a north-south axis, with Guam being the southernmost island in the archipelago. Additionally, there is a chain of submerged seamounts located approximately 120 nm west of the Mariana Islands, also in a north-south pattern, reaching southwest of Guam. Seamounts are mountains rising from the ocean seafloor that do not reach the water’s surface. Species richness is greater near seamounts than nearshore or oceanic areas, creating hotspots of pelagic biodiversity (Morato et al. 2010). Also running in a north-south pattern located east of the island chain, the Mariana Trench is the deepest location on earth with its deepest point, the Challenger Deep, at 11,000 meters (m), which is located just outside of the US EEZ.

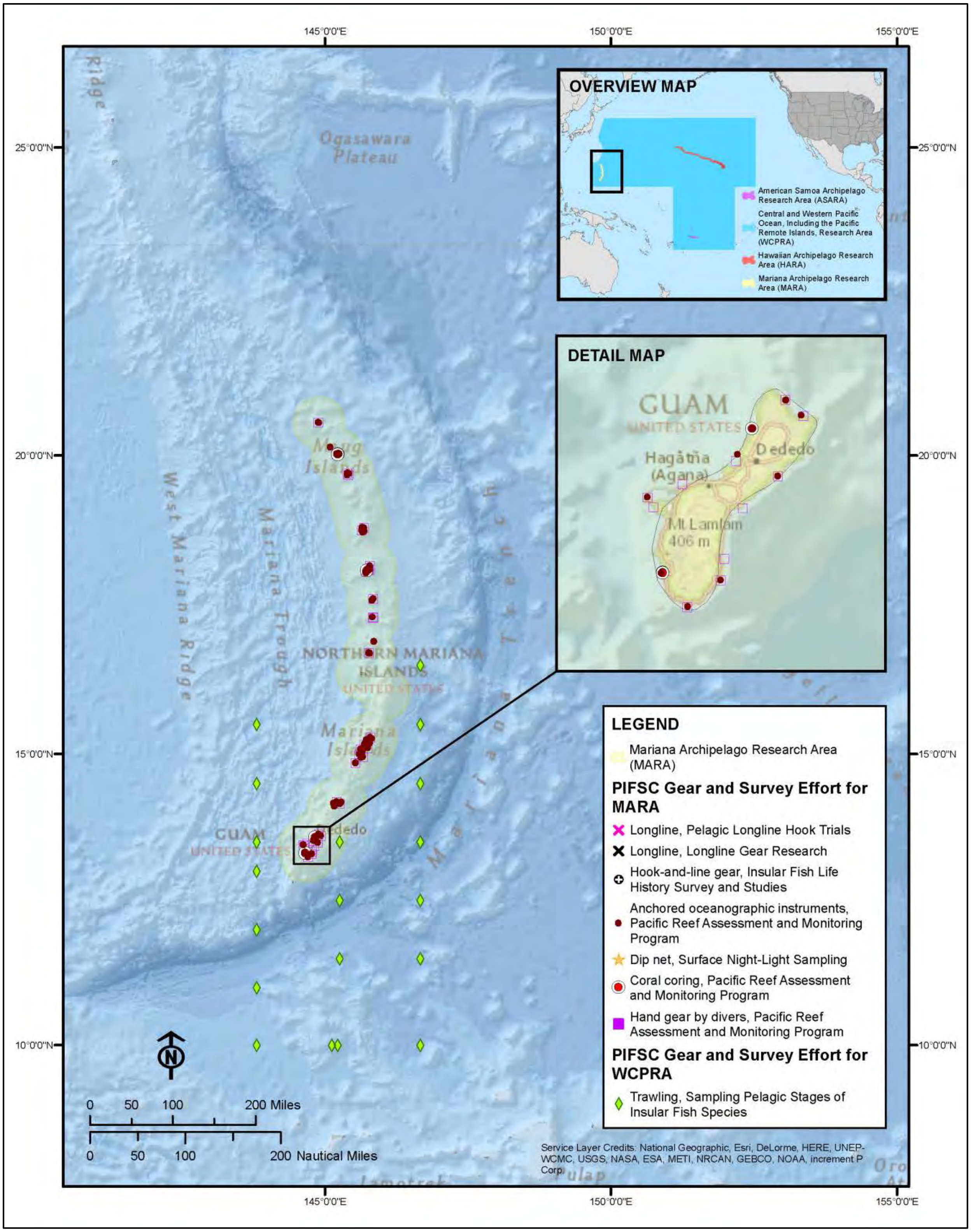


Figure 2.2 Mariana Archipelago Research Area showing representative locations of past fisheries and ecosystem research activities

2.2.3 American Samoa Archipelago Research Area

The ASARA includes waters surrounding the American Samoa archipelago to a seaward extent of approximately 24 nm. The Samoa archipelago is located northeast of Tonga and consists of seven major volcanic islands, several small islets, and two coral atolls. The two largest islands in this chain, Upolu and Savai‘i are governed by the Independent State of Samoa and are not included in the ASARA. The five major inhabited islands of American Samoa are Tutuila, Aunu‘u, Ofu, Olosega, and Ta‘u. The total land mass of American Samoa is about 200 km^2 and surrounded by an EEZ of approximately 390,000 km^2. The largest island, Tutuila, is nearly bisected by Pago Pago Harbor, the deepest and one of the most sheltered embayments in the South Pacific.

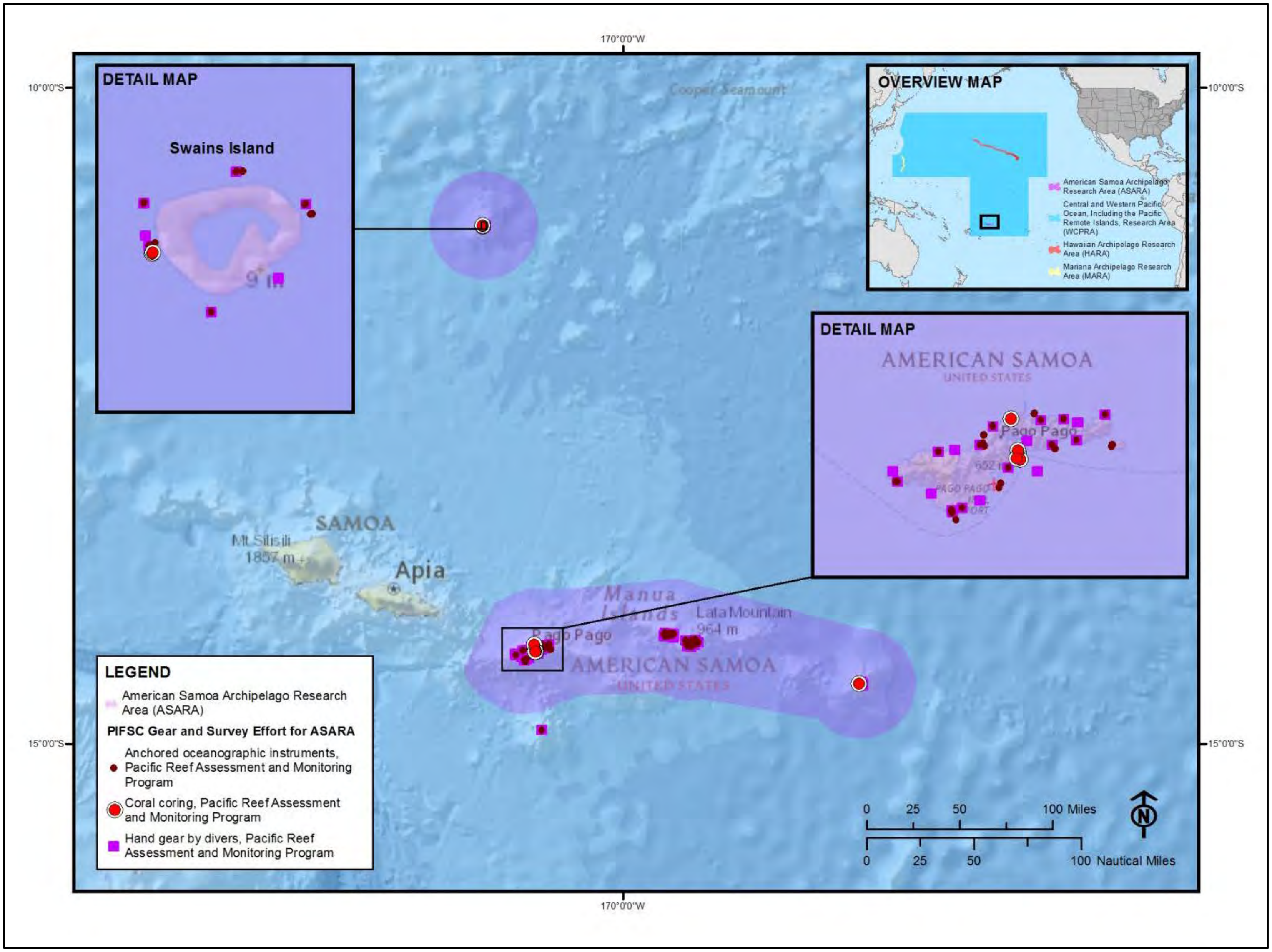


Figure 2.3 American Samoa Archipelago Research Area showing representative locations of past fisheries and ecosystem research activities

2.2.4 Western and Central Pacific Research Area, including the Pacific Remote Islands.

The WCPRA includes part of the high seas (i.e., international ocean waters) considered under the jurisdiction of the Western and Central Pacific Fisheries Commission. The WCPRA also includes the Pacific Remote Islands Area comprised of Baker Island, Howland Island, Jarvis Island, Johnston Atoll, Kingman Reef, Wake Atoll, and Palmyra Atoll. This large area essential captures all past, present, and future PIFSC high seas research surveys (e.g., longline gear, oceanography) that occur outside of the HARA, MARA, and ASARA. It is important to recognize this is an extensive, vast region comprised of nearly 25,000 islands built primarily by a combination of volcanic and layers of calcium carbonate secreting reef building corals and algae. For example, Baker Island is located approximately 13 miles north of the equator and approximately 1,600 nm to the southwest of Honolulu, Hawai‘i. Palmyra Atoll is approximately 1,056 nm south of Honolulu and consists of 52 islets surrounding three central lagoons. Johnston Atoll is approximately 720 nm southwest of Honolulu and Wake Atoll is approximately 2,100 miles west of Hawai‘i. PIFSC fisheries research activities occur throughout this region.

As described in Table 1.1, a range of different surveys would be conducted in the WCPRA. These surveys could be divided into (1) ones that occur near the islands and atolls of the PRIA and (2) ones that occur far away from any islands or atolls, in deep, pelagic waters. In general, nearshore surveys include: Cetacean Ecology, Marine Debris Research and Removal, Coral Reef Benthic Habitat Mapping, Deep Coral and Sponge Research, Insular Fish Life History Survey and Studies, RAMP, Insular Fish and Abundance Estimation Comparison Survey, and Lagoon Ecosystem Characterization. In general, off-shore surveys include: Sampling Pelagic Stages of Insular Species, Spawning Dynamics of Highly Migratory Species, Surface Night-Light Sampling, Pelagic Troll and Handline Sampling, Pelagic Longline, Troll, and Handline Gear Trials, and Pelagic Oceanographic Cruise.

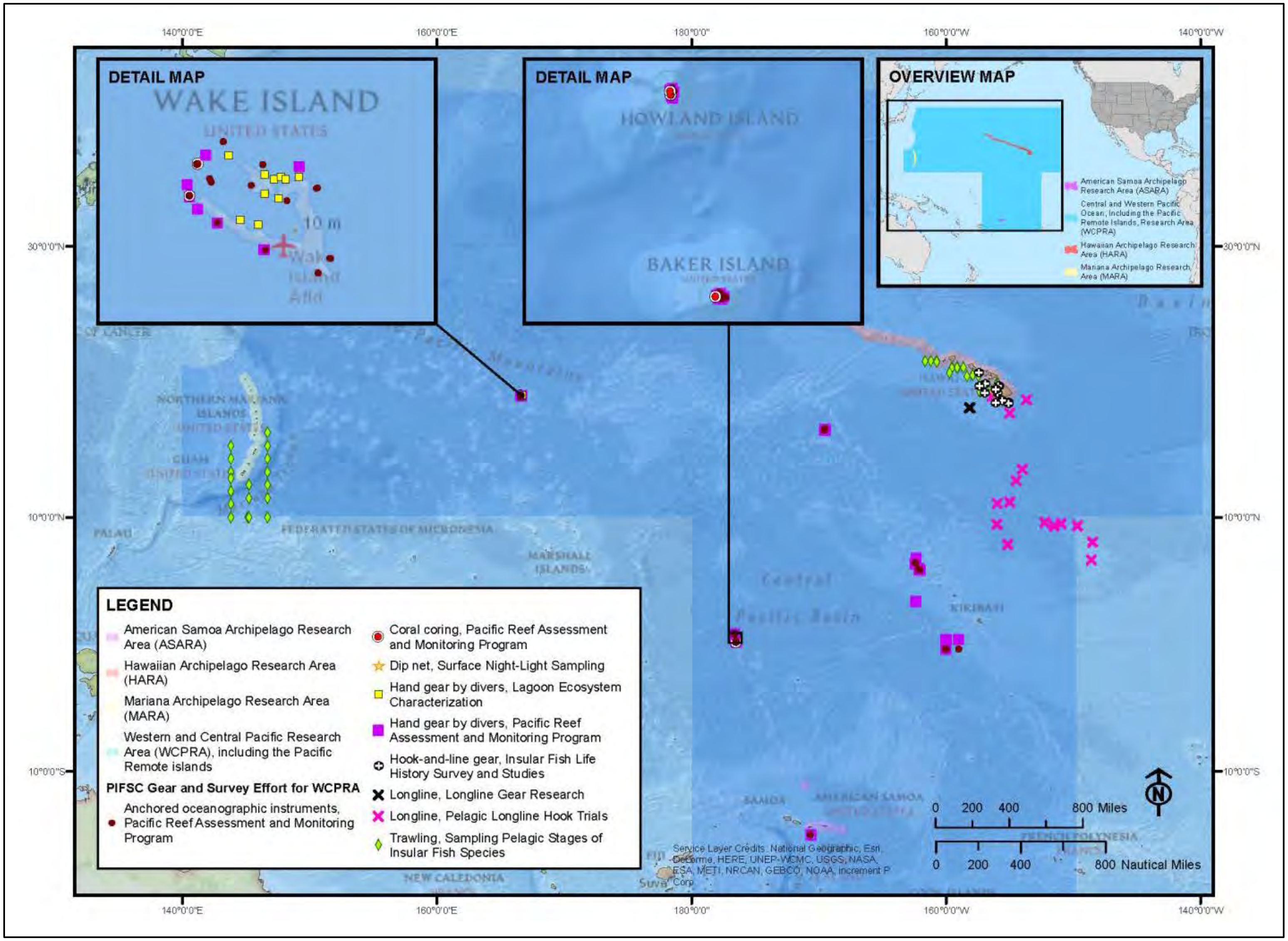


Figure 2.4 Western Central Pacific Research Area showing representative locations of past fisheries and ecosystem research activities

3.0 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 study area. For nearly all Hawai‘i stocks, the stock boundaries extend beyond the EEZ, but abundance estimates apply only to the EEZ portion. 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), which can be found online at: http://www.nmfs.noaa.gov/pr/sars/region.htm. These surveys may also extend beyond U.S. waters. When available, both stock abundance and survey abundance are used in this application to determine marine mammal density within the study area.

The species and approximate numbers of marine mammals likely to be found in the four PIFSC activity areas are shown in Table 3.1. Extralimital species 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. Extralimital species within the PIFSC fisheries research areas are identified in Table 3.2. Extralimital species are not likely to be ‘taken’ pursuant to the MMPA during survey operations and therefore are not included in the take request.

Table 3.1 lists the 25 cetacean species (46 stocks) and one pinniped species that occur in the waters of the Hawaiian Archipelago, Mariana Archipelago, American Samoa Archipelago, and Western and Central Pacific, including the Pacific Remote Islands and High Seas Research Areas, exclusive of extralimital species. It should be recognized that the indication of what species occurs within which area is not absolute because so many of these species may occupy or transit through all regions and because clear boundaries for hypothesized restricted distributions have not been well defined due to poorly understood movement patterns and limited population assessment research throughout such a vast area. The list includes six cetacean species (blue whale, fin whale, humpback whale, sei whale, sperm whale, and the Main Hawaiian Islands insular stock of the false killer whale) and one pinniped listed as endangered under the ESA (Hawaiian monk seal). As seen in Table 1.1, PIFSC survey activity occurs during most months of the year; trawl surveys occur primarily during May through June and September but do occur during all months, hook and line surveys occur during fall, and purse seine surveys occur April-October. Thus many of the marine mammal species that occur in the activity area may be present whenever surveys occur. Seasonal occurrence and estimated density for some cetacean species found around the main Hawaiian Islands is shown in Table 3.3.

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 are known to occur[1] in the PIFSC Research Areas and their status under the ESA and MMPA

Abbreviations: Hawaiian Archipelago Research Area (HARA), Mariana Archipelago Research Area (MARA), American Samoan Archipelago Research Area (ASARA), and Western and Central Pacific Research Area, including the Pacific Remote Islands (WCPRA), Endangered Species Act (ESA), and Marine Mammal Protection Act (MMPA). Asterisks (*) indicate species occurence in the research area is based on expert knowledge of PIFSC marine mammal scientists and unpublished observations; density estimates for these regions were extrapolated from data for the species from adjacent regions. Sources: best available information from NMFS Stock Assessment Reports and published literature (see Table 6.5 for sources).

Species		HARA	MARA	ASARA	WCPRA	Federal ESA/MMPA Status[2]
Common Name	**Scientific Name**					
CETACEANS						
Rough-toothed dolphin	*Steno bredanensis*	X	X	*	X	-
Risso's dolphin	*Grampus griseus*	X	X		X	-
Bottlenose dolphin	*Tursiops truncatus*	X[3]	X	*	X	-
Pantropical spotted dolphin	*Stenella attenuata*	X[4]	X	*	X	-
Spinner dolphin	*Stenella longirostris*	X[5]	X	*	X	-
Striped dolphin	*Stenella coeruleoalba*	X	X		X	-
Fraser's dolphin	*Lagenodelphis hosei*	X	*		X	-
Melon-headed whale	*Peponocephala electra*	X[6]	X		X	-
Pygmy killer whale	*Feresa attenuata*	X	X		X	-
False killer whale	*Pseudorca crassidens*	X[7]	X	*	X	Endangered [8]/ depleted
Killer whale	*Orcinus orca*	X	*	*	X	-
Short-finned pilot whale	*Globicephala macrorhynchus*	X	X	*	X	-
Blainville's beaked whale	*Mesoplodon densirostris*	X	*		X	-
Cuvier's beaked whale	*Ziphius cavirostris*	X	*	*	X	-
Longman's beaked whale	*Indopacetus pacificus*	X			X	-
Deraniyagala's beaked whale	*Mesoplodon hotaula*				X	-
Pygmy sperm whale	*Kogia breviceps*	X	X		X	-
Dwarf sperm whale	*Kogia sima*	X	*	*	X	-
Sperm whale	*Physeter macrocephalus*	X	X	*	X	Endangered/ depleted
Blue whale	*Balaenoptera musculus*	X	X		X	Endangered/ depleted
Fin whale	*Balaenoptera physalus*	X	X		X	Endangered/ depleted

Species		HARA	MARA	ASARA	WCPRA	Federal ESA/MMPA Status[2]
Common Name	**Scientific Name**					
Bryde's whale	*Balaenoptera edeni*	X	X	X	X	-
Sei whale	*Balaenoptera borealis*	X	X		X	Endangered/ depleted
Minke whale	*Balaenoptera acutorostrata scammoni*	X	X	X	X	-
Humpback whale[9]	*Megaptera novaeangliae*	X	X	X	X	Endangered/ depleted
PINNIPEDS						
Hawaiian monk seal	*Neomonachus schauinslandi*	X			X	Endangered/ depleted

1. Note: the current state of knowledge about stock structure and distribution for many of the species within the vast region considered by this request remains incomplete. Thus even though the presence of some species within an area is noted, it may be possible that there are populations that may be comprised of as yet undefined stocks. There may also be instances in certain regions where a species/stock in fact occurs but has yet to be reported as present.
2. Denotes ESA listing as either endangered or threatened, or MMPA listing as depleted. By default, all species listed under the ESA as threatened or endangered are also considered depleted under the MMPA. All marine mammal stocks are considered protected under the MMPA.
3. Kauai and Ni'ihau stock, Oahu stock, the "4-Island Region" (Molokai, Lanai, Maui, Kaho'olawe) stock, Hawai'i Island stock, and the Hawaiian pelagic stocks.
4. Hawaiian Islands stock complex : Oahu, 4-Islands, Hawai'i Island, and Hawaiian pelagic stocks.
5. Hawai'i Island, Oahu/ 4 -Islands, Kauai/Ni'ihau, Pearl and Hermes Atoll, Kure/Midway, Hawai'i pelagic, and American Samoa stocks.
6. Hawaiian Islands stock complex: Hawaiian Islands and Kohala Resident stocks.
7. Hawaiian Islands stock complex: Hawai'i Insular, Hawai'i pelagic, Northwestern Hawaiian Islands, Palmyra Atoll, and American Samoa stocks.
8. Pertains only to the Main Hawaiian Islands insular false killer whale distinct population segment.
9. American Samoa and Central North Pacific stocks.

Table 3.2 Possible extralimital species that may occur within the four PIFSC research areas

Extralimital species	Within PIFSC research areas:
North Pacific right whale	All, but ASARA
Omura's whale	All
Antarctic minke whale	ASARA, WCPRA
Southern bottlenosed whale	ASARA, WCPRA
Common dolphin, sp.	All
Northern elephant seal	HARA, WCPRA
Northern fur seal	HARA, WCPRA

Table 3.3 Group size and seasonality of occurrence of cetacean species found around the main Hawaiian Islands based on small boat surveys and sighting data 2000-2012

Abbreviations: all = all seasons, w = winter, sp = spring, su = summer, f = fall

Common Name	Scientific Name	Mean group size	Standard deviation of group size	Group size min/max	Number of months/seasons documented
Rough-toothed dolphin	*Steno bredanensis*	11.1	12.1	1/90	12/all
Risso's dolphin	*Grampus griseus*	8.1	8.2	1/25	6/all
Bottlenose dolphin	*Tursiops truncates*	9.3	15.9	1/200	12/all
Pantropical spotted dolphin	*Stenella attenuata*	65.4	49.6	1/350	12/all
Spinner dolphin	*Stenella longirostris*	38.7	35.1	1/185	12/all
Striped dolphin	*Stenella coeruleoalba*	28.3	23.4	2/110	8/all
Fraser's dolphin	*Lagenodelphis hosei*	80.0	7.1	75/85	2/w, sp
Melon-headed whale	*Peponocephala electra*	251.8	167.6	1/800	12/all
Pygmy killer whale	*Feresa attenuata*	10.2	7.0	2/25	10/all
False killer whale	*Pseudorca crassidens*	15.6	8.8	1/35	12/all
Killer whale	*Orcinus orca*	4.0	0	4/4	2/sp
Short-finned pilot whale	*Globicephala macrorhynchus*	20.0	15.6	1/195	12/all
Blainville's beaked whale	*Mesoplodon densirostris*	3.7	2.4	1/11	11/all
Cuvier's beaked whale	*Ziphius cavirostris*	2.1	1.2	1/5	9/all
Longman's beaked whale	*Indopacetus pacificus*	35.0	n/a	35/35	1/su
Pygmy sperm whale	*Kogia breviceps*	1.4	0.6	1/2	4/w,sp,su
Dwarf sperm whale	*Kogia sima*	2.7	1.8	1/8	10/all
Sperm whale	*Physeter macrocephalus*	6.2	6.0	1/25	8/all
Unidentified odontocete		1.3	.8	1/4	9/all
Unidentified small delphinid		3.4	6.9	1/30	8/all
Unidentified beaked whale		1.8	.8	1/3	5/w, su, f
***Kogia* sp.**		1.8	.8	1/3	3/w, su, f

Source: Modified from Baird et al. 2013

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

The following information summarizes data on the affected species, by research area, their 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. A brief synopsis of marine mammal acoustics and hearing precedes the species descriptions.

Marine mammals rely on sound production and reception for social interactions (e.g., reproduction, communication), to find food, to navigate, and to respond to predators. 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 and Hastings (2008). Several recent studies on hearing in individual species or species groups of odontocetes and pinnipeds also exist (e.g., Kastelein et al. 2009, Kastelein et al. 2013, Ruser et al. 2014). Interfering with these functions through anthropogenic noise could result in potential adverse impacts.

Southall et al. (2007) provided a comprehensive review of marine mammal acoustics including designating functional hearing groups. Assignment was based on behavioral psychophysics (the relationship between stimuli and responses to stimuli), evoked potential audiometry, auditory morphology, and, for pinnipeds, whether they were hearing through air or water. Because no direct measurements of hearing exist for baleen whales, hearing sensitivity was estimated from behavioral responses (or lack thereof) to sounds, commonly used vocalization frequencies, body size, ambient noise levels at common vocalization frequencies, and cochlear measurements. NOAA modified the functional hearing groups of Southall et al. (2007) to extend the upper range of low-frequency cetaceans and to divide the pinniped hearing group into Phocid and Otariid hearing groups (NOAA 2013). Detailed descriptions of marine mammal auditory weighting functions and functional hearing groups are available in NOAA (2013). Table 4.1 presents the functional hearing groups and representative species or taxonomic groups for each that occur in PIFSC research areas. Most species found in the PIFSC research areas are in the first two groups, low frequency cetaceans (baleen whales) and mid frequency cetaceans (odontocetes); the only pinniped in the PIFSC research area is the Hawaiian monk seal, a phocid.

Table 4.1 Summary of the five functional hearing groups of marine mammals

Functional Hearing Group	Estimated Auditory Bandwidth	Species or Taxonomic Groups
Low frequency cetaceans (Mysticetes–Baleen whales)	7 Hz to 25 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)	Includes species in the following genera: *Steno*, *Tursiops*, *Stenella*, *Delphinus*, *Lagenodelphis*, *Grampus*, *Peponocephala*, *Feresa*, *Orcinus*, *Globicephala*, *Physeter*, *Pseudorca* *Ziphius*, *Mesoplodon*
High frequency cetaceans (Odontocetes)	200 Hz to 48 kHz (best hearing is from approximately 10-150 kHz)	Includes species in the genus *Kogia*
Phocid pinnipeds (true seals)	75 Hz to 100 kHz (best hearing is from approximately 1-30 kHz)	Hawaiian monk seal
Otariid pinnipeds (sea lions and fur seals)	100 Hz to 48 kHz (best hearing is from approximately 1-16 kHz)	None occur in PIFSC research areas

All life history and abundance data for the marine mammal species described below is obtained from literature as cited and, where not cited, is from the most recent NMFS Stock Assessment Reports (Caretta et al. 2015, Allen and Angliss 2015). The minimum population size presented in each species account is calculated as the lower 20th percentile of the log-normal distribution of the most recent abundance estimate (Barlow et al. 1995). The potential biological removal (PBR) is calculated as the minimum population size within the U.S. EEZ of the stock's region times one half the default maximum net growth rate for the species, times a recovery factor that varies from 1.0 to 0.1 depending on the status of the stock (Wade and Angliss 1997).

NMFS manages the species described below by designating stocks based on their geographic ranges, habitat use, genetics, and other factors. For the purposes of this LOA and the corresponding Draft PEA, the geographic research areas within the PIFSC region were broken into four research areas (HARA, MARA, ASARA, and WPCRA). The stock structure of marine mammals is well defined in the HARA and described in the Stock Assessment reports. However, the stock structure of many species is unknown or has not been completely determined in the other PIFSC research areas. In addition, the boundaries of the known stocks may differ from the boundaries of the PIFSC research areas as defined in this document, i.e., the stock may be known to occur within the HARA but may also occur in the adjacent WPCRA or in several research areas. The name of a stock (e.g., Hawaiʿi stock) may imply the species is only found in the HARA when in actuality it could also occur in the WCPRA or other areas. Given these sources of uncertainty regarding stock structures, we have attempted to make clear where each species is known to occur within the context of the four research areas. Source information for data found outside of the Stock Assessment reports is provided, since not all data is currently published or publically available.

4.1 Rough-Toothed Dolphin *(Steno bredanensis)*

Description: The rough-toothed dolphin is so named because of unique vertical ridges on their teeth. Rough-toothed dolphins are distinctive in appearance, with a smooth sloping forehead, long beak, tall dorsal fin, and long flippers. They are generally darkly colored, 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).

Behavior and life history: Rough-toothed dolphins commonly occur in mixed schools with other delphinids and have been observed associating with flotsam (Jefferson 2009b). School size is variable, but commonly in the range of 10-20 (Jefferson 2009b). 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). 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 to 160 kHz (Southall et al. 2007) (Table 4.1). Directional clicks and pulses of up to 200 kHz have been recorded (Jefferson 2009b).

Distribution and habitat preferences: Rough-toothed dolphins are known to occur in the HARA, MARA, ASARA, and WCPRA; see Table 6.5 for more detailed information regarding sighting data and density calculations for this species. Rough-toothed dolphins are a tropical to warm temperate species found in oceanic waters worldwide, as well as over continental shelf and coastal waters in some areas (Jefferson 2009b, May-Collado 2005). A population estimate for this species is available from the eastern tropical Pacific (Wade and Gerrodette 1993), but it is not known whether these animals are part of the same population that occurs around the Hawaiian Islands.

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.

Marine Mammal Protection Act (MMPA) stock assessment reports provide information for two Pacific management stocks, the: 1) Hawai‘i stock and 2) American Samoa stock. The Hawai‘i stock includes animals found both within the Hawaiian Islands EEZ and in adjacent high seas waters; however, because data on abundance, distribution, and human-caused impacts are largely lacking for high seas waters, the status of this stock is evaluated based on data from the U.S. EEZ waters of the Hawaiian Islands (NMFS 2005).

4.1.1 Hawai‘i Stock

Rough toothed dolphins are present around all the MHIs, though they are uncommon near the 4-Islands region (Baird et al. 2013) and have been observed close to the islands and atolls at least as far northwest as Pearl and Hermes Reef (Bradford et al. 2013). Rough-toothed dolphins have occasionally been seen offshore throughout the EEZ of the Hawaiian Islands (Barlow 2006, Bradford et al. 2013). However, preliminary results of genetic studies of individuals sampled from Kauai/Ni‘ihau and Hawai‘i Island, together with resight data, suggest there may be at least two island-associated stocks of rough-toothed dolphins in the MHIs (Oleson et al. 2013).

A 2002 shipboard line-transect survey of the entire Hawaiian Islands EEZ resulted in an abundance estimate of 8,709 rough-toothed dolphins (Barlow 2006). A 2010 shipboard line-transect survey of the Hawaiian Islands EEZ resulted in an abundance estimate of 6,288 rough-toothed dolphins (Bradford et al. 2013). This is currently the best available abundance estimate for this stock. The minimum population size is 4,581 rough-toothed dolphins within the Hawaiian Islands EEZ. The potential biological removal (PBR) level for the Hawai‘i stock of rough-toothed dolphins is 46 rough-toothed dolphins per year (Wade and Angliss 1997).

As summarized in Carretta et al. (2015) the status of the Hawai‘i stock of rough-toothed dolphins relative to its optimum sustainable population (OSP) is unknown, and there are insufficient data to evaluate trends in abundance. No habitat issues are known to be of concern for this species. It is not listed as “threatened” or “endangered” under the ESA, nor as “depleted” under the MMPA.

Rough-toothed dolphins are known to take bait and catch from several Hawaiian sport and commercial fisheries operating near the main islands. They have been specifically reported to interact with the day handline fishery for tuna (palu-ahi), the night handline fishery for squid (ika-shibi), and the troll fishery for billfish and tuna (Carretta et al. 2015 and citations therein). Baird et al. (2008) reported an increase in vessel avoidance by rough-toothed dolphins off the island of Hawai‘i relative to those off Kauai or Ni‘ihau and attributed this to possible shooting of dolphins that were stealing bait or catch from recreational fisherman off the island of Hawai‘i (Carretta et al. 2015 and citations therein). No estimates of human caused mortality or serious injury are currently available for nearshore hook-and-line fisheries in Hawaii, as these fisheries are not observed or monitored for protected species bycatch (Carretta et al. 2015).

There are two longline fisheries based in Hawai‘i: a deep-set longline (DSLL) fishery that targets primarily tunas, and a shallow-set longline fishery (SSLL) that targets swordfish. Between 2007 and 2011, no rough-toothed dolphins were observed hooked or entangled in the SSLL fishery (100% observer coverage) or the DSLL fishery (20-22% observer coverage) (Carretta et al. 2015 and citations therein). However, eight unidentified cetaceans were taken in the DSLL fishery, and two unidentified cetaceans were taken in the SSLL fishery, some of which may have been rough-toothed dolphins (Carretta et al. 2015). Given the absence of recent fishery-related mortality or serious injuries, the Hawaiian stock of rough-toothed dolphins is not considered strategic under the 1994 amendments to the MMPA, and the total fishery mortality and serious injury can be considered to be insignificant and approaching zero.

4.1.2 American Samoa Stock

Rough-toothed dolphins have been observed during summer and winter surveys around the American Samoan island of Tutuila (Johnston et al. 2008) and are thought to be common throughout the Samoan archipelago (Craig 2005). Rough-toothed dolphins were among the most commonly-sighted cetaceans during small boat surveys conducted from 2003 to 2006 around Tutuila, though not observed during a 2006 survey of Swain's Island and the Manu'a Group. Photo-identification data collected during the surveys suggest the presence of a resident population of rough-toothed dolphins in the waters surrounding Tutuila. They are common in the South Pacific from the Solomon Islands, where they were taken by dolphin hunters, to French Polynesia and the Marquesas (reviewed by Reeves et al. 1999).

Status and trends: In American Samoa, no abundance estimates are currently available and PBR has not been determined. However, density estimates for other tropical Pacific regions can provide a plausible range estimate of 692-3,115 (Carretta et al. 2015). While there is insufficient data to calculate maximum net productivity rates or determine current population trends, a plausible range can be determined for the minimum population estimate (426-3,171) and therefore, PBR would likely fall between 3.4 and 22 rough-toothed dolphins per year (Carretta et al. 2015).

Prior to 1995, bottom fishing and trolling were the primary fisheries in American Samoa but they became less prominent after longlining was introduced (Levine and Allen 2009). Nearshore subsistence fisheries include spear fishing, rod and reel, collecting, gill netting, and throw netting (Craig 1993, Levine and Allen 2009). Information on fishery-related mortality of cetaceans in the nearshore fisheries is unknown, but the gear types used in American Samoan fisheries are responsible for marine mammal mortality and serious injury in other fisheries throughout U.S. waters. Gillnets appear to capture marine mammals wherever they are used. Although boat-based nearshore fisheries have been randomly monitored since 1991, by the American Samoa Department of Marine and Wildlife Sources (DMWR), no estimates of annual human-caused mortality and serious injury of cetaceans are available.

One rough-toothed dolphin was taken entangled near 40-fathom bank, south of the islands by the American Samoa-based longline fishery in 2008 (Oleson 2009), indicating some rough-toothed dolphins maintain a more pelagic distribution.

4.2 Risso's Dolphin (*Grampus griseus*)

Description: Risso's dolphins belong to the order Cetacea, suborder Odontoceti, and are the fifth largest member of the family Delphinidae. 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 2009a). The anterior body is robust, with a relatively small dorsal fin, tapering to a narrow tail stock. Their bulbous heads have a distinct vertical crease along the anterior surface of the melon (Baird 2009a). 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 (sickle shaped) and black (Baird 2009a). They are often confused with killer whales due to the large size of their dorsal fin.

Distribution and habitat preferences: Risso's dolphins are known to occur in the HARA, MARA, and WCPRA; see Table 6.5 for more detailed information regarding the sighting data and density calculations. Risso's dolphins are distributed world-wide in tropical and warm-temperate waters and are generally considered rare in Hawaiian waters. 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 2009a).

Behavior and life history: As summarized in Baird (2009a, 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" and generally harassing 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 2009a).

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).

4.2.1 Hawaiian Stock

The Hawaiian stock includes animals found both within the Hawaiian Islands EEZ and in adjacent international waters; however, because data on abundance, distribution, and human caused impacts are largely lacking for international waters, the status of this stock is evaluated based on data from U.S. EEZ waters of the Hawaiian Islands. As oceanographic conditions vary, Risso’s dolphins may spend time outside the U.S. EEZ.Status and trends: A 2002 shipboard line-transect survey of the entire Hawaiian Islands EEZ resulted in an abundance estimate of 2,372 Risso’s dolphins (Barlow 2006). A 2010 shipboard line-transect survey of the Hawaiian Islands EEZ resulted in an abundance estimate of 7,256 Risso’s dolphins (Bradford et al. 2013); this is currently the best available abundance estimate for this stock. The minimum population estimate is 5,207 with a PBR of 42 Risso’s dolphins (Carretta et al. 2015).

The status of Risso's dolphins in Hawaiian waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. No habitat issues are known to be of concern for this species. It is not listed as “threatened” or “endangered” under the ESA, nor as “depleted” under the MMPA. The Hawaiian stock of Risso’s dolphins is not considered strategic under the 1994 amendments to the MMPA.

In the Hawaiʻi based longline fisheries from 2007 to 2011, 21 Risso’s dolphins were observed killed or injured in the SSLL fishery (100% observer coverage), and 3 Risso’s dolphins were observed killed or seriously injured in the DSLL fishery (20-22% observer coverage) (Bradford and Forney 2013, McCracken 2013). One Risso’s dolphin in the DSLL fishery and two in the SSLL fishery were killed, 16 in the SSLL fishery and two in the DSLL fishery were considered to have been seriously injured, and it was later determined that the three animals with reported interactions in the SSLL fishery, were not seriously injured (Bradford and Forney 2013). Average estimates of annual mortality and serious injury for 2007-2011 are 4.5 Risso’s dolphins outside of U.S. EEZs and 0.6 within the Hawaiian Islands EEZ (McCracken 2013). Eight additional unidentified cetaceans were taken in the DSLL fishery; two unidentified cetaceans were taken in the SSLL fishery, one or both of which may have been Risso’s dolphins. The estimated rate of fisheries related mortality or serious injury within the Hawaiian Islands EEZ (0.6 animals per year) is less than the PBR of 42. The total fishery mortality and serious injury can be considered to be insignificant and approaching zero because the estimated mortality and serious injury rates are less than 10% of PBR. The potential effect of injuries sustained by Risso’s dolphins in U.S. pelagic longline fisheries in international waters is not known, because no abundance or bycatch estimates are available for international waters. Risso’s dolphins are among the most commonly hooked or entangled cetaceans in the Hawaii-based shallow-set longline fishery outside of U.S. EEZ waters (Bradford and Forney 2013).

4.3 Bottlenose Dolphin (*Tursiops truncatus truncatus*)

Description: Bottlenose dolphins belong to the order Cetacea, suborder Odontoceti, and family Delphinidae. Bottlenose dolphins are large and robust, varying in color from light to charcoal gray. 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 ranging from 1.9 to 3.8 m (Wells and Scott 2009).

Distribution and habitat preferences: Bottlenose dolphins are known to occur in the HARA, MARA, ASARA, and WCPRA; see Table 6.5 for more detailed information regarding sighting data and density calculations for this species. 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° 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 separate coastal and offshore populations exist and there is some evidence that these two populations occur in Hawaiian waters. As summarized in Carretta et al. (2012, and citations therein), over 99% of the bottlenose dolphins linked through photo-identification to one of the insular populations around the MHIs have been documented in waters of 1000 m or less (Baird et al. 2009, Martien and Baird 2009). Based on these data, the boundaries between the insular stocks and the Hawaiʻi pelagic stock have been placed along the 1000 m isobath. Since that isobath does not separate Oahu from the 4-Islands Region, the boundary between those stocks would run approximately equidistant between the 500 m isobaths around Oahu and the 4-Islands Region, through the middle of Kaʻiwi Channel.

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. The bottlenose dolphin diet consists of a large variety of fish and squid, but 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 fish consumed by bottlenose dolphins are bottom dwellers and sharks are probably the most important predators on bottlenose dolphins. As summarized in DON (2008a, and citations therein), dive durations as long as 15 minutes 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).

Status and trends: As summarized in Carretta et al. (2012, and citations therein), recent photo-identification and genetic studies off Oahu, Maui, Lanai, Kauai, Niʻihau, and Hawaiʻi suggest limited movement of bottlenose dolphins between islands and into offshore waters. These data suggest the existence of demographically distinct resident populations at each of the four main Hawaiian Island groups – Kauai & Niʻihau, Oahu, the "4- Islands Region" (Molokai, Lanai, Maui, Kahoolawe), and Hawaii. In addition, the genetic data indicate that the deeper waters surrounding the MHIs are utilized by a larger pelagic population. Bottlenose dolphins within the Pacific U.S. EEZ are divided into seven stocks, five of which occur in the PIFSC research areas: (1) Kauai and Niʻihau, (2) Oahu, (3) the "4-Islands Region" (Molokai, Lanai, Maui, Kahoʻolawe), (4) Hawaiʻi Island and (5) the Hawaiian pelagic stock, including animals found both within the Hawaiian Islands EEZ and in adjacent international waters (Carretta et al. 2015 and citations within).

No estimates of human-caused mortality or serious injury are currently available for nearshore hook-and–line or gillnet fisheries because these fisheries are not observed or monitored for protected species bycatch. There are at least two reports of bottlenose dolphins being entangled and drowning in gillnets off Maui; although gillnet fisheries are not monitored. Hawaiʻi state regulations now ban gillnetting around Maui and much of Oahu and in areas where gillnetting is permitted, fishermen are required to monitor their nets for bycatch every 30 minutes (Carretta et al. 2015 and citations therein).

Observations of bottlenose dolphins stealing bait and catch have been made in the following fisheries: the day handline fishery (palu-ahi) for tuna, the night handline fishery for tuna (ika-shibi), the handline fishery for mackerel scad, the troll fishery for billfish and tuna, the inshore set gillnet fishery, and from handlines used to catch bottomfish off the island of Hawaiʻi and Kaula Rock and formerly on several banks of the Northwestern Hawaiian Islands (Nitta and Henderson 1993). The following stock summaries are from Carretta et al. (2015, 2014 and 2012) and citations therein. No habitat issues are known to be of concern for any of these stocks of bottlenose dolphins. None are listed as "threatened" or "endangered" under the ESA, or as "depleted" under the MMPA. Hawaiian stocks of bottlenose dolphins are not considered strategic under the 1994 amendments to the MMPA.

4.3.1 Kauai and Niʻihau Stock

A photo-identification study conducted from 2003 to 2005 identified 102 individual bottlenose dolphins around Kauai and Niʻihau and an analysis of photo-identification data resulted in an abundance estimate of 147, or 184 animals when corrected for the proportion of marked individuals (Baird et al. 2009). The minimum population estimate based on a population model is 168 which is greater than the number of distinct individuals (102) identified during the photo-identification study; the PBR is 1.7 bottlenose dolphins per year (Carretta et al. 2015).

The status of bottlenose dolphins in the Kauai/Niʻihau stock relative to OSP is unknown, and there are insufficient data to evaluate abundance trends. There have been no reports of recent mortality or serious injuries; however, there is no systematic monitoring for interactions with protected species within near-shore fisheries that may take this species, thus mean annual takes are undetermined. Insufficient information is available to determine whether the total fishery mortality and serious injury for bottlenose dolphins is insignificant and approaching zero (Carretta et al. 2015).

4.3.2 Oahu Stock

Baird et al. (2009) identified 67 individual bottlenose dolphins around Oahu and an analysis of photo-identification data resulted in an abundance estimate of 594, or 743 animals when corrected for the proportion of marked individuals. The estimate does not include individuals from the Northeastern (windward) side of the island.

The minimum population, mark-recapture estimate is 485 which is substantially greater than the number of distinct individuals (67) identified during the photo-identification study. No data are available on current population trends and the PBR is 4.9 bottlenose dolphins, per year. The status of bottlenose dolphins in Oahu waters relative to OSP is unknown, and there are insufficient data to evaluate abundance trends (Carretta et al. 2015).

There have been no reports of recent mortality or serious injuries; however, there is no systematic monitoring for interactions with protected species within near-shore fisheries that may take this species, thus mean annual takes are undetermined. Insufficient information is available to determine whether the total fishery mortality and serious injury for bottlenose dolphins is insignificant and approaching zero (Carretta et al. 2015).

4.3.3 4-Islands Stock

Baird et al. (2009) identified 98 individual bottlenose dolphins around Maui and Lanai and an analysis of their photo-identification data resulted in an abundance estimate of 153, or 191 when corrected for marked animals. This abundance underestimates the total number of bottlenose dolphins in the 4-Islands region because it does not include individuals from the Northeastern (windward) sides of Maui and Molokai.

The minimum population estimated from mark-recapture is 156. This is greater than the number of distinct individuals (98) identified during the photo-identification study. PBR is 1.6 bottlenose dolphins, per year. The status of bottlenose dolphins in 4-Islands waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance (Carretta et al. 2015).

There have been no reports of recent mortality or serious injuries of this stock; however, there is no systematic monitoring for interactions with protected species within near-shore fisheries that may take this species, thus mean annual takes are undetermined. Insufficient information is available to determine whether the total fishery mortality and serious injury for bottlenose dolphins is insignificant and approaching zero (Carretta et al. 2015).

4.3.4 Hawaiʻi Island Stock

Baird et al. (2009) identified 69 individual bottlenose dolphins around the island of Hawaiʻi and an analysis of their photo-identification data resulted in an abundance estimate of 102, or 128 animals when corrected for marked individuals. This abundance underestimates the total number of bottlenose dolphins around the island of Hawaiʻi because it does not include individuals from the Northeastern (windward) side of the island.

The minimum population estimated from mark-recapture is 115. This is greater than the number of distinct individuals (69) identified during the photo-identification study. No data are available on current population trends. PBR is 1.1 bottlenose dolphins, per year. The status of bottlenose dolphins in waters around Hawaiʻi Island relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance (Carretta et al. 2015).

There have been no reports of recent mortality or serious injuries; however, there is no systematic monitoring of takes in near-shore fisheries that may take this species, thus mean annual takes are undetermined. Insufficient information is available to determine whether the total fishery mortality and serious injury for bottlenose dolphins is insignificant and approaching zero (Carretta et al. 2015).

4.3.5 Hawaiian Pelagic Stock

Population estimates have been made in Japanese waters (Miyashita 1993) and the eastern tropical Pacific (Wade and Gerrodette 1993), but it is not known whether these animals are part of the same population that occurs around the Hawaiian Islands. A 2010 shipboard line-transect survey of the Hawaiian Islands EEZ resulted in an abundance estimate of 5,950 for the Hawaiʻi pelagic stock of bottlenose dolphins (Bradford et al. 2013). This is currently the best available abundance estimate for the Hawaiian pelagic stock. The minimum population estimate is 3,755 bottlenose dolphins; PBR is 38 bottlenose dolphins per year. The status of the Hawaiian pelagic stock of bottlenose dolphins relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance (Carretta et al. 2015).

Seven bottlenose dolphins were observed hooked or entangled in the SSLL fishery (100% observer coverage), and two bottlenose dolphins were observed taken in the DSLL fishery (20-22% observer coverage) from 2007-2011 (Bradford and Forney 2013, McCracken 2013). It is assumed, based on the locations, these animals were from the Hawaiʻi pelagic stock of bottlenose dolphins. Eight of the nine dolphins were considered to have been seriously injured (Bradford and Forney 2013). In addition, eight unidentified cetaceans were taken in the DSLL fishery and two in the SSLL fishery, some of which may have been bottlenose dolphins.

Using incidental mortality and serious injury data for bottlenose dolphins in commercial longline fisheries, within and outside of the U.S. EEZs, the mean annual take was estimated using 2007-2011 data and were prorated to deaths, serious injuries, and non-serious injuries based on the observed proportions of each outcome. The estimated rate of fisheries-related mortality or serious injury for the pelagic stock during 2007-2011 is 3.1 outside the U.S. EEZ, and 0.2 within the Hawaiian Islands EEZ which is 0.53% of PBR. The total fishery mortality and serious injury for Hawaiʻi pelagic bottlenose dolphins is insignificant and approaching zero.

4.4 Pantropical Spotted Dolphin (*Stenella attenuata attenuata*)

Description: Pantropical 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. Adults can be 1.7-2.6 m long and weigh up to 119 kg, with a great deal of geographic variation (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).

Distribution and habitat preferences: Pantropical spotted dolphins are known to occur in the HARA, MARA, ASARA, and WCPRA; see Table 6.5 for more detailed information regarding sighting data and density calculations for this species. Spotted dolphins are primarily found in tropical and subtropical waters worldwide (Perrin et al. 2009). Much of what is known about the species in the North Pacific has been learned from specimens obtained in the large directed fishery in Japan and in the eastern tropical Pacific (ETP) tuna purse-seine fishery (Perrin et al. 2009). Spotted dolphins are common and abundant throughout the Hawaiian archipelago, including nearshore where they are the second most frequently sighted species during nearshore surveys (Baird et al. 2013).

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 in the ETP 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).

Acoustics and hearing: Spotted dolphins are classified 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).

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). Based on an overview of all available information on pantropical spotted dolphins in Hawaiian waters, and NMFS guidelines for assessing marine mammal stocks (NMFS 2005), Oleson et al. (2013) proposed designation of three new island associated stocks in Hawaiian waters, as well as recognition of a fourth broadly distributed spotted dolphin stock, given the frequency of sightings in pelagic waters. Fishery interactions with pantropical spotted dolphins demonstrate that this species also occurs in U.S. EEZ waters around Palmyra Island, but it is not known whether these animals are part of the Hawaiian stock or a separate stock of pantropical spotted dolphins. Morphological differences and distribution patterns indicate that the spotted dolphins around the Hawaiian Islands belong to a stock that is distinct from those in the ETP.

For the MMPA stock assessment reports, there are four Pacific management stocks within the Hawaiian Islands EEZ: the Oahu stock, which includes spotted dolphins within 20km of Oahu; the 4-Islands stock, which includes spotted dolphins within 20km of Maui, Molokai, Lanai, and Kahoolawe, collectively; the Hawaiʻi Island stock, which includes spotted dolphins found within 65km from Hawaiʻi Island; and the Hawaiʻi pelagic stock, which includes animals inhabiting the waters throughout the Hawaiian Islands EEZ, outside of the insular stock areas, but including adjacent high seas waters (Oleson et al. 2013). Because data on abundance, distribution, and human-caused impacts are largely lacking for high seas waters, the status of the Hawaiʻi pelagic stock is evaluated based on data from U.S. EEZ waters of the Hawaiian Islands (NMFS 2005).

Using incidental mortality and serious injury data for pantropical spotted dolphins in commercial longline fisheries, within and outside of the U.S. EEZs, the mean annual take was estimated using 2007-2011 data and were prorated to deaths, serious injuries, and non-serious injuries based on the observed proportions of each outcome. The estimated rate of fisheries-related mortality or serious injury outside the Hawaiian

Islands EEZ is 0.6 spotted dolphins and 0.0 in the PIFSC research area, which is 0% of PBR. The total fishery mortality and serious injury can be considered to be insignificant and approaching zero.

Pantropical spotted dolphins are not listed as "threatened" or "endangered" under the ESA, nor designated as "depleted" under the MMPA. None of the four stocks of spotted dolphins within the PIFSC research areas are considered strategic under the 1994 amendments to the MMPA and no habitat issues are known to be of concern for this species.

The following stock summaries are from Carretta et al. (2015) and citations therein.

4.4.1 Oahu Stock

The population of the Oahu stock of spotted dolphins has not been estimated, therefore there is no minimum population estimate, nor a PBR. The status of Oahu spotted dolphins relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance for this stock.

4.4.2 4-Islands Region Stock

The population of the 4-Islands stock of spotted dolphins has not been estimated, therefore there is no minimum population estimate, nor a PBR. The status of 4-Islands stock spotted dolphins relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance for this stock.

There is no information with which to determine whether the total fishery mortality and serious injury for this stock is insignificant and approaching zero.

4.4.3 Hawai‘i Island Stock

The population of the Hawai‘i Island stock of spotted dolphins has not been estimated, therefore there is no minimum population estimate, nor a PBR. The status of Hawai‘i Island spotted dolphins relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance for this stock.

There is an extensive collection of identification photos from the Hawai‘i Island stock, but a photo-identification catalog has not been developed. A photo-identification catalog could help to develop mark-recapture estimates, but no such analyses have been conducted, as of yet.

There are insufficient data to determine whether the total fishery mortality and serious injury for this stock is insignificant and approaching zero.

4.4.4 Hawai‘i Pelagic Stock

Population estimates are available for Japanese waters, but it is not known whether any of these animals are part of the stocks that occur around the Hawaiian Islands (Carretta et al. 2015 and citations therein). A 2010 shipboard line-transect survey of the Hawaiian Islands EEZ resulted in an abundance estimate of 15,917 spotted dolphins within the pelagic stock area, which is the best available abundance estimate for pantropical spotted dolphins within the Hawaiian Islands EEZ (Carretta et al. 2015, Bradford et al. 2013). The minimum population estimate is 11,508 and the PBR is 115 pantropical spotted dolphins, per year. However, due to the broad and overlapping confidence intervals associated with the 2002 and 2010 abundance estimates, population trends cannot be determined. The status of Hawai‘i pelagic pantropical spotted dolphins relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance.

4.5 Spinner Dolphin -'Gray's spinner dolphin' (*Stenella longirostris longirostris*)

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, 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).

Distribution and habitat preferences: Spinner dolphins are known to occur in the HARA, MARA, ASARA, and WCPRA; see Table 6.5 for more detailed information regarding sighting data and density calculations for this species. 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. However, eastern spinners 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). Within the central and western Pacific, spinner dolphins are island-associated and use shallow protected bays to rest and socialize during the day then move offshore at night to feed. They are common in nearshore waters throughout the Hawaiian archipelago (Carretta et al. 2012, and citations therein).

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 dislodging 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. The 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 to 160,000 Hz (Table 4.1). All Hawaiian spinner dolphin stocks are potentially exposed to high levels of naval sonar and frequent detonations during training exercises; however, the sensitivity of spinner dolphins to these sound levels is unknown and therefore the impact of these exercises on spinner dolphin stocks is unknown (Carretta et al. 2015).

Status and trends: Spinner dolphins belong to the order Cetacea, suborder Odontoceti, and family Delphinidae. Three recognized stocks of spinner dolphins occur in the Pacific Ocean. 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). Hawaiian spinner dolphins belong to a stock that is separate from those involved in the tuna purse-seine fishery in the eastern tropical Pacific. Spinner dolphins are not listed as threatened or endangered under the ESA, nor as depleted or strategic under the MMPA. There are seven stocks found within the PIFSC fisheries and ecosystem research areas: 1) Hawai'i Island, 2) Oahu/4-Islands, 3) Kauai/Ni'ihau, 4) Pearl & Hermes Reef, 5) Kure/Midway, 6) Hawai'i pelagic, including animals found both within the Hawaiian Islands EEZ (outside of island- associated boundaries) and in adjacent international waters, and 7) the American Samoa stock, which includes animals inhabiting the EEZ waters around American Samoa. Spinner dolphins involved in the eastern tropical Pacific tuna purse-seine fisheries are managed separately under the MMPA (Carretta et al. 2015).

Interactions with cetaceans have been reported for all Hawaiʻi pelagic fisheries (Nitta and Henderson 1993). Both the SSLL and DSLL fisheries operate in Hawaii; however, longline fishing is prohibited within an area approximately 25-75 miles from shore in the MHI, and 50 miles from shore in the NWHI (within the Papahānaumokuākea Marine National Monument) where insular or island-associated species occur (Carretta et al. 2015). Between 2006 and 2010, no spinner dolphins were observed hooked or entangled in the SSLL fishery (100% observer coverage) or the DSLL fishery (20-28% observer coverage) (McCracken 2011).

Two spinner dolphins have been reported hooked or entangled by fishing gear in the main Hawaiian Islands between 2007 and 2011 (Bradford & Lyman 2013). One animal was seen in November 2009 off Lahaina, Maui (Oahu/4-Islands stock) with a hook embedded in its right lower jaw and through the tongue, preventing the dolphin from closing its mouth. The animal was seen again two days later, but has not been seen since. One spinner dolphin was seen in September 2011 off Kailua-Kona, Hawaiʻi (Hawaiʻi Island stock) with a section of netting entangled around its rostrum and trailing down its side. This animal was swimming behind other dolphins in the group and may not have been able to open its mouth. Based on the description and photographs, both injuries are considered serious under the most recently developed criteria for assessing serious injury in marine mammals (NMFS 2012). It is not possible to attribute either interaction to a specific fishery given insufficient details about the gear involved. There are six additional reports between 1991 and 2006 of spinner dolphins found entangled, hooked, or shot (Bradford & Lyman 2013). No estimates of annual human-caused mortality and serious injury are available for nearshore hook and line or gillnet fisheries because these fisheries are not observed or monitored for protected species interactions.

All Hawaiian spinner dolphin stocks are potentially exposed to high levels of Navy sonar and frequent detonations during training exercises. The sensitivity of spinner dolphins to these sound levels is unknown and therefore the impact of these exercises on spinner dolphin stocks is unknown.

The estimated rate of mortality and serious injury within the Hawaiian Islands and American Samoa EEZ is zero. However, there is no systematic monitoring of nearshore fisheries that may take animals from both island-associated and pelagic regions of the stock complex. Insufficient information is available to determine whether the total fishery mortality and serious injury for any Hawaiian spinner dolphin stock is insignificant and approaching zero.

The following stock summaries are from Carretta et al. (2015) and citations therein.

4.5.1 Hawaiʻi Island Stock

Mark-recapture estimates in 2010 and 2011 resulted in an abundance estimate of 631 for the Hawaiʻi Island stock of spinner dolphins (Tyne et al. 2014). Considerable seasonal variation in spinner dolphin occurrence on the leeward versus south and east sides of the island is thought to occur, with lower abundance off the leeward Kona coast in the winter, potentially due to increased wind and swell in that region. Because the most recent abundance estimate is based on year-round surveys, at least some of the animals present on the leeward side seasonally have likely been seen. However, because only four bays were surveyed, it is likely that some portion of the population is not included in this abundance estimate and the new estimate is an underestimate of total population size. The minimum population estimate for the Hawaiʻi Island stock is 585 and the PBR is calculated as 5.9 spinner dolphins per year. The status of Hawaiʻi Island spinner dolphins relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance for this stock.

Insufficient information is available to determine whether the total fishery mortality and serious injury for this Hawaiʻi Island spinner dolphin stock is insignificant and approaching zero (Carretta et al. 2015).

A habitat issue of increasing concern is the potential effect of “swim-with-dolphin” programs and other tourism activities on spinner dolphins around the MHIs (Danil et al. 2005, Courbis and Timmel 2009).

4.5.2 Oahu/4-Islands Stock

Mark-recapture estimates based on photo-identification studies were used to derive seasonal abundance estimates for the Oahu/4-Islands stock. Closed-capture models for July to September 2007 (Hill et al. 2011) estimate a population of 355. While the 2007 estimate is the best-available estimate of the population size of the Oahu/4-Islands stock, it is likely an underestimate, as it includes only dolphins found off the leeward coast of Oahu, and does not account for individuals that may spend most of their time along other parts of Oahu or somewhere else in the 4-Islands area. The minimum abundance estimate is 329 spinner dolphins, but is likely negatively biased, as it only includes data from the leeward Oahu coast in 2007. No data are available to speak to population trends and PBR is 3.3 spinner dolphins, per year.

Insufficient data are available to determine if the total fishery mortality and serious injury for this stock is insignificant and approaching zero (Carretta et al. 2015).

A habitat issue of increasing concern is the potential effect of “swim-with-dolphin” programs and other tourism activities on spinner dolphins around the MHIs (Danil et al. 2005, Courbis and Timmel 2009).

4.5.3 Kauai/Ni‘ihau Stock

Mark-recapture estimates based on photo-identification studies have resulted in a new seasonal abundance estimate for the Kauai/Ni‘ihau stock of spinner dolphins. Closed capture models provide an estimate of 601 for the leeward coast of Kauai for the period October to November 2005. This estimate is considered the best-available estimate of the population size; however, it is likely an underestimate as it only includes dolphins found off the leeward coast of Kauai, and does not account for individuals that may spend most of their time along other parts of Kauai, Ni‘ihau, or Kaula Rock.

The minimum population estimate is 509 spinner dolphins, but this estimate is several years old and may not represent the current population. The minimum abundance estimate is also likely to be an underestimate, as it only includes animals along the leeward Kauai coast in 2005; no data were included from the rest of the stock range near Ni‘ihau or Kaula Rock (Carretta et al. 2015). No data are available to determine current population trends, but using the minimum population estimate, PBR is estimated at 5.1 spinner dolphins per year. Insufficient data are available to determine whether the total fishery mortality and serious injury for the Kauai/Ni‘ihau spinner dolphin stock is insignificant and approaching zero (Carretta et al. 2015).

A habitat issue of increasing concern is the potential effect of “swim-with-dolphin” programs and other tourism activities on spinner dolphins around the MHIs (Danil et al. 2005, Courbis and Timmel 2009).

4.5.4 Pearl and Hermes Reef Stock

There is no information available regarding the abundance of spinner dolphins in the Pearl & Hermes Reef stock of spinner dolphins. There is insufficient data to determine minimum abundance, PBR, or population trends for this stock.

A photo-identification catalog of individual spinner dolphins from this stock is available; however, inadequate survey effort and low re-sighting rates prevent a robust estimation of abundance (Carretta et al. 2015).

Insufficient data are available to determine if the total fishery mortality and serious injury for this stock is insignificant and approaching zero (Carretta et al. 2015).

4.5.5 Midway Atoll/Kure Stock

In the NWHI, a multi-year photo-identification study at Midway Atoll resulted in a population estimate of 260 spinner dolphins based on 139 identified individuals (Karczmarski et al. 1998). This abundance estimate for the Midway Atoll/Kure stock of spinner dolphins is now more than 15 years old and therefore will no longer be used for assessing abundance (NMFS 2005). A 2010 shipboard line-transect survey within the Hawaiian EEZ resulted in a single-off sighting of spinner dolphins at Kure Atoll. This sighting cannot be used within a line-transect framework, but the photographs of individuals may be used in the future to estimate the abundance of spinner dolphins at Midway Atoll/Kure, using mark-recapture methods (Carretta et al. 2015). There is no current minimum population estimate for this stock, therefore there is insufficient data to calculate PBR or determine a current population trend (Carretta et al. 2015)

Insufficient data are available to determine if the total fishery mortality and serious injury for the Midway Atoll/Kure spinner dolphin stock is insignificant and approaching zero (Carretta et al. 2015).

4.5.6 Hawai‘i Pelagic Stock

A 2002 shipboard line-transect survey of the entire Hawaiian Islands EEZ resulted in an abundance estimate of 3,351 spinner dolphins; however, this estimate outdated and will no longer be used (Barlow 2006, NMFS 2005). A 2010 shipboard line-transect survey within the Hawaiian EEZ did not result in any sightings of pelagic spinner dolphins; therefore, there is no abundance estimate for this stock. There are no estimates for the minimum population, PBR, or current population trends of the Hawai‘i pelagic stock of spinner dolphins.

Interactions with cetaceans have been reported for all Hawai‘i pelagic fisheries (Nitta and Henderson 1993). Between 2006 and 2010, no spinner dolphins were observed hooked or entangled in the SSLL fishery (100% observer coverage) or the DSLL fishery (20-28% observer coverage) (McCracken 2011).

4.5.7 American Samoa Stock

Spinner dolphins are considered common in American Samoa (Reeves et al. 1999), but there are no current abundance estimates available for this stock. During small-boat surveys from 2003 to 2006 in the waters surrounding the island of Tutuila, the spinner dolphin was the most frequently encountered species (i.e., 34 of 52 sightings) and was found in waters with a mean depth of 44 m. Density estimates for spinner dolphins in other tropical Pacific regions yields a range of likely abundance estimate of 553-51,773 spinner dolphins in this unsurveyed region (Wade and Gerrodette 1993, Ferguson and Barlow 2003, Barlow 2006, Mobley et al. 2000). There is no minimum population estimate for the American Samoa stock of spinner dolphins, but based on the densities observed elsewhere, are estimated to range from 317-41,483. The status of spinner dolphins in American Samoa relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance for any stock.

Information on fishery-related mortality of cetaceans in American Samoan waters is limited, but the gear types used in American Samoa’s fisheries are responsible for marine mammal mortality and serious injury in other fisheries throughout U.S. waters. The primary fishery in American Samoa is the commercial pelagic longline fishery that targets tunas, which was introduced in 1995. This fishery has been monitored since March 2006 under a mandatory observer program, which records all interactions with protected species and no interactions with spinner dolphins have been recorded (Pacific Islands Regional Office 2009, Levine and Allen 2009). Prior to 1995, bottomfishing and trolling were the primary fisheries in American Samoa, but became less prominent after the introduction of the longline fishery (Levine and Allen 2009).

Information on fishery-related mortality of cetaceans in the nearshore fisheries is unknown, but the gear types used in American Samoan fisheries are responsible for marine mammal mortality and serious injury in other fisheries throughout U.S. waters. Gillnets appear to capture marine mammals wherever they are used and float lines from lobster traps and longlines can be expected to occasionally entangle whales (Perrin et al. 1994). Boat-based nearshore fisheries have been randomly monitored by the American Samoa Department of Marine and Wildlife Sources (DMWR) since 1991, but no estimates of annual human-caused mortality and serious injury of cetaceans are available.

4.6 Striped Dolphin (*Stenella coeruleoalba*)

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).

Distribution and habitat preferences: Striped dolphins are known to occur in the HARA, MARA, and WCPRA; see Table 6.5 for more detailed information regarding the sighting data and density calculations for this species.

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 males mature between 7 and 15 years of age. 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 kHz to > 24 kHz (DON 2008a) (Table 4.1).

Status and trends: Striped dolphins belong to the order Cetacea, suborder Odontoceti, and family Delphinidae. Striped dolphins are found in tropical to warm-temperate waters throughout the world (Perrin et al. 2009). Striped dolphins within the Pacific U.S. EEZ are divided into two discrete, non-contiguous areas: 1) waters off California, Oregon and Washington, and 2) waters around Hawaii, including animals found both within the Hawaiian Islands EEZ and in adjacent international waters (Carretta et al. 2015).

4.6.1 Hawaiian Stock

Distribution and habitat preferences: In the Hawai‘i region, sightings have historically been infrequent in nearshore waters (Carretta et al. 2015 and references therein). Shipboard surveys conducted in the summer and fall in the waters of the U.S. EEZ in the Hawaiian Islands, resulted in 15 sightings of striped dolphins in 2002 and 29 in 2010 (Barlow 2006, Bradford et al. 2013). 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.

The abundance of striped dolphins in the PIFSC research area 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. Population estimates are available for Japanese waters and the eastern tropical Pacific, but it is not known whether any of these animals are part of the same population that occurs around the Hawaiian Islands (Carretta et al. 2015 and references therein). A 2010 shipboard line-transect survey of the entire Hawaiian Islands EEZ resulted in an abundance estimate of 20,650 striped dolphins (Bradford et al. 2013). This is currently the best available abundance estimate for this stock. The minimum population estimate is 15,391 striped dolphins with a PBR of 154 dolphins. The status of striped dolphins in Hawaiian waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance.

Information on fishery-related mortality and serious injury of cetaceans in Hawaiian waters is limited, but the gear types used in Hawaiian fisheries are responsible for marine mammal mortality and serious injury in other fisheries throughout U.S. waters. Entanglement and hooking of small cetaceans have been reported in various hook-and-line fisheries in Hawaiʻi (Nitta and Henderson 1993). One striped dolphin was found entangled in fishing gear in 2005, but the responsible fishery could not be determined, as the entangled gear was not described (Carretta et al. 2015 and references therein). No estimates of human-caused mortality or serious injury are currently available for nearshore hook-and-line or gillnet fisheries because these fisheries are not observed or monitored for protected species bycatch (Carretta et al. 2015). Between 2007 and 2011, one striped dolphin was killed and two seriously injured in the SSLL fishery (100% observer coverage), and one striped dolphin was killed in the DSLL fishery (20-22% observer coverage) (Bradford and Forney 2013, McCracken 2013). Unidentified cetaceans were taken in the DSLL and SSLL fishery, eight and two respectively, some of which may have been striped dolphins. Average annual mortality and serious injury for 2007-2011 are 1.4 dolphins outside of U.S. EEZs, and 0.0 within the Hawaiian Islands EEZ.

No habitat issues are known to be of concern for this species. It is not listed as “threatened or endangered” under the ESA, or as depleted or strategic under the MMPA.

4.7 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).

Distribution and habitat preferences: Fraser’s dolphins are known to occur in the HARA, MARA, and WCPRA; see Table 6.5 for more detailed information regarding sighting data and density calculations for this species. Fraser’s dolphins are a tropical species generally found between 30° N and 30° S (Dolar 2009). 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 to 160 kHz (Southall et al. 2007) (Table 4.1).

Status and trends: Fraser’s dolphins belong to the order Cetacea, suborder Odontoceti, and family Delphinidae. Population estimates for Fraser’s dolphins have been made in the eastern tropical Pacific (Wade and Gerrodette 1993), but it is not known whether these animals are part of the same population that occurs around the Hawaiian Islands and in the central North Pacific.

No habitat issues are known to be of concern for this species. It is not listed as “threatened” or “endangered” under the ESA, nor as “depleted” or strategic under the MMPA.

4.7.1 Hawaiian Stock

Status and trends: As summarized in Carretta et al. (2015, and citations therein), they have only recently been documented within the U.S. EEZ of the Hawaiian Islands, during a 2002 cetacean survey (Barlow 2006) and were seen four times during a 2010 survey. No strandings of Fraser’s dolphins have been documented in the Hawaiian Islands during 13 years of nearshore surveys in the leeward MHI.

A 2010 shipboard line-transect estimated the Hawaiian Islands EEZ population at 16,992 (Bradford et al. 2013). The minimum population estimate for Fraser’s dolphins is 10,241; resulting in a PBR of 102 dolphins per year. There are no data available on the current population trends. The status of Fraser's dolphins in Hawaiian waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance.

No Fraser’s dolphins have been observed as hooked or entangled in Hawaii’s DSLL or SSLL fisheries; however, ten unidentified cetaceans were taken in the longline fisheries (eight in the DSLL and two in the SSLL), some of which may have been Fraser’s dolphins. No interactions between nearshore fisheries and Fraser’s dolphins have been reported in Hawaiian waters. Given the absence of recent fishery-related mortality or serious injuries the total fishery mortality and serious injury can be considered to be insignificant and approaching zero.

4.8 Melon-Headed Whale (*Peponocephala electra*)

Description: Melon-headed whales belong to the order Cetacea, suborder Odontoceti, and family Delphinidae. 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. At sea, this species is hard to distinguish from pygmy killer whales. Length for males is 2.5 m and for females is 2.4 m and there is some sexual dimorphism, males have longer flippers, taller dorsal fins, broader flukes, and are more robust than females (Perryman 2009).

Distribution and habitat preferences: Melon-headed whales are known to occur in the HARA, MARA, and WCPRA; see Table 6.5 for more detailed information regarding sighting data and density calculations for this species. Melon-headed whales are distributed worldwide in tropical and warm-temperate waters. The distribution of reported sightings suggests that the oceanic habitat of this species is in primarily equatorial waters (Perryman et al. 1994). 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).

Little is known about this species elsewhere in its range, as most knowledge comes from mass strandings (Perryman et al. 1994). Photo-identification and telemetry studies suggest there are two demographically-independent populations of melon-headed whales in Hawaiian waters, the Hawaiian Islands stock and the Kohala resident stock (Carretta et al. 2015). Resighting data and social network analyses of photographed individuals indicate very low rates of interchange between the Hawaiian Islands and Kohala resident stocks (0.0009/yr) (Aschettino et al. 2012). This finding is supported by preliminary genetic analyses that suggest a restricted gene flow between the Kohala residents and other melon-headed whales sampled in Hawaiian waters (Oleson et al. 2013).

Behavior and life history: Melon headed whales are often in large schools (mean school size is about 200), including 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 to 160 kHz and seem to be sensitive to sonar sounds (Southall et al. 2006, 2007) (Table 4.1). There has been increasing concern that loud underwater sounds, such as active sonar and seismic operations, may be harmful to beaked whales and other cetaceans, including melon-headed whales and pygmy killer whales (*Feresa attenuata*) (Cox et al. 2006, Southall et al. 2006, Wang and Yang 2006). The use of active sonar from military vessels has been implicated in mass strandings of beaked whales and recent mass-stranding reports suggest some delphinids may be impacted, as well.

A 2004 mass-stranding of 150-200 melon-headed whales in Hanalei Bay, Kauai occurred during a multi-national sonar training event around Hawaiʻi (Southall et al. 2006). Although data limitations regarding the position of the whales prior to their arrival in the Bay, the magnitude of sonar exposure, behavioral responses of melon-headed whales to acoustic stimuli, and other possible relevant factors preclude a conclusive finding regarding the role of Navy sonar in triggering this event, sonar transmissions were considered a plausible cause of the mass stranding based on the spatiotemporal link between the sonar exercises and the stranding, the direction of movement of the transmitting vessels near Hanalei Bay, and propagation modeling suggesting the sonar transmissions would have been audible at the mouth of Hanalei Bay (Southall et al. 2006, Brownell et al. 2009). In 2008, approximately 100 melon-headed whales stranded within a lagoon off Madagascar during high-frequency multi-beam sonar use by oil and gas companies surveying offshore. Although the multi-beam sonar cannot be conclusively deemed the cause of the stranding event, the very close temporal and spatial association and directed movement of the sonar use with the stranding event, the unusual nature of the stranding event, and that all other potential causal factors were considered unlikely to have contributed, an independent scientific review panel found that multi-beam sonar transmissions were a “plausible, if not likely” contributing factor in this mass stranding event (Southall et al. 2013). This examination, together with that of Brownell et al. (2009), suggests that melon-headed whales may be particularly sensitive to impacts from anthropogenic sounds. No estimates of potential mortality or serious injury are available for U.S. waters.

Status and trends: Information on fishery-related mortality and serious injury of cetaceans in U.S. EEZ of the Hawaiian Islands waters is limited, but the gear types used in Hawaiʻi fisheries are responsible for marine mammal mortality and serious injury in other fisheries throughout U.S. waters. No interactions between nearshore fisheries and melon-headed whales have been reported in Hawaiian waters. No estimates of human-caused mortality or serious injury are currently available for nearshore hook-and-line or gillnet fisheries because these fisheries are not observed or monitored for protected species bycatch. Long-term photo-identification studies have noted individuals from both the Kohala Resident and Hawaiian Islands stocks with bullet holes in their dorsal fin or with linear scars on their fins or bodies which may be consistent fisheries interactions (Aschettino 2010).

There are two Pacific management stocks within the Hawaiian Islands EEZ (Oleson et al. 2013): 1) the Hawaiian Islands stock, which includes melon-headed whales inhabiting waters throughout the U.S. EEZ of the Hawaiian Islands, including the area of the Kohala resident stock, and adjacent high seas waters, and 2) the Kohala resident stock, which includes melon-headed whales off the Kohala Peninsula and west coast of Hawaiʻi Island and in less than 2500m of water. At this time, assignment of individual melon-headed whales within the overlap area to either stock requires photographic-identification of the animal.

Between 2007 and 2011, no melon-headed whales were observed hooked or entangled in the SSLL fishery (100% observer coverage) or the DSLL fishery (20-22% observer coverage) (Bradford and Forney 2013, McCracken 2013). However, eight unidentified cetaceans were taken in the DSLL fishery, and two unidentified cetaceans were taken in the SSLL fishery, some of which may have been melon-headed whales.

The following stock summaries are from Carretta et al. (2015) and citations therein.

4.8.1 Hawaiian Islands Stock

A 2010 shipboard line transect survey of the Hawaiian Islands EEZ resulted in an abundance estimate of 2,860 melon-headed whales (Bradford et al. 2013). Using the photo-ID catalog of individuals encountered between from 2002-2009 near the MHIs, Achettino (2010) used a POPAN open-population model to produce a mark-recapture abundance estimate of 5,794 individuals. A portion of the data used in that analysis is more than 10 years old; however, full sighting histories were required to produce a valid model for mark-recapture analyses, such that an estimate restricted to only the later years of the period is not available (Carretta et al. 2015). Although this estimate includes individuals that have died since 2002, the mark-recapture estimate is the best available abundance estimate for the Hawaiian Islands stock, given the significantly larger dataset used to produce the estimate versus a single linetransect encounter (Carretta et al. 2015). The minimum population size is 4,904 melon-headed whales in the Hawai‘i pelagic stock (Aschettino 2010).

Because data on abundance, distribution, and human-caused impacts are largely lacking for high seas waters, the status of the Hawaiian Islands stock is evaluated based on data from U.S. EEZ waters of the Hawaiian Islands (NMFS 2005).

No trend analyses have been conducted on Hawaiian Islands melon-headed whales from line-transect surveys because only two estimates exist; however, photographic mark-recapture data will be evaluated in the future to assess whether sufficient data exists to assess trends. The PBR for this stock is 49 melon-headed whales per year. The status of this stock relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. Melon-headed whales are not listed as threatened or endangered under the ESA, nor designated as depleted or strategic under the MMPA.

There have been no reports of recent mortality or serious injuries; however, there is no systematic monitoring of takes in near-shore fisheries that may take this species. Given the above noted bullet holes and potential line injuries on individuals from this stock, insufficient information is available to determine whether the total fishery mortality and serious injury for Hawaiian Islands melon-headed whales is insignificant and approaching zero (Carretta et al. 2015).

Although a 2004 mass-stranding in Hanalei Bay, Kauai could not be conclusively linked to Naval training events in the region (Southall et al. 2006), the spatiotemporal link between sonar exercises and the stranding raises concern on the potential impact on the Hawaiian Islands population due to its frequent use of nearshore areas within the main Hawaiian Island.

4.8.2 Kohala Resident Stock

An abundance estimate of 447 was determined by Achettino (2010), by modeling photo-ID data of sighted animals between 2002 and 2009. A portion of the data used in that analysis is more than 10 years old; however, full sighting histories were required to produce a valid model for mark-recapture analyses, such that an estimate restricted to only the later years of the period is not available. Although this estimate includes individuals that have died since 2002 and should be considered an overestimate, it is currently the best available abundance estimate for the resident stock. The minimum population estimate is 404 melon-headed whales in the Kohala resident stock, resulting in a PBR of 4.0. The status of this stock relative to OSP is unknown and there is insufficient data to determine trends in abundance.

There have been no reports of recent mortality or serious injuries; however, there is no systematic monitoring of takes in near-shore fisheries that may take this species. Despite reports of bullet holes and potential line injuries on individuals from this stock, insufficient information is available to determine whether the total fishery mortality and serious injury for Kohala Resident melon-headed whales is insignificant and approaching zero.

The restricted range and small population size of Hawaiʻi Island resident melon-headed whales suggests this population may be at risk due to its proximity to U.S. Navy training, including sonar transmissions, in the Alenuihaha Channel between Hawaiʻi Island and Maui (Anonymous 2006 in Carretta et al. 2015). Although a 2004 mass-stranding in Hanalei Bay, Kauai could not be conclusively linked to Naval training events in the region (Southall et al. 2006) the spatiotemporal link between sonar exercises and the stranding does raise concern on the potential impact on the Kohala Resident population due to sonar training nearby.

4.9 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).

Distribution and habitat preferences: Pygmy killer whales are known to occur in the HARA, MARA, and WCPRA; see Table 6.5 for more detailed information regarding sighting data and density calculations for this species. 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). As summarized in Carretta et al. (2014, 2012 and citations therein), most knowledge of this species in Hawaiian waters is from stranded or live-captured specimens.

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.

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).

Acoustics and hearing: Pygmy killer whales are classified 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). As noted previously for melon headed whales, there has been increasing concern that loud underwater sounds, such as active sonar and seismic operations, may be harmful to beaked whales and other cetaceans, including pygmy killer whales (Carretta et al. 2015 and citations therein). The use of active sonar from military vessels has been implicated in mass strandings of beaked whales, and recent mass stranding reports suggest some delphinids may be impacted as well. Two mass-strandings of pygmy killer whales occurred in the coastal areas of southwest Taiwan in February 2005 and were possibly associated with offshore naval training exercises; a necropsy of one of the pygmy killer whales revealed hemorrhaging in the cranial tissues of the animal (Carretta et al. 2015 and citations therein).

Status and trends: Pygmy killer whales belong to the order Cetacea, suborder Odontoceti, and family Delphinidae. A population estimate has been made for this species in the eastern tropical Pacific (Wade and Gerrodette 1993), but it is not known whether any of these animals are part of the same population that occurs around the Hawaiian Islands.

No habitat issues are known to be of concern for this species. This species is not listed as “threatened” or “endangered” under the ESA, nor as “depleted” under the MMPA.

4.9.1 Hawaiian Stock

Pygmy killer whales have been observed several times off the lee shore of Oahu, and Pryor et al. (1965) stated that "they seem to be regular residents of the Hawaiian area." Although all sightings up to that time had been off Oahu and the Big Island, Shallenberger (1981) stated that this species might be found elsewhere in Hawaii, as well. More recently, pygmy killer whales have also been seen off the islands of Ni‘ihau and Lanai. Three sightings of pygmy killer whales were made during a 2002 shipboard survey of U.S EEZ waters surrounding the Hawaiian Islands (Barlow 2006). Six strandings have been documented from Maui and the island of Hawaii. Several recent studies suggest that while relatively rare in Hawaiian waters, a small resident population of pygmy killer whales reside in the MHIs (Carretta et al. 2015). A 22 year study off the island of Hawai‘i indicates a year round and stable social group of pygmy killer whales, such that division of this population into a separate island-associated stock may be warranted in the future (Carretta et al. 2015).

A 2010 shipboard line-transect survey of the entire Hawaiian Islands EEZ resulted in an abundance estimate of 3,433 pygmy killer whales (Bradford et al. 2013). This is currently the best available abundance estimate for this stock. The minimum population estimate for this stock is 2,274 pygmy killer whales within the Hawaiian EEZ. No data are available on current population trend and the calculated PBR is 23 pygmy killer whales. The status of pygmy killer whales in Hawaiian waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance.

Information on fishery-related mortality and serious injury of cetaceans in Hawaiian waters is limited, but the gear types used in Hawai‘i fisheries are responsible for marine mammal mortality and serious injury in other fisheries throughout U.S. waters. Entanglement in gillnets and hooking or entanglement in various hook and line fisheries have been reported for small cetaceans in Hawai‘i (Nitta & Henderson, 1993). A stranded pygmy killer whale from Oahu showed signs of hooking injury (Schofield 2007) and mouthline injuries have also been noted in some individuals (Baird unpublished data), though it is not known if these interactions result in serious injury or mortality. No estimates of human-caused mortality or serious injury are currently available for nearshore hook and line or gillnet fisheries because these fisheries are not observed or monitored for protected species bycatch.

There are currently two distinct longline fisheries based in Hawaii: a deep-set longline (DSLL) fishery that targets primarily tunas, and a shallow-set longline fishery (SSLL) that targets swordfish. Both fisheries operate within U.S. waters and on the high seas. Between 2007 and 2011, no pygmy killer whales were observed hooked or entangled in the SSLL fishery (100% observer coverage) or the DSLL fishery (20-22% observer coverage) (Bradford & Forney 2013, McCracken 2013). However, eight unidentified cetaceans were taken in the DSLL fishery, and two unidentified cetaceans were taken in the SSLL fishery, some of which may have been pygmy killer whales. Given the absence of recent fishery-related mortality or serious injuries, the Hawaiian stock of pygmy killer whales is not considered strategic under the 1994 amendments to the MMPA, and the total fishery mortality and serious injury can be considered to be insignificant and approaching zero.

In recent years, there has been increasing concern that loud underwater sounds, such as active sonar and seismic operations, may be harmful to beaked whales (Cox et al. 2006) and other cetaceans, including melon-headed whales (Southall et al. 2006, 2013, Brownell et al. 2009) and pygmy killer whales (Wang and Yang 2006). The use of active sonar from military vessels has been implicated in mass strandings of beaked whales, and recent mass stranding reports suggest some delphinids may be impacted as well. Two mass-strandings of pygmy killer whales occurred in the coastal areas of southwest Taiwan in February 2005, possibly associated with offshore naval training exercises (Wang and Yang 2006). A necropsy of one of the pygmy killer whales revealed hemorrhaging in the cranial tissues of the animal. Additional research on the behavioral response of delphinids in the presence of sonar transmissions is needed in order to understand the level of impact. No estimates of potential mortality or serious injury are available for U.S. waters.

4.10 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 2009b).

Distribution and habitat preferences: False killer whales are known to occur in the HARA, MARA, ASARA, and WCPRA; see Table 6.5 for more detailed information regarding sighting data and density calculations for this species. 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 2009b). Sightings, based on surveys from 1986 to 2005, are distributed across the ETP (Hamilton et al. 2009). One on-effort sighting of false killer whales was made during a 2002 shipboard survey, and six during the 2010 shipboard survey of waters within the U.S. EEZ of the Hawaiian Islands. Smaller-scale surveys conducted around the MHIs show that false killer whales are also encountered in nearshore waters, and a single on-effort and three off-effort sightings during the 2010 shipboard survey reveal that the species also occurs near shore in the NWHI (Baird et al. 2005, Mobley et al. 2000, Baird et al. 2013). This species also occurs in U.S. EEZ waters around Palmyra Atoll, Johnston Atoll, and American Samoa.

False killer whales have a diverse diet that includes a variety of squid and fish and 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 (Baird 2009b).

There are seven stranding records from Hawaiian waters.

Behavior and life history: False killer whales 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 2009b). 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 2009b).

Acoustics and hearing: False killer whales are classified 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).

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 2009b). As summarized in Carretta et al. (2015, and citations therein), in the North Pacific this species is well known from southern Japan, Hawaii, and the eastern tropical Pacific. Five stocks are recognized in the US EEZ of the Pacific Ocean: 1) the Main Hawaiian Islands insular stock, which includes animals found within 72 km (38.9 nm) of the MHIs; 2) the NWHI stock, which includes animals inhabiting waters within the NWHI and a 50 nm radius around Kauai; 3) the Hawaiʻi pelagic stock, which includes animals found inhabiting waters greater than 11 km (5.9 nm) from the MHI, including adjacent high seas waters; 4) the Palmyra Atoll stock, which includes animals found within the U.S. EEZ of Palmyra Atoll; and 5) the American Samoa stock, which includes animals found within the U.S. EEZ of American Samoa.

Using incidental mortality and serious injury data for Hawaiian Islands stock complex (Hawaiʻi pelagic, MHI insular, and NWHI stocks) of false killer whales and unidentified blackfish in U.S. commercial longline fisheries, within and outside of the U.S. EEZs, the mean annual take was estimated using 2008-2012 data and were prorated to deaths, serious injuries, and non-serious injuries based on the observed proportions of each outcome. A new alternative was explored for prorating take among three stocks;

please refer to Carretta et al. 2015 for more information regarding how takes were estimated). The estimated rate of fisheries-related mortality or serious injury for the Hawaiian Islands stock complex is 24.2, per year.

Because of high rates of false killer whale mortality and serious injury in Hawaii-based longline fisheries, a Take Reduction Team (Team) was established in January 2010 (75 FR 2853, 19 January 2010). The Team was charged with developing recommendations to reduce incidental mortality and serious injury of the Hawai‘i pelagic, MHI insular, and Palmyra stocks of false killer whales in the DSLL and SSLL fisheries. The Team submitted a draft Take Reduction Plan (Plan) to NMFS (http://www.nmfs.noaa.gov/pr/pdfs/interactions/fkwtrp_draft.pdf), and NMFS published a final Plan based on the Team’s recommendations (77 FR 71260, 29 November, 2012). Take reduction measures include gear requirements for the deep-set fishery, time-area closures, and measures to improve captain and crew response to hooked and entangled false killer whales. Additionally, the Plan includes non-regulatory measures that NMFS will implement to improve data quality and dissemination to the Team and the public.

4.10.1 Main Hawaiian Islands Insular Stock

A Status Review for the MHIs insular stock (Oleson et al. 2010) used recent, unpublished estimates for two time periods, 2000-2004 and 2006-2009 in their Population Viability Analysis. Two separate estimates for 2006-2009 were, 151 and 170, depending on whether animals photographed near Kauai were included in the estimate, as these animals have not been seen to associate with others in the insular population. The best estimate of population size is taken as the smaller estimate not including those animals seen near Kauai. The minimum population estimate is 138 false killer whales and the calculated PBR is 0.3 false killer whales per year (Carretta et al. 2015, and citations therein).

Based on the best available scientific information (Carretta et al. 2015), the MHIs insular false killer whales have been declining over the past 20 years. Listed as endangered under the ESA (77 FR 70915, 28 November, 2012), they are automatically considered “strategic” under the 1994 amendments to the MMPA (Carretta et al. 2015, Oleson et al. 2010). The estimated average annual human-caused mortality and serious injury from longline fisheries for this stock (0.9 animals per year) is more than the PBR (0.3), so is not approaching zero mortality and serious injury rate because it exceeds 10% of PBR (NMFS 2004).

4.10.2 Hawai‘i Pelagic Stock

As summarized in Carretta et al. (2015, and citations therein), analyses of a 2010 shipboard line-transect survey of the Hawaiian Islands EEZ resulted in an abundance estimate of 484 false killer whales within the Hawaiian Islands EEZ (Barlow and Rankin 2007). Analysis of the 2010 HICEAS shipboard line-transect data resulted in an abundance estimate of 1,540 false killer whales outside of 40 km of the main Hawaiian Islands (Bradford et al. 2015, 2014). Beyond 75 nm from the MHIs, the minimum population estimate for the pelagic stock is 935 false killer whales. The minimum abundance estimate has not been corrected for vessel attraction and may be an over-estimate of minimum population size (Carretta et al. 2015). The calculated PBR is 9.4 false killer whales per year. The status of the Hawai‘i pelagic stock of false killer whales relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance (Carretta et al. 2015). It would be incorrect to interpret the increase in abundance estimates between 2002 and 2010 as an increase in population size; rather, it can be attributed to survey design, the analytical framework, and a lack of understanding of the oceanographic processes that drive distribution of the stock over time (Carretta et al. 2015).

Because the rate of mortality and serious injury to the Hawai‘i pelagic stock of false killer inside the Hawai‘i EEZ is 13.0 animals per year (in an addition to 9.9 animal per year outside the U.S. EEZ, which is not included in the calculation), it exceeds the PBR of 9.4 animals per year), so cannot be considered to be insignificant and approaching zero. This stock is considered a “strategic stock” under the 1994 amendments to the MMPA.

4.10.3 Northwestern Hawaiian Islands Stock

A 2010 line transect survey that included the waters surrounding the NWHIs produced an abundance estimate of 617 false killer whales attributed to the NWHI stock (Bradford et al. 2015, 2014). This is the best available abundance estimate for false killer whales within the NWHI. Bradford et al. (2014) reported that most (64%) false killer whale groups seen during the 2010 HICEAS survey were seen moving toward the vessel when detected by the visual observers. Together with a significant increase in sightings close to the trackline, this behavioral data suggests vessel attraction is likely occurring and may be significant. Although Bradford et al. (2012) employed a half-normal model to minimize the effect of vessel attraction, the abundance estimate is likely still positively biased as a result of vessel attraction, though the extent of any bias is unknown (Carretta et al. 2015). The minimum population size is estimated as 262 false killer whales, resulting in a PBR of 2.6 whales per year. No data are available on the current population trend because there is only one estimate of abundance from 2010 (Carretta et al. 2015).

This stock is not listed as “threatened” or “endangered” under the Endangered Species Act (1973), nor as “depleted” under the MMPA. The rate of fishery mortality and serious injury to NWHI false killer whales is estimated at 0.4 animals per year, which is less than the PBR of 2.6 false killer whales per year, but is not approaching zero mortality and serious injury rate because it exceeds 10% of PBR. However, because commercial and recreational fishing is prohibited within Monument waters and longlines are excluded from the majority of the stock’s range, this stock is likely not exposed to high levels of fishing effort (Carretta et al. 2015). Biomass of some false killer whale prey species may have declined around the NWHI, despite the closure of the commercial longline fishery within the Papahānaumokuākea Marine National Monument (Oleson et al. 2010, Boggs and Ito 1993, Reeves et al. 2009).

4.11 Killer Whale (*Orcinus orca*)

Description: Killer whales belong to the order Cetacea, suborder Odontoceti, and family Delphinidae. Except in the northeastern Pacific where "resident", "transient", and “offshore” stocks have been described for coastal waters of Alaska, British Columbia, and Washington to California, little is known about stock structure of killer whales in the North Pacific. The Hawaiian stock is one of eight stocks recognized by NMFS and the only one that occurs in Hawaiian waters. 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.

Distribution and habitat preferences: Killer whales are known to occur in the HARA, MARA, ASARA, and WCPRA; see Table 6.5 for more detailed information regarding sighting data and density calculations for this species. 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. As summarized by Carretta et al. (2015, and citations therein), they are considered rare in Hawaiian waters.

Behavior and life history: Killer whales are very social and the basic social unit is based on a matrilineal 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 living female's line may contain four generations. The pod is the next level of organization, which 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 five-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 years and males typically live to about 29 years of age (Ford 2009).

Unlike killer whales in the Pacific Northwest, which have diets varying by ecotype (resident ecotype primarily prey on fish and transient ecotype prey on marine mammals), tropical pelagic killer whales have a broad diet including fish, sharks, and marine mammals (Baird et al. 2006).

Although killer whales regularly dive to depths greater than 150 m, there appears to be a trend toward a greater frequency of shallower dives and it is observed that males dive deeper than females (Krahn et al. 2004). Seven resident killer whales followed in 2002, had 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. 2003). 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 are classified 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). 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 referenced to 1 micropascal at one meter (dB re 1 µPa-m). The source level of social vocalizations ranges between 137-157 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 are likely 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). Killer whales have the lowest frequency of maximum sensitivity of all toothed whales; they also have one of the lowest high frequency hearing limits (100 kHz).

Status and trends: As summarized in Carretta et al. (2014, 2012, and citations therein), the population sizes for killer whales in the coastal waters of British Columbia and Washington are known from photo-identification studies, while the population of killer whales in the eastern tropical Pacific has been estimated from shipboard sightings surveys (Wade and Gerrodette 1993).

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

4.11.1 Hawaiian Stock

No killer whales were seen during 1993-98 aerial surveys within about 25 nm of the MHIs, but one sighting was reported during subsequent surveys. Two sightings of killer whales were made during a 2002 shipboard survey of waters within the U.S. EEZ of the Hawaiian Islands. Three strandings have been reported since 1950, including one since 2007, and 18 additional sightings were reported around the MHIs, French Frigate Shoals, and offshore of the Hawaiian Islands (Baird et al. 2006). 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.

A 2002 shipboard line-transect survey of the entire Hawaiian Islands EEZ resulted in an abundance estimate of 349 killer whales (Barlow 2006). A 2010 shipboard line-transect survey of the Hawaiian Islands EEZ resulted in an abundance estimate of 101 killer whales (Bradford et al. 2013). This is currently the best available abundance estimate for this stock. The minimum population estimate is the log-normal 20th percentile of the 2010 abundance estimate, or 50 killer whales within the Hawaiian Islands EEZ; the calculated PBR is 1.0 killer whale per year (Carretta et al. 2015). The status of killer whales in Hawaiian waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance.

Given the absence of recent fishery-related mortalities or serious injuries, the total fishery mortality and serious injury is considered to be insignificant and approaching zero.

No habitat issues are known to be of concern for this stock (Carretta et al. 2015). Information on fishery-related mortality and serious injury of cetaceans in Hawaiian waters is limited; however, the gear types used in Hawaiian fisheries are responsible for marine mammal mortalities and serious injuries in other fisheries throughout U.S. waters (Carretta et al. 2015). There are no documented reports of human-caused mortalities or serious injuries reported for nearshore hook-and-line or gillnet fisheries; however, these fisheries are not observed or monitored for protected species bycatch. In 1990, a solitary killer whale was reported to have removed the catch from a longline in Hawaii, but killer whale interactions with Hawai‘i fisheries appear to be rare (Dollar 1991). Between 2007 and 2011, no killer whales were observed hooked or entangled in the SSLL fishery (100% observer coverage) or the DSLL fishery (20-22% observer coverage) (McCracken 2013, Bradford and Forney 2013).

4.12 Short-Finned Pilot Whale (*Globicephala macrorhynchus*)

Description: Pilot whales appear black or dark gray with a robust body, broad-based dorsal fin, and thick tailstock. The melon is exaggerated and bulbous and there is either no beak or a barely discernible one (Olson 2009). They exhibit striking sexual dimorphism with adult males growing larger than females, reaching an average length of 6 m, and having a larger dorsal fin (Olson 2009).

Distribution and habitat preferences: Short-finned pilot whales are known to occur in the HARA, MARA, ASARA, and WCPRA; see Table 6.5 for more detailed information regarding sighting data and density calculations for this species. The short-finned pilot whale is found in tropical to warm-temperate seas. Worldwide, pilot whales are usually 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 (Seagars and Henderson 1984). The most common prey item identified was *Loligo opalescens*, which has been documented in spawning concentrations at depths of 20-55 m, although deeper water species of squid were identified in these stomachs.

Acoustics and hearing: Short-finned pilot whale whistles and clicks have a dominant frequency range of 2 to 18 kHz and a source level of 180 dB re 1 μPa-m for whistles (DON 2008b, Baumann-Pickering et al. 2015). *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).

Status and trends: Short-finned pilot whales belong to the order Cetacea, suborder Odontoceti, and family Delphinidae.

Fishery interactions with short-finned pilot whales demonstrate that this species also occurs in U.S. EEZ waters of Palmyra Atoll and Johnston Atoll, but it is not known whether these animals are part of the Hawai‘i stock or whether they represent separate stocks of short-finned pilot whales (Carretta et al. 2015). For the purposes of the MMPA stock assessment reports, short-finned pilot whales within the Pacific U.S. EEZ are divided into two discrete areas: 1) Hawaiian waters and 2) waters off California, Oregon and Washington (Carretta et al. 2015). The Hawai‘i stock includes animals found both within the Hawaiian Islands EEZ and in adjacent high seas waters (Carretta et al. 2015).

No habitat issues are known to be of concern for this species. It is not listed as "threatened" or "endangered" under the ESA, nor as "depleted" under the MMPA. The Hawaiian stock of short-finned pilot whales is not considered strategic under the 1994 amendments to the MMPA.

4.12.1 Hawaiian Stock

Short-finned pilot whales are commonly observed around the MHIs and are also present around the NWHIs (Shallenberger 1981, Barlow 2006, Baird et al. 2013, Bradford et al. 2013).

A 2002 shipboard line-transect survey of the entire Hawaiian Islands EEZ resulted in an abundance estimate of 8,846 short-finned pilot whales (Barlow 2006). A 2010 shipboard line-transect survey of the Hawaiian Islands EEZ resulted in an abundance estimate of 12,422 short-finned pilot whales (Bradford et al. 2013). This is currently the best available abundance estimate for short-finned pilot whales within the Hawaiian Islands EEZ. The minimum population size is estimated as 8,782 short-finned pilot whales, resulting in a PBR of 70.

Information on fishery-related mortality of cetaceans in Hawaiian waters is limited, but the gear types used in Hawaiian fisheries are responsible for marine mammal mortality and serious injury in other fisheries throughout U.S. waters (Carretta et al. 2015). Entanglement and hooking in various hook-and-line fisheries have been reported for small cetaceans in Hawai‘i (Nitta and Henderson 1993). No estimates of human caused mortality or serious injury are currently available for nearshore hook-and-line or gillnet fisheries because these fisheries are not observed or monitored for protected species bycatch (Carretta et al. 2015). Between 2007 and 2011, no short-finned pilot whales were observed hooked or entangled in the SSLL fishery (100% observer coverage), and four short-finned pilot whales were observed taken in the DSLL fishery (20-22% observer coverage) (Bradford and Forney 2013, McCracken 2013). Of the four short-finned pilot whales taken, two were considered not seriously injured, and the other two were considered seriously injured (Bradford and Forney 2013). Seven additional unidentified "blackfish" (unidentified cetaceans known to be either false killer whales or short-finned pilot whales) were also seriously injured during 2007-2011, that may have been pilot whales (Bradford and Forney 2013). Additionally, one unidentified blackfish was taken on the high seas in the DSLL fishery in 2011, but was not seriously injured (Carretta et al. 2015). Five of the seven serious injuries were taken in the DSLL fishery within U.S. EEZ waters and the remaining two serious injuries were taken the SSLL fishery on the high seas. The status of short-finned pilot whales in Hawaiian waters relative to OSP is unknown, and there are insufficient data exist to evaluate trends in abundance.

Using incidental mortality and serious injury data for 2007-2011, the mean annual take was estimated as 1.1 short-finned pilot whales outside of U.S. EEZs and 0.1 within the Hawaiian Islands EEZ. The PBR is 70, so the estimated take is less than 10% of PBR, allowing the total fishery and serious injury to be considered insignificant and approaching zero.

4.13 Blainville's Beaked Whale (*Mesoplodon densirostris*)

Description: Blainville's beaked whales belong to the order Cetacea, suborder Odontoceti, and family Ziphiidae. As adults, Blainville's beaked whales can reach estimated lengths of approximately 15-20 ft (4.5-6 m) and weigh 1,800-2,300 lbs (820-1,030 kg). Males can easily be distinguished from females and juveniles due to a pair of large visible tusk-like teeth that erupt and point forward from a heavily arched lower jaw. Females and juveniles have teeth also, but they remain hidden beneath the gum tissue of the mouth, and their jawline is less curved.

Blainville's beaked whales have a relatively medium-sized round body with a small, wide-based, slightly falcate dorsal fin located far down (about two-thirds) the animal's back. The whale's head has a low, sloping forehead and indistinct "melon". Their coloration varies from dark gray to brownish and bluish. The face and underside of the animal is pale gray or white, giving it a counter-shading appearance. The skin may appear wrinkled on the dorsal area and is covered with linear and oval-shaped scars and other markings. Individuals, especially mature males, accumulate scars and scratches with age. Also, diatom (a single-celled algae) infestation may discolor areas of the skin.

Distribution and habitat preferences: Blainville's beaked whales are known to occur in the HARA, MARA, and WCPRA; see Table 6.5 for more detailed information regarding sighting data and density calculations for this species. Blainville's beaked whales have a cosmopolitan distribution in tropical and temperate waters; they have the most extensive known distribution of any *Mesoplodon* species (Mead 1989). Analysis of Blainville's beaked whale resighting and movement data near the MHIs suggest the existence of an insular and offshore (pelagic) population of this species in Hawaiian waters and a division of an additional island-associated stock may be warranted in the future (Carretta et al. 2015 and citations therein). 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); however, Baird et al (2013) reported sightings of bimodal depth distributions between 500-1500m and 3500-4000 m depth. They were sighted 1000 km offshore, on average, but distance from shore ranged from 40 to over 3,700 km (Ferguson et al. 2006).

Behavior and life history: Blainville's beaked whales are usually found individually or in small social groups averaging between 3-7 individuals, but have been seen occasionally in larger groups of up to 12 animals. Groups may consist of various combinations and/or be segregated depending on age or sex. Adult populations in productive waters over the continental shelf (as in the Bahamas) may be grouped in harems and consist of several adult females with a single adult mature male (Jefferson et al. 2008). Males commonly battle over access to females, which is probably the cause of the long linear scars seen on individuals.

Like other beaked whales, these whales are deep divers. Regular dives range from 20-45 minutes, and commonly reach depths of at least 1,600-3,300 ft (500-1000 m), although dives of over 54 minutes and up to 4,600 ft (1,400 m) have been recorded (Jefferson et. al., 2008). While diving, they use suction to feed on small fish and cephalopods (e.g., squid) in deep water.

Blainville's beaked whales may reach sexual maturity at about 9 years of age. A sexually mature female will give birth to a single newborn calf that is about 6-8.5 ft (1.9-2.6 m) long and weighs about 130 lbs (60 kg). The estimated lifespan of this species is unknown.

Acoustics and hearing: *Mesoplodon,* and all beaked whale species, are in the mid-frequency functional hearing group (with an estimated auditory bandwidth of 150 Hz to 160 kHz) and show sensitivity to sonar, echosounder, and air gun transmissions (Southall et al. 2007). Vocalization ranges are similar at 300 Hz to 135 kHz (DON 2008) (Table 4.1). The impacts of anthropogenic sound on beaked whales are of concern (Barlow and Gisiner 2006, Cox et al. 2006, Hildebrand et al. 2005, Weilgart 2007).

Anthropogenic sound sources, such as military sonar and seismic testing have been implicated in the mass strandings of beaked whales, including atypical events involving multiple beaked whale species (Carretta et al. 2015 and citations therein). While D'Amico et al. (2009) notes that most mass strandings of beaked whales are not associated with documented sonar activities, lethal or sublethal effects of activities such as this would rarely be documented, due to the remote nature of such activities and the low probability that an injured or dead beaked whale would strand. Filadelpho et al. (2009) reported statistically significant correlations between military sonar use and mass strandings of beaked whales in the Mediterranean and Caribbean Seas, but not in Japanese and Southern California waters. Filadelpho hypothesized that regions with steep bathymetry adjacent to coastlines are more conducive to stranding events in the presence of sonar use. In Hawaiian waters, Faerber and Baird (2010) suggested that the probability of stranding is lower than other regions due to nearshore currents carrying animals away from beaches, and that stranded animals are less likely to be detected due to low human population density near many of Hawaii's beaches. Actual and simulated sonar are known to interrupt the foraging dives and echolocation activities of beaked whales and responses such as avoidance, prolonged diving, and cessation of echolocation click production associated with foraging have all been documented (Tyack et al. 2011, DeRuiter et al. 2013). Fernández et al. (2013) reports that there have been no mass strandings of beaked whales in the Canary Islands following a 2004 ban on sonar activities in that region. The absence of beaked whale bycatch in California drift gillnet fisheries following the introduction of acoustic pingers, implies additional sensitivity of beaked whales to anthropogenic sound (Carretta et al. 2015 and citations therein). The impact of sonar exercises on resident versus offshore populations of beaked whales may be significantly different with offshore animals less frequently exposed and possibly exhibiting more extreme reactions (Baird et al. 2009). No estimates of potential mortality or serious injury are available for U.S. waters (Carretta et al. 2015).

4.13.1 Hawai'i Stock

Status and trends: A 2010 shipboard line-transect survey of the entire Hawaiian Islands EEZ resulted in an abundance estimate of 2,338 for the Hawai'i stock of Blainville's beaked whales (Bradford et al. 2013). The minimum population estimate is the log-normal 20th percentile of the 2010 abundance estimate, or 1,088 Blainville's beaked whales within the Hawaiian Islands EEZ; the calculated PBR is 11 beaked whales per year (Carretta, et al. 2014, Bradford et al. 2013, Barlow 2006).

The status of Blainville's beaked whales in Hawaiian waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. It is not listed as "threatened" or "endangered" under the ESA, nor as "depleted" or strategic under the MMPA. Information on fishery-related mortality of cetaceans in Hawaiian waters is limited, but gear types used in Hawaiian fisheries are responsible for marine mammal mortality and serious injury in other fisheries throughout U.S. waters. No interactions between nearshore fisheries and no estimates of human-caused mortality or serious injury are currently available for nearshore hook-and-line fisheries, as these fisheries are not observed or monitored for protected species bycatch (Carretta et al. 2015).

From 2007 to 2011, no Blainville's beaked whales were observed killed or seriously injured within the Hawaiian EEZ in the SSLL fishery (with 100% observer coverage) or the DSLL fishery (20-22% observer coverage) (Bradford and Forney 2013, McCracken 2013). However, one Blainville's beaked whale was observed taken, but not seriously injured, in the SSLL fishery and one unidentified Mesoplodont whale and one unidentified beaked whale were taken in the SSLL fishery and both were considered to be seriously injured (Bradford and Forney 2013). Additionally, eight unidentified cetaceans were taken in the DSLL fishery and two unidentified cetaceans were taken in the SSLL fishery, some of which may have been Blainville's beaked whales (Carretta et al. 2015).

Average annual mortality and serious injury for 2007-2011 are zero Blainville's beaked whales within or outside of the U.S. EEZs, and 0.4 Mesoplodont or unidentified beaked whales outside the U.S. EEZs (Carretta et al. 2015); therefore, the total fishery and serious injury can be considered insignificant and approaching zero.

4.14 Deraniyagala's Beaked Whale (*Mespolodon hotaula*)

Description: To date, information on the external appearance of Deraniyagala's beaked whale is based only on two dead, stranded specimens. These specimens were described as having a relatively compressed body, a strong lateral ridge, a slender head with an elongate beak, and eyes located about half a beak length behind the angle of the gape (Dalebout et al. 2014). Whales were blue-black dorsally, grading to blue-gray ventrally; the blue-black color of the body continued on the head, forming a dark cap that extended along the anterior surface of the rostrum and to the posterior end of the mouth line (Dalebout et al. 2014). Coloration around the eye was a lighter mottled gray, becoming lighter ventrally. The tip of the lower jaw was gray but the lower jaw itself was predominantly white; this white color pattern extended on the lower jaw to behind the tooth and continued above the mouthline to the rostrum (Dalebout et al. 2014). The upper lips were whitish, grading to gray and blue-black on the rostrum. The gray mottling of the cheek and eye area formed a distinct wedge of color against the white of the ventral chin and throat region, cutting across the posterior ends of the throat grooves. The tips of the teeth of both adult males were broken. This suggests that male to male combat using the teeth as weapons occurs in this species, although the Seychelles specimen did not have any of the white linear tooth rake scars that appear to result from such behavior (Mead et al. 1982, Heyning 1984). Between the specimens found, there were differences observed with the tail, one had a median lobe with a small caudal notch and the other tail lacked a median notch and the coloration was different (Dalebout et al. 2014).

Distribution and habitat preferences: Within the PIFSC research area, the Deraniyagala's beaked whale is only known to occur in the WCPRA. Deraniyagala's beaked whales are found around Palmyra Atoll and Kingman Reef, Line Islands, where they are likely an insular population and occur in small numbers around other oceanic islands (Brownell 2013). PIFSC researchers noted a suspected Deraniyagala's beaked whale sighting during their 2012 PICEAS Leg-2 survey. *M. hotaula* has an equatorial distribution in the Indo-Pacific (Dalebout et al. 2014).

Behavior and life history: Of the seven known specimens of *M. hotaula*, three were assumed to be adult males, two were adult females, and two were of unknown sex. Total lengths from the two female specimens were 450 cm from Sri Lanka and 480 cm from Palmyra Atoll (Brownell 2013). In *M. ginkgodens*, total lengths for the largest known male and female specimens are 495 cm and 490 cm, respectively (Yamada et al. 2012). The total length of a purported *M. ginkgodens* neonate from Phuket, Thailand, was 208 cm (Chantrapornsyl et al. 1996), but the species identification of this specimen was not confirmed and it could have been *M. hotaula* (Brownell 2013).

The mean school size of mesoplodonts at Palmyra was 2.2 individuals (n=8). The schools ranged in size from two to three, though all except one of the sightings were of paired animals, including at least two cow/calf pairs; no biopsy samples were collected (Brownell 2013). Four of the sightings were confirmed *Mesoplodon* sp.; another 4 were unidentified ziphiids and probably mesoplodonts (Brownell 2013).

Acoustics and hearing: Baumann-Pickering et al. (2010) reported that, "The echolocation signals of the mesoplodont beaked whale at Palmyra Atoll were spectrally and temporally different to previously published frequency-modulated pulse beaked whale signals. The use of regularly spaced FM pulses and the switch to broadband clicks for the buzz (probably indicating prey capture), is a signal structural strategy already known for another beaked whale, *Mesoplodon densirostris*."

Status and trends: Oleson et al. (2013) reviewed the available evidence for island-associated stocks of small cetaceans around the Hawaiian Islands and suggested that Blainville's and Cuvier's beaked whales show evidence of insular and pelagic stocks. If this is also true for *M. hotaula* around Palmyra Atoll and Kingman Reef, this will have important management implications as is the case for other insular island populations of small cetaceans (Brownell 2013).

No quantitative abundance or trend data exists for this species. However, passive acoustic detections of *M. hotaula* echolocation signals were made every day, many times a day, during four months of monitoring at Kingman Reef, Line Islands (Brownell 2013). This is the highest rate of acoustic encounters observed at 24 sites across the North Pacific (Baumann-Pickering et al. 2014).

4.15 Cuvier's Beaked Whale (*Ziphius cavirostris*)

Description: Cuvier's beaked whales belong to the order Cetacea, suborder Odontoceti, and family Ziphiidae. Cuvier's beaked whales resemble other beaked whales in that they have a robust, cigar-shaped body with a smallish falcate dorsal fin, set about two thirds back and their small flippers fit into a slight depression, as with other beaked whales (Heyning and Mead 2009). Their heads are blunt with a small poorly defined rostrum that grades into a generally sloping melon region (Heyning and Mead 2009). The minimum length at sexual maturity for females is 5.3 m and the average length at sexual maturity is 5.5 m for males (Perrin 2009).

Distribution and habitat preferences: Cuvier's beaked whales are known to occur in the HARA, MARA, ASARA, and WCPRA; see Table 6.5 for more detailed information regarding sighting data and density calculations for this species. Cuvier's beaked whales are distributed in all oceans and seas except the high Polar Regions. Cuvier's beaked whales are generally sighted in waters >200 m deep, and are frequently recorded at depths >1,000 m; they are commonly sighted around seamounts, escarpments, and canyons (Heyning and Mead 2009). Resighting and movement data of individual Cuvier's beaked whales suggest the existence of insular and offshore populations of this species in Hawaiian waters. A 21-yr study off Hawai'i Island suggests long-term site fidelity and year-round occurrence (McSweeney et al 2007). Eight Cuvier's beaked whales have been tagged off Hawai'i Island since 2006, with all remaining close to the island of Hawai'i for the duration of tag data received (Baird et al 2013). Approximately 95% of all locations were within 45 km of shore and the farthest offshore an individual was documented was 67 km (Baird et al. 2013). The satellite data suggest that a resident population may occur near Hawai`i Island, distinct from offshore, pelagic Cuvier's beaked whales. This conclusion is further supported by the long-term site fidelity evident from photo-identification data (McSweeney et al. 2007). Division of this population into a separate island-associated stock may be warranted in the future.

Behavior and life history: Little is known of the feeding preferences of Cuvier's beaked whales. They may be midwater 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 a 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. Echolocation clicks for Cuvier's beaked whales were recorded at frequencies from 20 to 70 kHz. 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). As discussed in Section 4.15, the impacts of anthropogenic sound on beaked whales remain a concern (Barlow and Gisiner 2006, Cox et al. 2006, Hildebrand et al. 2005, Weilgart 2007).

Status and trends: 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. Wade and Gerrodette (1993) made an estimate for Cuvier's beaked whales in the ETP, but it is not known whether any of these animals are part of the same population that occurs around the Hawaiian Islands.

4.15.1 Hawai'i Stock

A 2002 shipboard line-transect survey of the entire Hawaiian Islands EEZ resulted in an abundance estimate of 15,242 Cuvier's beaked whales (Barlow 2006), including a correction factor for missed diving animals. In 2010, a shipboard line-transect survey of the entire Hawaiian Islands EEZ resulted in an abundance estimate of 1,941 Cuvier's beaked whales (Bradford et al. 2013), including a correction factor for missed diving animals. This is currently the best available abundance estimate for this stock.

The significant decrease in abundance estimates between the 2002 and 2010 surveys are attributed to the use of higher sea states (Beaufort 0–5) in estimating the trackline detection probability for the 2010 survey (Carretta et al. 2015). Comparatively, the 2002 survey only utilized Beaufort Sea state data (0-2) (Bradford et al. 2013). This change, in the methodology used for analysis, resulted in far less extrapolation over the survey area, resulting in a more representative estimate of abundance (Carretta et al. 2015). The 2002 survey data have not been reanalyzed using this method.

The minimum population estimate is the log-normal 20th percentile of the 2010 abundance estimate (Barlow et al. 1995) is 1,142 Cuvier's beaked whales within the Hawaiian Islands EEZ and a calculated PBR of 11.4 Cuvier's beaked whales per year. The status of Cuvier's beaked whales in Hawaiian waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. Cuvier's beaked whales are not listed as threatened or endangered under the ESA, nor as depleted or strategic under the MMPA.

In 1998, a Cuvier's beaked whale stranded possibly entangled, with scars and cuts from fishing gear along its body; however, the fishing gear was not described and could not be attributed to a specific fishery (Bradford and Lyman 2013). No other interactions between nearshore hook-and-line fisheries and Cuvier's beaked whales have been reported in Hawaiian waters, though these fisheries are not observed or monitored for protected species bycatch (Carretta et al. 2015). From 2007 to 2011, no Cuvier's beaked whales were observed killed or seriously injured within the Hawaiian EEZ in the SSLL fishery (with 100% observer coverage) or the DSLL fishery (20-22% observer coverage) (Bradford and Forney 2013, McCracken 2013). However, one unidentified beaked whale was taken in the SSLL fishery and considered seriously injured and eight unidentified cetaceans were taken in the DSLL fishery, some of which may have been Cuvier's beaked whales (Carretta et al. 2015). The estimated annual takes for Cuvier's beaked whales are estimated as 0.0 animals inside or outside the US EEZ and 0.2 unidentified beaked whales outside of the U.S. EEZ: therefore, total mortality and serious injury can be considered to be insignificant and approaching zero.

4.16 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 large well-defined melon that is almost perpendicular to their long, tube-shaped beak (Garrigue et al. 2014). A crease may distinguish the melon from the beak. A dark patch has been observed around the eye and a dark band extended to the pectoral fin (Garrigue et al. 2014). As they grow older, the melon develops into a steeper more bulbous shape that may hang over the beak. Some variation in coloration is observed, but generally, their color is gray on both sides with black margins and light streaks on their ventral side (Garrigue et al. 2014). 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.

Males exhibit a single pair of teeth visible at the tip of the lower jaw which are known to collect barnacles; females have similar pairs of teeth, though theirs are embedded in their gums (Garrigue et al. 2014). A few parallel scars have been observed, likely coming from tooth rakes, potentially inflicted by conspecifics (Heyning, 1984) were visible on the back and flanks of the three adult females examined. The general coloration of the young animal was of a lighter grey than its mother and presented no or rare scars. 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 Longman’s beaked whale implies that cephalopods (e.g., squid and octopus) comprise the majority of their diet.

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 are known to occur in the HARA and WCPRA; see Table 6.5 for more detailed information regarding sighting data and density calculations for this species. 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.

Behavior and life history: Nothing is known about the reproduction or lifespan of this species. Due to their rarity, their 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: Longman’s beaked whales produce sounds similar to but distinct (in terms of frequency structure) from those of other beaked whales having an overlapping distribution (Rankin et al. 2011). Several types of pulsed sounds including short-duration clicks, long-duration FM pulses and burst pulses are produced. Like other beaked whales, anthropogenic noise is thought to be a threat to this species. As discussed in Section 4.15, the impacts of anthropogenic sound on beaked whales remain a concern as anthropogenic sound sources, such as military sonar and seismic testing have been implicated in the mass strandings of beaked whales, including atypical events involving multiple beaked whale species (Simmonds and Lopez-Jurado 1991, Frantiz 1998, Anon. 2001, Jepson et al. 2003, Cox et al. 2006, Barlow and Gisiner 2006, Cox et al. 2006, Hildebrand et al. 2005, Weilgart 2007).

4.16.1 Hawai‘i Stock

A single stranding of a Longman’s beaked whale was reported in Hawai‘i in 2010 near Hana, Maui (West et al. 2012). Over the course of 13 years of nearshore surveys off the leeward waters of the MHIs, a single sighting of a Longman’s beaked whale was seen off the Kona coast (Baird et al. 2013). Shipboard surveys of the waters within the U.S. EEZ of the Hawaiian Islands resulted in one sighting in 2002 and three in 2010 of a Longman’s beaked whale (Barlow 2006, Bradford et al. 2013).

Status and trends: There is one described Pacific stock of Longman’s beaked whales, found within waters of the Hawaiian Islands EEZ (Carretta et al. 2015). A 2002 shipboard line-transect survey of the entire Hawaiian Islands EEZ resulted in an abundance estimate of 1,007 Longman’s beaked whales (Barlow 2006). A 2010 shipboard line-transect survey of the Hawaiian Islands EEZ, resulted in an abundance estimate of 4,571 Longman’s beaked whales, which is currently the best available abundance estimate for this stock (Bradford et al. 2013).

The increase in abundance estimates between the 2002 and 2010 surveys are attributed to the use of higher Beaufort Sea states (Beaufort 0–5) in estimating the trackline detection probability for the 2010 survey (Carretta et al. 2015). Comparatively, the 2002 survey only utilized Beaufort Sea state data (0-2) (Bradford et al. 2013). This change in the analysis methodology precludes evaluation of population trends, at this time (Caretta et al. 2014).

The minimum population size 2,773 Longman's beaked whales within the Hawaiian Islands EEZ and the calculated PBR is 28.

No interactions between nearshore hook-and-line fisheries and Longman's beaked whales have been reported in Hawaiian waters; however, these fisheries are not observed or monitored for protected species bycatch (Carretta et al. 2015). Between 2007 and 2011, no Longman's beaked whales were observed hooked or entangled in the SSLL fishery (with 100% observer coverage) or the DSLL fishery (20-22% observer coverage) (Bradford and Forney 2013, McCracken 2013). However, two unidentified cetaceans, one unidentified Mesoplodont, and one unidentified beaked whale, may have included Longman's beaked whale was taken in the SSLL fishery and eight unidentified cetaceans were taken in the DSLL fishery, some of which may have been Longman's beaked whales (Carretta et al. 2015).

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. Longman's beaked whales are not listed as threatened or endangered under the ESA, nor as depleted or strategic under the MMPA. Given the absence of recent recorded fishery-related mortality or serious injuries, the total fishery mortality and serious injury can be considered to be insignificant and approaching zero.

4.17 Pygmy Sperm Whale (*Kogia breviceps*)

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. Adults are bluish-gray to blackish-brown dorsally and lighter ventrally. 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." *Kogia* spp. have the shortest rostrum of any cetacean, and the skull is markedly asymmetrical.

Distribution and habitat preferences: Pygmy sperm whales are known to occur in the HARA, MARA, and WCPRA; see Table 6.5 for more detailed information regarding sighting data and density calculations for this species. Pygmy sperm whales have a worldwide distribution in tropical and warm temperate waters of the Atlantic, Pacific, and Indian Oceans (Caldwell and Caldwell 1989, 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.

Behavior and life history: As summarized in DON (2008b and citations therein), pygmy and dwarf sperm whales probably prey on fish and invertebrates that feed on the zooplankton in tropical and temperate waters. There is no information regarding 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 and 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, as 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). Vocalization 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 (13-33 kHz) with durations of 0.3 to 0.5 seconds (Jérémie et al. 2006). Recordings of stranded pygmy sperm whales were in the 60 to 200 kHz range (DON 2008a).

Pygmy sperm whales are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor designated as "depleted" under the MMPA.

4.17.1 Hawai‘i Stock

Pygmy sperm whales have been observed in nearshore waters off Oahu, Maui, Ni‘ihau, and Hawai‘i Island (Shallenberger 1981, Mobley et al. 2000, Baird 2005, Baird et al. 2013). Two sightings were made during a 2002 shipboard survey of waters within the EEZ of the Hawaiian Islands (Barlow 2006); a freshly dead pygmy sperm whale was picked up approximately 100 nm north of French Frigate Shoals on a similar 2010 survey (NMFS, unpublished data). Nothing is known about stock structure for this species.

Status and trends: A 2002 shipboard line-transect survey of the entire Hawaiian Islands EEZ resulted in an abundance estimate of 7,138 pygmy sperm whales (Barlow 2006), including a correction factor for missed diving animals. This estimate for the Hawaiian EEZ is more than 8 years old and therefore will no longer be used, based on NMFS Guidelines for Assessing Marine Mammal Stocks (NMFS 2005). A 2010 shipboard line-transect survey within the Hawaiian EEZ did not result in any sightings of pygmy sperm whales (Bradford et al. 2013). No minimum estimate of abundance is available for pygmy sperm whales, as there were no on-effort sightings during a 2010 shipboard line-transect survey of the Hawaiian EEZ. No data are available to determine population abundance or trends and since there is no minimum population size estimate for pygmy sperm whales in Hawaii, the PBR is undetermined.

Information on fishery-related mortality of cetaceans in Hawaiian waters is limited, but the gear types used in Hawaiian fisheries are responsible for marine mammal mortality and serious injury in other fisheries throughout U.S. waters. One pygmy sperm whale was found entangled in fishing gear off Oahu in 1994 (Bradford & Lyman 2013), but the gear was not described and the fishery not identified. No estimates of human-caused mortality or serious injury are currently available for nearshore hook and line fisheries because these fisheries are not observed or monitored for protected species bycatch.

Between 2007 and 2011, one pygmy or dwarf sperm whale was observed hooked in the SSLL fishery (100% observer coverage) (Bradford & Forney 2013, McCracken 2013). Based on an evaluation of the observer’s description of the interaction and following the most recently developed criteria for assessing serious injury in marine mammals (NMFS 2012), this animal was considered not seriously injured (Bradford & Forney 2013). No pygmy sperm whales were observed hooked or entangled in the DSLL fishery (20-22% observer coverage). Eight unidentified cetaceans were taken in the DSLL fishery, and two unidentified cetaceans were taken in the SSLL fishery, some of which may have been pygmy sperm whales. Given the absence of recent recorded fishery-related mortality or serious injuries within the Hawaiian Islands EEZ, the total fishery mortality and serious injury can be considered to be insignificant and approaching zero.

The increasing level of anthropogenic noise in the world’s oceans has been suggested to be a habitat concern for whales (Richardson et al. 1995), particularly for deep-diving whales like pygmy sperm whales that feed in the oceans’ “sound channel.” One pygmy sperm whale found stranded in the main Hawaiian Islands tested positive for morbillivirus (Jacob 2012). Although morbillivirus is known to trigger lethal disease in cetaceans (Van Bressem et al. 2009), its impact on the health of the stranded animal is unknown (Jacob 2012). The presence of morbillivirus in 10 species of cetacean in Hawaiian waters (Jacob 2012) raises concerns about the history and prevalence of this disease in Hawai‘i and the potential population impacts on Hawaiian cetaceans.

4.18 Dwarf Sperm Whale (*Kogia sima*)

Description: *Kogia* spp. are porpoise-like and robust with a distinctive under-slung lower jaw. Dwarf sperm whales are small, at 2.7 m and 272 kg (McAlpine 2009). Adults are bluish-gray to blackish-brown dorsally and light ventrally. 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.” *Kogia* spp. have the shortest rostrum of any cetacean and the skull is markedly asymmetrical.

Distribution and habitat preferences: Dwarf sperm whales are known to occur in the HARA, MARA, ASARA, and WCPRA; see Table 6.5 for more detailed information regarding sighting data and density calculations for this species. Dwarf sperm whales have a worldwide distribution in tropical and temperate waters of the Atlantic, Pacific, and Indian Oceans (McAlpine 2009).

Behavior and life history: As summarized in DON (2008b, and citations therein) pygmy and dwarf sperm whales likely prey on fish and invertebrates that feed on the zooplankton in tropical and temperate waters. There is no information regarding 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 and 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 may 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).

Dwarf sperm whales belong to the order Cetacea, suborder Odontoceti, and family Kogiidae.

Dwarf sperm whales are not listed as “threatened” or “endangered” under the ESA, nor as “depleted” under the MMPA.

4.18.1 Hawai‘i Stock

Status and trends: The Hawaiian stock of pygmy sperm whales includes animals found both within the Hawaiian Islands EEZ and in adjacent international waters; however, because data on abundance, distribution, and human-caused impacts are largely lacking for international waters, the status of this stock is evaluated based on data from U.S. EEZ waters of the Hawaiian Islands (NMFS 2005).

The Hawaiian stock of dwarf sperm whales includes animals found both within the Hawaiian Islands EEZ and in adjacent international waters; however, because data on abundance, distribution, and human-caused impacts are largely lacking for international waters, the status of this stock is evaluated based on data from U.S. EEZ waters of the Hawaiian Islands. Baird (2005) reports that dwarf sperm whales are the sixth most commonly sighted odontocete around the MHIs. This species’ small size, tendency to avoid vessels, deep-diving habits, combined with the high proportion of Kogia sightings that are not identified to the species level, may result in negatively biased relative abundances in this region. A 2002 shipboard line-transect survey of the entire Hawaiian Islands EEZ resulted in an abundance estimate of 17,519 dwarf sperm whales (Barlow 2006), including a correction factor for missed diving animals. There were no on-effort sightings of dwarf sperm whales during the 2010 shipboard survey of the Hawaiian EEZ (Bradford et al. 2013, Carretta et al. 2015). Since no dwarf sperm whales were sighted during the 2010 line transect survey, there is no current abundance estimate for this stock and therefore no minimum population estimate or PBR (Carretta et al. 2015). The status of dwarf sperm whales in Hawaiian waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance.

Information on fishery-related mortality of cetaceans in Hawaiian waters is limited, but the gear types used in Hawaiian fisheries are responsible for marine mammal mortality and serious injury in other fisheries throughout U.S. waters. No interactions between nearshore fisheries and dwarf sperm whales have been reported in Hawaiian waters. No estimates of human-caused mortality or serious injury are currently available for nearshore hook and line fisheries because these fisheries are not observed or monitored for protected species bycatch.

Between 2007 and 2011, one pygmy or dwarf sperm whale was observed hooked in the SSLL fishery (100% observer coverage). Based on an evaluation of the observer’s description of the interaction and following the most recently developed criteria for assessing serious injury in marine mammals (NMFS 2012), this animal was considered not seriously injured (Bradford & Forney 2013). No dwarf sperm whales were observed hooked or entangled in the DSLL fishery (20-22% observer coverage). Eight unidentified cetaceans were taken in the DSLL fishery, and two unidentified cetaceans were taken in the SSLL fishery, some of which may have been dwarf sperm whales. Given the absence of recent fishery-related mortality or serious injuries within the Hawaiian Islands EEZ, the Hawaiian stock of dwarf sperm whales is not considered strategic under the 1994 amendments to the MMPA and the total fishery mortality and serious injury can be considered to be insignificant and approaching zero.

4.19 Sperm Whale (*Physeter macrocephalus*)

Description: Sperm whales belong to the order Cetacea, suborder Odontoceti, and family Physeteridae. 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 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).

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). Sperm whales are known to occur in the HARA, MARA, ASARA, and WCPRA; see Table 6.5 for more detailed information regarding sighting data and density calculations for this species.

Behavior and life history: Females reach sexual maturity at about age 9, when they are 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. 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 100 Hz 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 a 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 500 Hz) 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). The increasing level of anthropogenic noise in the world's oceans has been suggested to be a habitat concern for whales, particularly for deep-diving whales like sperm whales that feed in the oceans' "sound channel" (Richardson et al. 1995).

Status and trends: As summarized in Carretta et al. (2014, 2013, and citations therein), sperm whales appear to be a good candidate for acoustic surveys due to their increased range of detection; however, visual estimates of group size are still required. In the eastern tropical Pacific, the abundance of sperm whales has been estimated as 22,700 (Wade and Gerrodette 1993). However, it is not known whether any or all of these animals routinely enter the U.S. EEZ of the Hawaiian Islands.

Whaling removed at least 436,000 sperm whales from the North Pacific between the year 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 Hawaiʻi 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.

4.19.1 Hawaiʻi Stock

As summarized in Carretta et al. (2012, and citations therein) the Hawaiian Islands marked the center of a major nineteenth century whaling ground for sperm whales. Since 1936, at least 18 strandings have been reported from Oahu, Kauai and Kure Atoll. Sperm whales have also been sighted around several of the NWHI, off the main island of Hawaii, in the Kauai Channel, and in the Alenuihaha Channel between Maui and the island of Hawaii. In addition, the sounds of sperm whales have been recorded throughout the year off Oahu. A summer/fall 2002 shipboard survey of waters within the Hawaiian Islands EEZ, resulted in 43 sperm whale sightings throughout the study area.

A 2002 shipboard line-transect survey of the entire Hawaiian Islands EEZ resulted in an abundance estimate of 6,919 sperm whales, including a correction factor for missed diving animals (Barlow 2006). A 2010 shipboard line-transect survey of the Hawaiian Islands EEZ resulted in an abundance estimate of 3,354 sperm whales, including a correction factor for missed diving animals (Bradford et al. 2013). This is currently the best available abundance estimate for this stock. The minimum population estimate is 2,539 sperm whales within the Hawaiian Islands EEZ and the calculated PBR is 10.2 sperm whales per year (Bradford et al. 2013).

Information on fishery-related mortality of cetaceans in Hawaiian waters is limited, but the gear types used in Hawaiian fisheries are responsible for marine mammal mortality and serious injury in other fisheries throughout U.S. waters. One stranded sperm whale was found with fishing line and netting in its stomach, though it is unclear whether the gear caused its death, nor what fisheries the gear came from (NMFS PIR MMRN). Nearshore hook-and-line fisheries are not observed or monitored for protected species bycatch, so no estimates of human-caused mortality or serious injury are currently available. From 2007-2011, no sperm whales were observed hooked or entangled in the SSLL fishery (100% observer coverage) and one was observed either hooked or entangled in the DSLL fishery (20-22% observer coverage) (Bradford and Forney 2013). The observer could not determine whether the whale was hooked or entangled; however, the mainline came under tension when the animal surfaced. The whale was cut free with the hook, 0.5m wire leader, 45g weight, 12m of branchline, and 25-30 ft of mainline possibly attached. This interaction was prorated as 75% probability of serious injury because the whale was hooked or entangled but the exact nature of the injury could not be determined (Bradford and Forney 2013). Average 5-yr estimates of annual mortality and serious injury for sperm whales during 2007-2011 are zero sperm whales outside of U.S. EEZs, and 0.7 within the Hawaiian Islands EEZ (McCracken 2013).

Sperm whales are formally listed as "endangered" under the ESA and consequently, the Hawaiian stock is automatically considered as a "depleted" and "strategic" stock under the MMPA. The estimated rate of fisheries related mortality or serious injury within the Hawaiian Islands EEZ (0.7 animals per year) is less than the PBR (10.2); however, insufficient data is available to determine whether the total fishery mortality and serious injury for sperm whales is insignificant and approaching zero.

4.20 Blue Whale (*Balaenoptera musculus*)

Description: The blue whale belongs to the order Cetacea, suborder Mysticeti, and family Balaenopteridae. The blue whale is the largest animal known to have 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). North Pacific blue whales were once thought to belong to as many as five separate stocks, but acoustic evidence suggests that there are only two stocks in the eastern and western north Pacific (Stafford 2003, Stafford et al. 2001, Reeves et al. 1998). Blue whales have a tapered, elongated shape with a huge broad, relatively flat, U-shaped head and their baleen is black. 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. Underwater, blue whales are slate blue, but above water they appear to be mottled with light and dark shades of gray.

Distribution and habitat preferences: Blue whales are known to occur in the HARA, MARA, and WCPRA; see Table 6.5 for more detailed information regarding sighting data and density calculations for this species. Blue whales have a worldwide distribution in circumpolar and temperate waters. They undertake seasonal migrations and were historically hunted in 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. As summarized in Carretta et al. (2012, and citations therein) blue whales belonging to the central Pacific stock appear to feed in summer southwest of Kamchatka, south of the Aleutians, and in the Gulf of Alaska, and in winter they migrate to lower latitudes in the western Pacific and less frequently in the central Pacific, including Hawaii.

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. 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 dove 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 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 to 400 Hz, with a dominant range of 12-25 Hz (DON 2008a) (Table 4.1). Blue whales react to low and mid-frequency sonar transmissions, including the interruption of foraging behavior (Goldbogen et al. 2013). Increasing levels of anthropogenic noise in the world's oceans have been suggested to be a habitat concern for blue whales (Reeves et al. 1998). Tagged blue whales exposed to simulated mid-frequency sonar and pseudo-random noise demonstrated a variety of behavioral responses, including no change in behavior, termination of deep dives, directed travel away from sound sources, and cessation of feeding (Goldbogen et al. 2013). Behavioral responses were highly dependent upon the type of sound source and the behavioral state of the animal at the time of exposure. For example, deep-feeding and non-feeding whales reacted more strongly to experimental sound sources than surface-feeding whales that typically showed no change in behavior (Carretta et al. 2015).

As summarized in Carretta et al. (2014, and references therein), the reported take of blue whales throughout the North Pacific 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. Between 2007 and 2011, no blue whales were observed hooked or entangled in the SSLL fishery (100% observer coverage) or the DSLL fishery (20-22% observer coverage) (McCracken 2013, Bradford and Forney 2013).

4.20.1 Central North Pacific Stock

The first published sighting record of blue whales near Hawaiʻi is that of Berzin and Rovnin (1966) and in November of 2010, two blue whales were seen with fin whales and an unidentified rorqual during a survey of Hawaiian U.S. EEZ waters (Bradford et al. 2013). Four sightings have been made by observers on Hawaii-based longline vessels (NMFS/PIR, unpublished data) and there is additional evidence that blue whales occur in this area based on acoustic recordings made off Oahu and Midway Islands which likely included at least some blue whales within the EEZ (Northrop et al. 1971, Thompson and Friedl 1982). The recordings made off Hawaiʻi Island showed bimodal peaks throughout the year with central Pacific call types heard during the winter, and eastern Pacific calls heard during summer (Stafford et al. 2001).

Status and trends: A 2010 shipboard line-transect survey of the entire Hawaiian Islands EEZ resulted in a summer/fall abundance estimate of 81 blue whales (Bradford et al. 2013). This is currently the best available abundance estimate for this stock, but is likely negatively biased, since the majority of blue whales would be expected to be at higher latitude feeding grounds at this time of year (Carretta et al. 2015). The minimum population size based on the 2010 abundance estimate is 38 blue whales, with a PBR of 0.1 Central North Pacific blue whales, per year (Carretta et al. 2015).

The status of blue whales in Hawaiian waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. Blue whales are formally listed as endangered under the ESA, and consequently the central Pacific stock is automatically considered as a depleted and strategic stock under the MMPA. Because there have been no reported fishery related mortality or serious injuries of blue whales within the Hawaiian Islands EEZ, the total fishery-related mortality and serious injury of this stock can be considered to be insignificant and approaching zero.

Increasing levels of anthropogenic noise in the world's oceans has been suggested to be a habitat concern for blue whales (Reeves et al. 1998). Tagged blue whales exposed to simulated mid-frequency sonar and pseudo-random noise demonstrated a variety of behavioral responses, including no change in behavior, termination of deep dives, directed travel away from sound sources, and cessation of feeding (Goldbogen et al. 2013). Behavioral responses were highly dependent upon the type of sound source and the behavioral state of the animal at the time of exposure. Deep-feeding and non-feeding whales reacted more strongly to experimental sound sources than surface-feeding whales that typically showed no change in behavior. The authors stated that behavioral responses to such sounds are influenced by a complex interaction of behavioral state, environmental context, and prior exposure of individuals to such sound sources. One concern expressed by the authors is if blue whales did not habituate to such sounds near feeding areas that "repeated exposures could negatively impact individual feeding performance, body condition and ultimately fitness and potentially population health." Currently, no evidence indicates that such reduced population health exists, but such evidence would be difficult to differentiate from natural sources of reduced fitness or mortality in the population.

4.21 Fin Whale (*Balaenoptera physalus*)

Description: The fin whale belongs to the order Cetacea, suborder Mysticeti, and family Balaenopteridae. 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. 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. The pigmentation is also visible in the baleen plates, which are gray and yellowish.

Distribution and habitat preferences: Fin whales are known to occur in the HARA, MARA, and WCPRA; see Table 6.5 for more detailed information regarding sighting data and density calculations for this species. As summarized in DON (2008b, and references therein), fin whales are widely distributed in the oceans of both Northern and Southern Hemispheres between 20–75° N and S latitudes. 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, they tend 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 (Aguillar 2009). 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 10-20 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). Increasing levels of anthropogenic sound in the world's oceans have been suggested to be a habitat concern for whales, particularly for baleen whales that may communicate using low-frequency sound (Croll et al. 2002).

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.

4.21.1 Hawai'i Stock

As summarized in Carretta et al. (2012, and citations therein), fin whales have been considered rare in Hawaiian waters and are absent to rare in eastern tropical Pacific waters. A multispecies feeding assemblage of 8-12 fin whales were observed on 20 May 1966 approx. 250 mi. south of Honolulu. Additional sightings were reported north of Oahu in May 1976 and in the Kauai Channel in February 1979. In February 1994, a single fin whale was observed north of Kauai, and five sightings were made during a 2002 survey of waters within the U.S. EEZ of the Hawaiian Islands (Barlow 2003). A 2010 shipboard line-transect survey resulted in an abundance estimate of 58 fin whales. While this abundance estimate is likely negatively biased, since fin whales are likely to be at higher latitude feeding grounds at this time of year, it is currently the best available abundance estimate for this stock within the Hawai'i EEZ (Bradford et al. 2013). A single stranding has been reported on Maui (Shallenberger 1981). Fin whales may migrate into Hawaiian waters mainly in fall and winter, based on acoustic recordings off Oahu and Midway Islands.

The minimum population estimate is 27 fin whales within the Hawaiian Islands EEZ, resulting in a PBR of 0.1 fin whales per year (Carretta et al. 2015). The broad and overlapping confidence intervals around the 2002 and 2010 abundance estimates, preclude assessment of population trends and the status of fin whales relative to OSP is unknown (Carretta et al. 2015). 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.

Status and trends: The status of fin whales in Hawaiian waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. Fin whales are formally listed as "endangered" under the ESA, and consequently the Hawaiian stock is automatically considered as a "depleted" and "strategic" stock under the MMPA. Between 2007 and 2011, no fin whales were observed to be hooked or entangled in the SSLL fishery (100% observer coverage) or the DSLL fishery (20-22% observer coverage) (McCracken 2013, Bradford and Forney 2013). Because there were no reported fishery related mortalities or serious injuries within the Hawaiian Islands EEZ, the total fishery-related mortality and serious injury of this stock can be considered to be insignificant and approaching zero, as of 2014 (Carretta et al. 2015). However, between January and March 2015, the Hawaii-based pelagic longline fishery reported an interaction with a fin whale, which was categorized as “released injured.” Following this interaction, NMFS will review the more detailed observer notes and calculate the total fishery-related mortality and serious injury designation for this stock.

Increasing levels of anthropogenic sound in the world’s oceans has been suggested to be a habitat concern for whales, particularly for baleen whales that may communicate using low-frequency sound (Croll et al. 2002). Behavioral changes associated with exposure to simulated mid-frequency sonar, including no change in behavior, cessation of feeding, increased swimming speeds, and movement away from simulated sound sources has been documented in tagged blue whales (Goldbogen et al. 2013), but it is unknown if fin whales respond in the same manner to such sounds.

4.22 Bryde's Whale (*Balaenoptera edeni*)

Description: Bryde’s whales belong to the order Cetacea, suborder Mysticeti, and family Balaenopteridae. 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).

Distribution and habitat preferences: Bryde’s whales are known to occur in the HARA, MARA, ASARA, and WCPRA; see Table 6.5 for more detailed information regarding sighting data and density calculations for this species. 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, 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). The increasing level of anthropogenic noise in the world's oceans has been suggested to be a habitat concern for whales (Richardson et al. 1995, Weilgart 2007).

Status and trends: 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. Bryde's whales within the Pacific U.S. EEZ are divided into two areas: 1) Hawaiian waters (this report), and 2) the eastern Pacific (east of 150° W and including the Gulf of California and waters off California).

4.22.1 Hawai'i Stock

The Hawaiian stock includes animals found both within the Hawaiian Islands EEZ and in adjacent international waters; however, because data on abundance, distribution, and human-caused impacts are largely lacking for international waters, the status of this stock is evaluated based on data from U.S. EEZ waters of the Hawaiian Islands

An estimate of 13,000 Bryde's whales was made from vessel surveys in the eastern tropical Pacific between 1986 and 1990 (Wade and Gerrodette 1993). The area to which this estimate applies is mainly east and somewhat south of the Hawaiian Islands, and it is not known whether these animals are part of the same population that occurs around the Hawaiian Islands. A 2002 shipboard line-transect survey of the entire Hawaiian Islands EEZ resulted in an abundance estimate of 469 Bryde's whales (Barlow 2006). A 2010 EEZ-wide survey resulted in an abundance estimate of 798 Bryde's whales (Bradford et al. 2013). This is currently the best available abundance estimate for this stock. The minimum population estimate of 633 Bryde's whales is based on the log-normal 20th percentile of the 2010 abundance estimate within the Hawaiian Islands EEZ, resulting in a PBR of 6.3 Bryde's whales per year.

Between 2007 and 2011, no Bryde's whales were observed hooked or entangled in the SSLL fishery (100% observer coverage) or the DSLL fishery (20-22% observer coverage) (McCracken 2013, Bradford and Forney 2013). However, one Bryde's whale was observed entangled in SSLL gear off the Hawaiian Islands in 2005 (Forney 2010).

The status of Bryde's whales in Hawaiian waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. They are not listed as "threatened" or "endangered" under the ESA, nor as "depleted" under the MMPA. Given the absence of recent recorded fishery-related mortalities or serious injuries within the Hawaiian Islands EEZ, the total fishery mortality and serious injury for the Hawaiian stock of Bryde's whales can be considered to be insignificant and approaching zero (Carretta et al. 2015).

4.23 Sei Whale (*Balaenoptera borealis borealis*)

Description: The sei whale belongs to the order Cetacea, suborder Mysticeti, and family Balaenopteridae. Two subspecies have been identified: the northern sei whale (*Balaenoptera borealis borealis*) and southern sei whale (*Balaenoptera borealis schleglii*) although definitive conclusions regarding this classification cannot be made (NMFS 2011, Rice 1998). The sei whale is a typical sleek rorqual and is the fourth largest baleen whale (behind the blue, fin, and humpback) 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. 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.

Distribution and habitat preferences: Sei whales are known to occur in the HARA, MARA, and WCPRA; see Table 6.5 for more detailed information regarding sighting data and density calculations for this species. 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). The increasing level of anthropogenic noise in the world's oceans has been suggested to be a habitat concern for whales (Richardson et al. 1995). A range of behavioral changes associated with exposure to simulated mid-frequency sonar has been documented in blue whales, including no change in behavior, cessation of feeding, increased swimming speeds, and movement away from simulated sound sources; however, it is unknown if sei whales respond in the same manner to such sounds (Goldbogen et al. 2013).

Status and trends: 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.

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.

4.23.1 Hawai‘i Stock

As summarized in Carretta et al. (2014, and references therein), a 2010 shipboard line-transect survey of the entire Hawaiian Islands EEZ resulted in a summer/fall abundance estimate of 178 sei whales (Bradford 2013). This is currently the best available abundance estimate for this stock, but the majority of sei whales would be expected to be at higher latitudes in their feeding grounds at this time of year. The minimum population estimate is 93 sei whales within the Hawaiian Islands EEZ and the calculated PBR is 0.2 sei whales per year.

Information on fishery-related mortality of cetaceans in Hawaiian waters is limited, but the gear types used in Hawaiian fisheries are responsible for marine mammal mortality and serious injury in other fisheries throughout U.S. waters (Carretta et al. 2015). In March 2011, a subadult sei whale was found near Lahaina, Maui entangled with heavy-gauge polypropylene line around the tailstock and trailing about 30 feet of line, including a large bundle (Bradford and Lyman 2013). Closer examination also revealed entanglement scars on the body near the dorsal fin. Although disentanglement was attempted, the gear could not be removed. The source of the line entangling the whale could not be determined and this injury was categorized as serious, according to NMFS' evaluation criteria, based on the extent of the trailing gear and the condition of the whale (Bradford and Lyman 2013, NMFS 2012). This serious injury record results in an average annual serious injury and mortality rate of 0.2 sei whales for the period 2007 to 2011. Between 2007 and 2011, no sei whales were observed as hooked or entangled in either the SSLL or DSLL fisheries (McCracken 2013, Bradford and Forney 2013). The observed rate of fisheries-related mortality or serious injury within the Hawaiian Islands EEZ (0.2 animals per year) is equal to the PBR (0.2), so the total fishery mortality and serious injury cannot be considered insignificant and approaching zero.

4.24 Minke Whale (*Balaenoptera acutorostrata scammoni*)

Description: The common minke whale belongs to the order Cetacea, suborder Mysticeti, and family Balaenopteridae and is 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). A second minke whale species is recognized in the southern hemisphere as the Antarctic minke whale (*B. bonaerensis*). As summarized by Perrin and Brownell (2009, and citations therein), the North Pacific minke whale is the second smallest baleen whale, with females growing somewhat larger than males. Females have been measured at 8.5 m and males at 7.9 m and weigh about 10 tons. Their body is dark gray to brownish dorsally and white to cream ventrally; their flippers have 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*).

Distribution and habitat preferences: Minke whales are known to occur in the HARA, MARA, ASARA, and WCPRA; see Table 6.5 for more detailed information regarding sighting data and density calculations for this species. 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). The minke whale generally occupies waters over the continental shelf, including inshore bays and estuaries. However, based on whaling catches and surveys worldwide, there is also a deep-ocean component to the minke whale's distribution. Little is known of specific habitat preferences for minke whales but they are seen in coastal, continental shelf, and deep pelagic waters.

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 depths for minke whales. Minke whales are preyed 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). Preliminary anatomical data indicate minke whales may be able to hear slightly above 22 kHz (Ketten and Mountain 2009). The anatomy of the baleen whale inner ear seems to be well-adapted for detection of low-frequency sounds (Ketten 1992b, 1992a, 1994).

Status and trends: The Hawai‘i stock of minke whales are not listed as threatened or endangered under the ESA, nor are they listed as depleted or strategic under the MMPA.

4.24.1 Hawai‘i Stock

As summarized in Carretta et al. (2014, 2012, and citations therein), minke whales occur seasonally around the Hawaiian Islands, and their migration routes or destinations are not known. One confirmed sighting of a minke whale was made in November 2002 during a survey of waters within the U.S. EEZ of the Hawaiian Islands (Barlow 2003), and additional acoustic detections of this species' distinctive call (known as the 'boing') were made that could not be visually verified. There are no known stranding records of this species from the MHIs (Nitta 1991, Maldini et al. 2005).

As summarized in Carretta et al. (2015, 2012, and citations therein), a summer/fall shipboard line-transect survey of the entire Hawaiian Islands EEZ was conducted in 2002 and 2010 and each resulted in one 'off effort' sighting of a minke whale following the acoustic detection of a so-called 'boing' (Barlow 2003, Bradford et al. 2013). These sightings were not part of regular survey operations and, therefore, could not be used to calculate an estimate of abundance. Furthermore, the majority of this survey took place during summer and early fall, when the Hawaiian stock of minke whales would be expected to be farther north. There currently is no abundance estimate for this stock of minke whales, which appears to occur seasonally (approximately November - March) around the Hawaiian Islands. There is no minimum population estimate for the Hawaiian stock of minke whales and therefore, no PBR can be determined (Carretta et al. 2015).

Information on fishery-related mortality and serious injury of cetaceans in Hawaiian waters is limited, but the gear types used in Hawaiian fisheries are responsible for marine mammal mortality and serious injury in other fisheries throughout U.S. waters. From 2007 to 2011, no minke whales were observed killed or seriously injured within the Hawaiian EEZ in the SSLL fishery (with 100% observer coverage) or the DSLL fishery (20-22% observer coverage) (McCracken 2013). Because there has been no reported fisheries related mortality or serious injury within the Hawaiian Islands EEZ, the total fishery mortality and serious injury for minke whales can be considered insignificant and approaching zero mortality and serious injury rate.

4.25 Humpback Whale (*Megaptera novaeangliae*)

Description: The humpback whale belongs to the order Cetacea, suborder Mysticeti, and family Balaenopteridae. 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.

Distribution and habitat preferences: Humpback whales are known to occur in the HARA, MARA, ASARA, and WCPRA; see Table 6.5 for more detailed information regarding sighting data and density calculations for this species. 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 Hawaiʻi 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 (Carretta et al. 2012).

NOAA Fisheries has proposed to revise the ESA listing for the humpback whale to identify 14 Distinct Population Segments (DPS) (Figure 4.1), list 2 as threatened (Central America and Western North Pacific DPSs) and 2 as endangered (Arabian Sea and Cape Verde Islands/Northwest Africa DPSs), and identify 10 others as not warranted for listing. The Hawaiʻi and Oceania DPSs can be found within the PIFSC research areas. More information about the proposed changes is available at: http://www.nmfs.noaa.gov/stories/2015/04/04_20_15humpback.html.

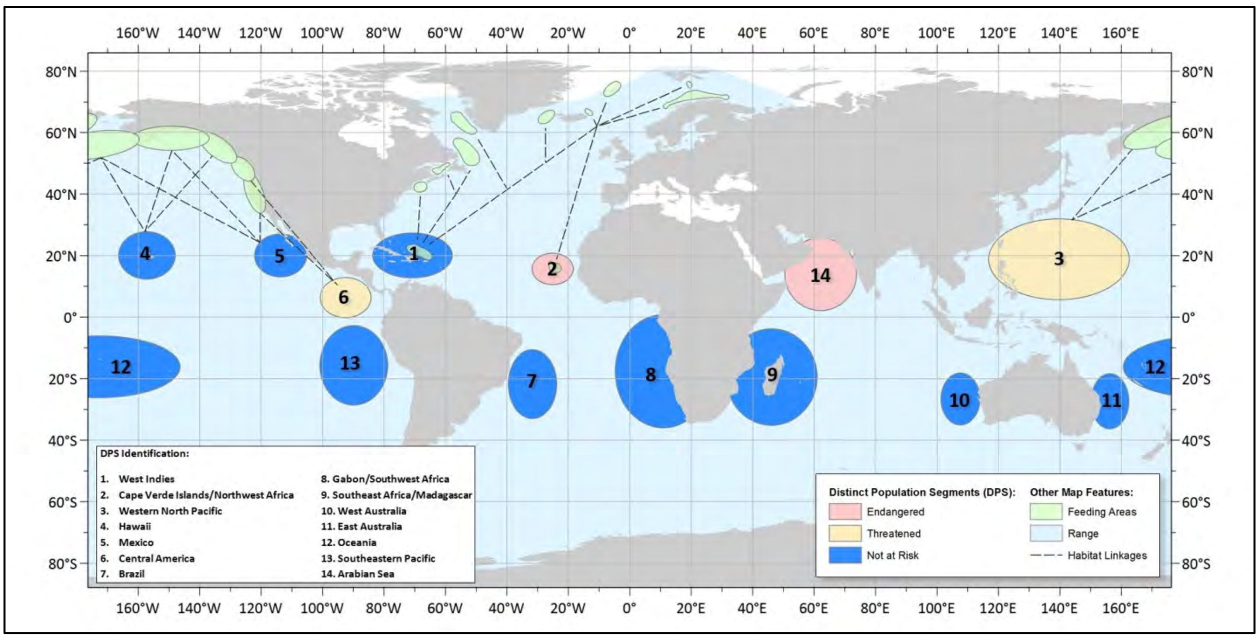


Figure 4.1 Distribution of the 14 proposed humpback whale Distinct Population Segments

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).

Behavior and life history: Humpback whales are known for their spectacular aerial behaviors and the complex songs of males. They breed in warm tropical waters after an 11 month gestation period and 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, and 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 200 and 300 Hz, 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). Increasing levels of anthropogenic sound in the world's oceans, such as those produced by shipping traffic, or LFA (Low Frequency Active) sonar, have been suggested to be a habitat concern for whales, particularly for baleen whales that may communicate using low-frequency sound (Andrew et al. 2002). Based on vocalizations, reactions to sound sources, and anatomical studies, humpback whales also appear to be sensitive to mid-frequency sounds, including those used in active sonar military exercises (Richardson et al. 1995, Au et al. 2006, Lien et al. 1990, 1992, Maybaum 1993, Hauser et al. 2001, U.S. Navy 2007).

4.25.1 American Samoa Stock

The Oceania subpopulation of humpback whales (as defined by the IUCN Red List process) ranges throughout the South Pacific, except the west coast of South America, and from the equator to the edges of the Antarctic ice. Humpback whales have been recorded across most of the lower latitudes of the South Pacific from approximately 30°S, northwards to the equator during the austral autumn and winter. There is currently no estimate of abundance for humpback whales in American Samoan waters (Carretta et al. 2014, and citations therein). A closed population estimate of 3,827 was calculated for eastern Oceania (breeding stocks E3 and F) for 1999-2004 and this may be the most relevant of those currently available, given observed exchange between American Samoa, Tonga, the Cook Islands, and French Polynesia. However, the extent and biological significance of the documented interchange is still poorly understood. The minimum population estimate for this stock is 150 whales, which is the number of unique humpbacks identified in the waters around American Samoa between via photo identification from 2003-2008. The calculated PBR is 0.4 humpback whales per year.

The status of humpback whales in American Samoan EEZ waters relative to OSP is unknown and there are insufficient data to estimate trends in abundance. However, humpback whale populations throughout the South Pacific were drastically reduced by historical whaling and IUCN classifies the Oceania subpopulation as "endangered." Worldwide, humpback whales are listed as "endangered" under the ESA so the Samoan stock is automatically considered a "depleted" and "strategic" stock under the MMPA. However, as discussed in Section 4.25, NOAA Fisheries is proposing to revise the ESA listing for the humpback whale. Under the proposed changes, the American Samoa stock would be delisted under the ESA, but protections under the MMPA will remain.

No human-related mortalities of humpback whales have been recorded in American Samoan waters; however, human-related mortality of humpback whales due to entanglements in fishing gear and collisions with ships have been reported elsewhere in the Southern Hemisphere (Carretta et al. 2015). Entanglements of humpback whales in pot lines have been reported in both New Zealand and Australia but there are no estimated rates available. Aside from a report of a humpback female with a calf entangled in a longline in 2007 in the Cook Islands (N. Hauser, reported in SPWRC 2008), there is little information about such mortality events from the rest of the South Pacific.

There are no known habitat concerns for this stock; however, Japan has proposed killing 50 humpback whales as part of its scientific research program under special permit called JARPA II in the IWC management areas IV and V in the Antarctic (Gales et al. 2005). Japan postponed their proposed catch in the 2007/08 and 2008/09 seasons but has not edited their future whaling program plans. The JARPA II program has the potential to negatively impact the recovery of humpbacks in Oceania (Carretta et al. 2015).

4.25.2 Central North Pacific Stock

Humpback whales seen in the Hawaiian Islands are principally from the Central North Pacific stock, consisting of winter/spring populations of the Hawaiian Islands which migrate primarily to northern British Columbia/Southeast Alaska, the Gulf of Alaska, and the Bering Sea/Aleutian Islands. The winter distribution of the Central North Pacific stock is primarily in the Hawaiian archipelago. In recent studies, sampling occurred on Kauai, Oahu, Penguin Bank (off the southwest tip of the island of Molokai), Maui and the island of Hawai‘i (the Big Island) and interchange within was extensive. Although most of the Hawai‘i identifications came from the Maui sub-area, identifications from the island of Hawai‘i and Kauai at the eastern and western end of the region showed a high rate of interchange with Maui. In the summer, the majority of whales from the Central North Pacific stock are found in the Aleutian Islands, Bering Sea, Gulf of Alaska, and Southeast Alaska/northern British Columbia.

The best estimate of humpback whale population size is 10,103 and the minimum population estimate for the Central North Pacific stock is 7,890 whales (Allen and Angliss 2014). Comparisons of SPLASH abundance estimates for the total North Pacific stock to estimates from 1991-93, represent an annual increase of 4.9% (Calambokidis et al. 2008). The PBR level for this stock is 82.8 humpback whales per year and the status of the entire stock relative to its OSP size is unknown.

Between 2008 and 2012, two humpback whales from the Central North Pacific stock, were reported taken in the Hawai‘i SSLL fishery (in 2011) for an estimated M&SI of 0.15 in HI. The total estimated annual mortality and serious injury rate for the entire stock (14.52 whales); therefore it is unlikely that the level of human-caused mortality and serious injury exceeds the PBR level (82.8) for the entire stock (Allen et al. 2014). The minimum estimated U. S. commercial fishery-related mortality and serious injury (0.75) for this stock is less than 10% of the calculated PBR for the entire stock (8.3) and, therefore, can be considered to be insignificant and approaching a zero mortality and serious injury rate. The humpback whale is listed as “endangered” under the Endangered Species Act, and therefore designated as “depleted” under the MMPA. As a result, the central North Pacific stock of humpback whale is classified as a strategic stock. However, the status of the entire stock relative to its Optimum Sustainable Population size is unknown.

As discussed previously, NOAA Fisheries is proposing to revise the ESA listing for the humpback whale. Under the proposed changes, the central North Pacific stock would be delisted under the ESA, but protections under the MMPA would remain.

4.26 Hawaiian Monk Seal (*Neomonachus schauinslandi*)

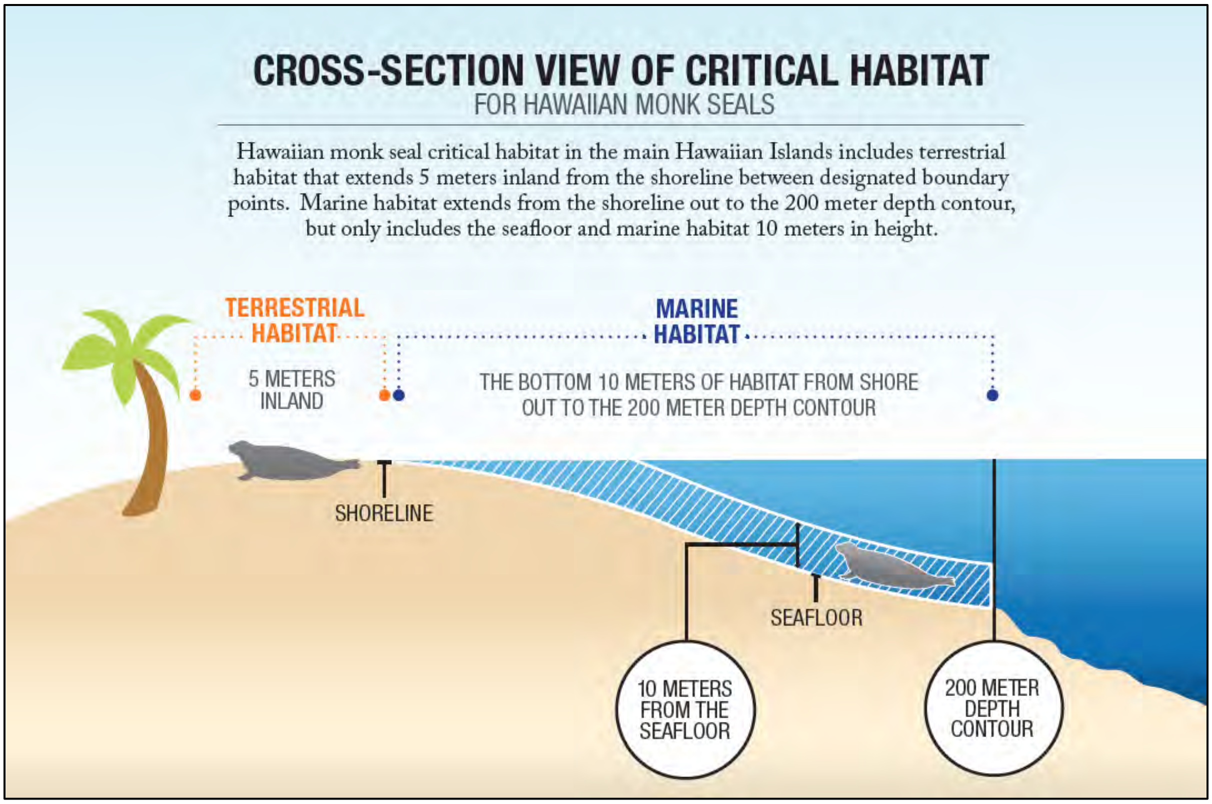
Description: Hawaiian monk seals are black at birth, occasionally with white nails and patches, known as natural bleaches. Pups turn a silvery gray after their first molt, changing to a yellowish brown as juveniles, and then darkening to gray, as adults (Gilmartin and Forcada 2009). Hawaiian monk seals undergo a catastrophic molt, where both the hair and epidermis are replaced during their 10-day molt, similar to elephant seals. Adult females may be somewhat larger than males; adult lengths are 2.1-2.4 m and weights are 170-240 kg; pups are 0.8-1.0 m in length and weigh 16-20 kg. The Hawaiian monk seal has a relatively small, flat head with large black eyes, eight pairs of teeth, and short snouts with the nostrils on top of the snout and vibrissae on each side. Hawaiian monk seal life expectancy is 25 to 30 years, though it is uncommon for them to live this long in the wild.

Distribution and habitat preferences: Hawaiian monk seals are known to occur in the HARA and WCPRA; see Table 6.5 for more detailed information regarding sighting data and density calculations for this species. The majority of the Hawaiian monk seal population can be found around the NWHI, but a small and growing population lives around the MHIs. As summarized in Carretta et al. (2014, 2012, and citations herein), Hawaiian m onk seals are distributed predominantly in six NWHI subpopulations at French Frigate Shoals, Laysan and Lisianski Islands, Pearl and Hermes Reef, and Midway and Kure Atoll. They also occur at Necker and Nihoa Islands, which are the southernmost islands in the NWHI. A few monk seals have been sighted at Johnston Atoll, part of the WCPRA, and a birth was documented in 1969. Genetic variation among NWHI monk seals is extremely low and may reflect both a long-term history at low population levels and more recent human influences (Schultz et al. 2008). On average, 10-15% of the seals migrate among the NWHI subpopulations. Thus, the NWHI subpopulations are not isolated, though the different island subpopulations have exhibited considerable demographic independence. Observed interchange of individuals among the NWHI and MHI regions is uncommon, and genetic stock structure analysis supports management of the species as a single stock.

The Hawaiian monk seal was listed as endangered throughout its range under the ESA in 1976 (41 FR 51611; November 23, 1976). In 1986, critical habitat for the Hawaiian monk seal was originally designated at all beach areas, sand spits and islets, including all beach crest vegetation to its deepest extent inland, lagoon waters, inner reef waters, and ocean waters out to a depth of 10 fathoms (18.3 m) around Kure Atoll, Midway Islands (except Sand Island), Pearl and Hermes Reef, Lisianski Island, Laysan Island, Gardner Pinnacles, French Frigate Shoals, Necker Island, and Nihoa Island in the NWHI (51 FR 16047; April 30, 1986). In 1988, critical habitat was expanded to include Maro Reef and waters around previously designated areas out to the 20 fathom (36.6 m) isobath (53 FR 18988; May 26, 1988) (Figures 4.2 and 4.3). On August 21, 2015 (80 FR 50925), a final rule was published in the Federal Register revising critical habitat for Hawaiian monk seals across the Hawaiian Archipelago. The revised boundaries include:

> "Specific areas for designation include sixteen occupied areas within the range of the species: ten areas in the Northwestern Hawaiian Islands (NWHI) and six in the main Hawaiian Islands (MHI). These areas contain one or a combination of habitat types: Preferred pupping and nursing areas, significant haul-out areas, and/or marine foraging areas, that will support conservation for the species. Specific areas in the NWHI include all beach areas, sand spits and islets, including all beach crest vegetation to its deepest extent inland, lagoon waters, inner reef waters, and including marine habitat through the water's edge, including the seafloor and all subsurface waters and marine habitat within 10 meters (m) of the seafloor, out to the 200-m depth contour line around the following 10 areas: Kure Atoll, Midway Islands, Pearl and Hermes Reef, Lisianski Island, Laysan Island, Maro Reef, Gardner Pinnacles, French Frigate Shoals, Necker Island, and Nihoa Island. Specific areas in the MHI include marine habitat from the 200-m depth contour line, including the seafloor and all subsurface waters and marine habitat within 10 m of the seafloor, through the water's edge 5 m into the terrestrial environment from the shoreline between identified boundary points on the islands of: Kaula, Ni'ihau, Kauai, Oahu, Maui Nui (including Kahoolawe, Lanai, Maui, and Molokai), and Hawaii. In areas where critical habitat does not extend inland, the designation ends at a line that marks mean lower low water."

Certain areas within these general boundaries were excluded from designation because they were inaccessible, lacked natural areas to support seals, presented national security benefits for exclusion, or were managed under an Integrated Natural Resource Management Plans (see 80 FR 50925). The final rule became effective September 21, 2015.



Source: http://www.fpir.noaa.gov/PRD/prd_critical_habitat.html

Figure 4.3 Cross-section view of critical habitat for Hawaiian monk seal

Behavior and life history: Hawaiian monk seals spend approximately two-thirds of their time at sea. Monk seals dive for an average of six minutes, but can hold their breath for as long as 20 minutes. They hunt for food primarily at depths of 60-300 feet. However, recent studies using temperature/depth recorders, and satellite telemetry has shown that monk seals actually spend much more time foraging in deeper water outside the reefs at depths of 300 m or more, than was previously understood. Hawaiian monk seals breed and haul-out on sand, corals, and volcanic rock; sandy beaches are more commonly used for pupping. Hawaiian monk seals eat a variety of fish species ranging from reef fish to deep water fish (i.e., at depths over 1,500 feet). They also eat squid, octopus, eels, and several types of crustaceans (i.e., crabs, shrimp, and lobsters). Juveniles and sub-adults prey more on smaller octopus species and eels, than adult Hawaiian monk seals. Tiger sharks, Galapagos sharks, and killer whales are all predators of the Hawaiian monk seal (Gilmartin and Forcada 2009).

Acoustics and hearing: Monk seals, as with all pinnipeds, 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 100 Hz to 3 kHz (DON 2008) (Table 4.1).

Status and trends: Hawaiian monk seals belong to the order Carnivora and family Phocidae. The genus *Neomonachus* includes the endangered Hawaiian monk seal and the extinct Caribbean monk seal (*Neomonachus tropicalis*) (Martin-Scheel 2014). The best estimate of the total population size is 1,153. The minimum population estimate is 909 at the six main NWHI reproductive sites, 38 at Necker Island, 89 for Nihoa Island, and 138 in the MHIs. The minimum population size for the entire stock (species) is the sum of these estimates, or 1,118 seals.

The Hawaiian monk seal population does not conform to the underlying assumptions built into PBR calculation, therefore PBR for the Hawaiian monk seal is undetermined. Population trends suggest a continuing decline in the Northwestern Hawaiian Islands of 3.3 percent per year (2003-2012) and an increasing trend of 6.5 percent in the MHI, as well as positive growth at Necker and Nihoa Islands (Carretta et al. 2014). Hawaiian monk seals are well below the OSP and have not recovered from past declines; therefore, it is considered a strategic stock under the MMPA.

In the NWHI, a major habitat issue for the Hawaiian monk seal involves loss of terrestrial habitat at French Frigate Shoals, where pupping and resting islets have shrunk or virtually disappeared (Antonelis et al. 2006). Global average sea levels are projected to rise and may further significantly reduce terrestrial habitat for monk seals in the NWHI (Baker et al. 2006, Reynolds et al. 2012). Remains of the seawall at Tern Island at French Frigate Shoals are an entrapment hazard for seals and vessel groundings also pose a continuing threat to monk seals and their habitat, through potential physical damage to reefs, oil spills, and release of debris into their habitat (Carretta et al. 2015).

In the MHIs, monk seal abundance is increasing and the excellent condition of pups weaned on these islands suggests that there may be ample prey resources available, perhaps in part due to fishing pressure that has reduced monk seal competition with large fish predators (sharks and jacks) (Baker et al. 2011, Baker and Johanos 2004). Monk seal population expansion in the MHI may bode well for the species' recovery and long-term persistence. However, there are many challenges that may limit the potential for growth in this region. New issues facing monk seals in the MHIs are the intentional killing of seals and two non-serious injuries attributed to boat propellers. Also, the fishing pressures that may have reduced the monk seal's competitors are also a source of injury and mortality (Carretta et al. 2015). Lastly, vessel traffic in the populated islands carries the potential for boat strikes and impacts from oil spills.

Hawaiian monk seals become entangled in fishing and other marine debris at rates higher than reported for other pinnipeds (Henderson 2001). Fishery interactions are a serious concern in the MHIs, especially those involving the nearshore fisheries, managed by the State of Hawaii. Nearshore gillnets have resulted in three confirmed Hawaiian monk seal deaths (2006, 2007, and 2010), and one additional seal in 2010 may have also died in similar circumstances, but the carcass was not recovered (Carretta et al. 2015). Numerous cases of seals with embedded hooks are also observed each year in the MHI. In 2011, 9 seals were observed hooked, though none of those constituted serious injuries. Most reported hookings and gillnet entanglements have occurred since 2000 (Carretta et al. 2015 and citations therein). No mortality or serious injuries have been attributed to the MHI bottomfish handline fishery, but results from prey analysis highlight the need to better understand the potential ecological interactions between the Hawaiian monk seal and the MHI bottomfish handline fishery (Carretta et al. 2015).

There are currently no fisheries operating within 50 nm of the NWHI because the area is protected as a Marine National Monument. However, Hawaiian monk seal mortalities have been reported due entanglement in fishing gear and other debris throughout their range (likely originating from various sources outside of Hawai'i). Historically, interactions between the Hawai'i-based domestic pelagic longline fishery and monk seals were documented; this fishery targets swordfish and tunas and does not compete with Hawaiian monk seals for prey (Nitta and Henderson 1993). In October 1991, in response to 13 unusual seal wounds, which were thought to have resulted from interactions with this fishery, NMFS established a Protected Species Zone extending 50 nautical miles around the NWHI and the corridors between the islands. Subsequently, no additional monk seal interactions with the swordfish or tuna components of the pelagic longline fishery have been observed.

Hawaiian monk seals are being hooked and entangled in the MHI at a rate that has not been reliably assessed, but is greater than zero. The information above represents only reported direct interactions, and without a directed observation effort, the true interaction rate cannot be estimated. The number of fisher self-reported loss of catch incidences to monk seals in the MHI (State of Hawai'i fisheries) appears to be increasing in recent years (Boggs et al. 2015).

In 1976, the Hawaiian monk seal was designated depleted under the Marine Mammal Protection Act of 1972 and as endangered under the Endangered Species Act of 1973. The Hawaiian monk seal is well below its optimum sustainable population (OSP) and has not recovered from past declines. Therefore, the Hawaiian monk seal is a strategic stock. Total fishery mortality and serious injury is not considered to be insignificant and approaching a rate of zero.

5.0 TYPE OF INCIDENTAL TAKE AUTHORIZATION REQUESTED

The promulgation of regulations and subsequent issuance of annual Letters of Authorization (LOA) for the incidental taking of marine mammals is requested pursuant to Section 101 (a)(5)(A) of the Marine Mammal Protection Act (MMPA). The request is for a five-year period commencing upon issuance of the permit.

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 injury) and Level B (disturbance).

PIFSC requests the promulgation of regulations and subsequent issuance of LOAs to authorize potential lethal and non-lethal incidental takes during its planned scientific research activities. The requested numbers of authorized lethal and serious injury takes, non-serious injury "Level A" harassment takes, and "Level B" harassment takes from acoustic and physical disturbance are discussed in Section 6. Although mortality and serious injury are anticipated to be rare during PIFSC research activities, PIFSC requests that the LOA authorize a small number of incidental, non-intentional, lethal or serious injury 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.

<u>Potential "Level A" harassment/mortality and serious injury takes:</u> PIFSC research surveys involve the use of gear and deployed instrumentation that has the potential to incidentally take marine mammals with two results: (1) potential entanglement, capture, or hooking in gear or instruments that may cause mortality and serious injury, and (2) potential entanglement, capture, or hooking in gear or instruments that may cause non-serious injury. The degree of injury in any given interaction, i.e., the distinction between serious and non-serious injury, is impossible to predict ahead of time so PIFSC has combined its gear take request for these two potential outcomes. PIFSC has no history of marine mammal takes in any research gear used during PIFSC fisheries and ecosystem surveys. The gear and instrument takes are requested based on analogy with takes in commercial fisheries using similar gear, analogy with other NMFS Fisheries Science Centers, and published reports of interactions.

PIFSC has no history of marine mammal takes using midwater trawl nets such as the midwater Cobb and Isaacs-Kidd trawl nets (see Table 1.1). The surveys using these nets are used to assess the occurrence and distribution of larval and juvenile fishes as well as their prey (i.e., plankton micronekton) and are integral to life history studies. Such an interaction might involve a small delphinid and be limited to a Cobb trawl due to the size of the net opening, configuration, and deployment method (see 6.1.2). PIFSC is also requesting a limited number of takes due to potential entanglement in lines used to deploy stereo-video instrumentation and bottom traps.

PIFSC also uses other hook-and line gears, bongo nets, SCUBA, free diver surveys, and other similar operations (Table 1.1) but is not requesting mortality/serious injury or non-serious Level A takes for these gear types since no gear takes have occurred historically due to PIFSC research activities and no marine mammals are expected to be taken by this gear in the future.

<u>"Level B" harassment takes:</u> The "Level B" harassment takes may occur as the result of acoustic gear used during survey operations in all areas surveyed by PIFSC. The take 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 PIFSC surveys in any of the four research areas.

Level B harassment takes also may occur to one pinniped species, the Hawaiian monk seal, due to physical presence of researchers. Physical presence could occur during small boat operations in nearshore waters while PIFSC carries out RAMP or marine debris research and removal operations. Currently, PIFSC staff implement mitigation measures to avoid and minimize the risk of inadvertently disturbing monk seals during nearshore and on-beach activities (See Section 11).

6.0 THE NUMBER OF MARINE MAMMALS THAT MAY BE TAKEN BY EACH TYPE OF TAKING, AND THE NUMBER OF TIMES SUCH TAKINGS BY EACH TYPE OF TAKING ARE LIKELY TO OCCUR

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

Potential take of this type during PIFSC surveys is limited to two forms: (1) take by accidental entanglement, capture, or hooking that may cause mortality and serious injury (M&SI), and (2) take by accidental entanglement, capture, or hooking that may cause non-serious injury (Level A harassment). Incidental take resulting in M&SI and Level A harassment may occur by longline gear, modified midwater trawl gear sampling, or due to entanglement in lines deploying instrumentation or bottom traps. The justification for potential take of marine mammal species and the estimated mortalities and injuries is discussed below.

6.1.1 Use of historical interactions as a basis for take estimates

The use of historical interactions as a basis to estimate future take of marine mammals in fisheries research gear has been utilized in the LOA applications of other NMFS Fisheries Science Centers (e.g., SWFSC, NWFSC). However, because PIFSC has no history of marine mammal take in any of the gear used during its fisheries and ecosystem research, that method is not relevant in this application. Instead, PIFSC will use information from commercial fisheries, other NMFS Fisheries Science Centers (FSCs) operations, and published interactions as described below.

Ship strikes: There have been no ship or small vessel strikes of large cetaceans by vessels engaged in PIFSC fisheries research. In 2009, there were two incidents where research vessels not affliated with PIFSC came into contact with a humpback whale's pectoral flipper while conducting research; the vessels were moving at less than 5 knots and no injuries were observed (Bradford and Lyman 2015). In 2011, a research vessel (non-PIFSC) struck a breaching humpback whale while traveling at 26 knots. However, PIFSC is not requesting any take due to ship strikes as it has never had a ship strike event, the relatively slow operating speeds of the NOAA ships, and because little can be done to further mitigate the chances of a future occurrence other than the precautions and operating procedures on vessel speed and watches while underway that are already being implemented.

6.1.2 Approach for estimating takes by analogy with species taken by other Fisheries Science Centers and commercial fisheries.

PIFSC believes it is appropriate to include estimates for future incidental takes of a number of species that have not been taken historically but inhabit the same areas and show similar types of behaviors and vulnerabilities to gear used at other FSCs and used in commercial fisheries (based on the 2015 List of Fisheries [LOF, see:
http://www.nmfs.noaa.gov/pr/interactions/fisheries/2015_list_of_fisheries_lof.html]). A number of factors were taken into account to determine whether a species may have a similar vulnerability to certain types of gear as species taken in commercial gear and research gear elsewhere (e.g., distribution, density, abundance, behavior, feeding ecology, travel in groups, and common association with other species historically taken in commercial gear or other FSCs). While such take could potentially occur, PIFSC believes that any occurrences would likely be rare given that no such take in PIFSC research has occurred, their behavioral and ecological characteristics which reduce the risk of incidental capture in research gear, and mitigation measures in place to reduce the risk of incidental capture.

Take involving M&SI and Level A harassment

While PIFSC has not historically interacted with marine mammal species in its longline gear, it is well documented that some species are taken in commercial longline fisheries. The 2015 LOF classifies commercial fisheries based on prior interactions with marine mammals, largely based on data from the draft 2013 SARs (which generally cover fisheries interaction data from 2007-2011. Although PIFSC 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 interactions with research longline gear etc.). Species that were previously caught in longlines (as outlined in the 2015 LOF) in what were deemed analogous commercial fisheries were considered to have a higher probability of potential take and were considered, but not necessarily included, for potential take by PIFSC.

While longline research would only be conducted outside of the longline exclusion areas (http://www.fisheries.noaa.gov/pr/pdfs/interactions/fkwtrp_guide.pdf), several species of small cetaceans were deemed to have a similar vulnerability to longline gear as some historically taken species by other FSCs or by commercial fisheries using factors outlined above. The commercial longline fisheries in US waters of the Pacific Ocean reported to have taken marine mammals include: HI deep-set longline (Category 1) and the HI shallow-set longline and American Samoa longline (both Category II) fisheries. The longline fisheries identified by the LOF to have taken marine mammals on the High Seas include: the Western Pacific Pelagic (HI Deep-set component, Category 1) and Western Pacific Pelagic (HI Shallow-set component, Category II). In addition one take of a Pymgy killer whale was reported in a commercial longline in 2014 but has yet to be included in the most recent LOF.

In these instances, PIFSC assumes any take of these species in longline fisheries research activities will be a rare occurrence. Therefore, PIFSC requests one potential take in longline gear over the five-year authorization period throughout the PIFSC research area for each of the following species: bottlenose dolphin - Hawai‘i pelagic stock, Blainville’s beaked whale - Hawai‘i pelagic stock, Cuvier’s beaked whale, Kogia spp. Hawai’i stocks (dwarf sperm whale and pygmy sperm whale), false killer whale - HI pelagic stock, Pantropical spotted dolphin - all stocks, pygmy killer whale, rough toothed dolphin – Hawai’i stock, Risso's dolphin – Hawai’i stock, short-finned pilot whale – Hawai‘i stock, and striped dolphin - Hawai’i stock (Table 6.1). While the LOF includes commercial fishery takes of false killer whale - American Samoa stock and rough-toothed dolphin - American Samoa stock, PIFSC is not requesting M&SI/Level A takes of these species/stocks because they do not anticipate conducting longline research anywhere within the range of these species/stocks throughout the time period addressed by this application (e.g., longline surveys in the WCPRA would occur within 500 nm of the HARA, which is at least 1600 nm from the ASARA). Additionally, the LOF includes commercial fishery takes of the MHI insular stock of false killer whales, but PIFSC will not be conducting longline research within the stock’s range, and so is not requesting M&SI/Level A takes of this stock. Spinner dolphins have not been reported taken in Hawai‘i based longline fisheries in the LOF; the PIFSC is therefore not requesting any take of this species in analogous fisheries research gear.

While PIFSC has not historically interacted with large whales in its longline gear, it is well documented that some of these species are taken in commercial longline fisheries. There are two large whale species that have been shown to interact with commercial longline fisheries and for which PIFSC is requesting a single take each over the five-year authorization period in longline gear: the humpback whale – central North Pacific stock and the sperm whale. Between 2008 and 2012, two humpback whales (Central North Pacific stock) were reported taken in the HI SSLL fishery (in 2011, Allen and Angliss 2014). One sperm whale was observed either hooked or entangled in the HI DSLL fishery; the lines were cut and the whale swam away with a hook and some line still attached (Bradford and Forney 2013). Both of these species are listed as “endangered” under the ESA and thus by definition, depleted under the MMPA. Although large whale species could become entangled in longline gear, the probability of interaction with PIFSC longline gear is extremely low considering a much lower level of survey effort effort and shorter duration sets relative to that of commercial fisheries. For example, in 2014 approximately 47.1 million hooks were deployed in commercial longline fishing in the PIFSC research areas (http://www.pifsc.noaa.gov/fmb/reports.php); in contrast PIFSC proposes to deploy up to 73,500 hooks/year or 0.0015% of the effort in these commercial fisheries. Although there is only a limited potential for take, PIFSC is requesting one take of humpback whale – central North Pacific stock in longline gear and one take of a Sperm whale – Hawaiʻi stock by analogy with commercial fisheries over the five-year authorization period of this application.

Bradford and Lyman (2015) reviewed humpback whale entanglement events in various types of fishing gear and lines. While most gear retrieved in such events could not be identified to a specific fishery, these gears were not recreational in nature. Humpback whales inhabit shallow waters, typically within the 100 fathom isobaths (http://dlnr.hawaii.gov/sanctuary/sanctuary-101/) in the Hawaiian Islands regions (Baird et al. 2000). PIFSC conducts a variety of instrument deployments and insular fish abundance surveys between 50m and 600m and bottomfish EFH surveys between 100-400m (Table 1.1) using gear similar to that used in a variety of commercial fisheries; thus such research gear has the potential for entangling humpback whales surfacing from shallow water dives. Such “instrument deployments” include aMOUSS, BotCam, BRUVS deployed from a vessel and connected to the surface with a line to a float or vessel; environmental sampling instruments deployed by line such as CTD; baited or unbaited bottom traps such as lobster traps and fish traps deployed from a vessel and connected to the surface with line to a float. Therefor PIFSC is requesting one take of humpback whale – central North Pacific stock in gear associated with “instrument deployments” and related electronic instrumentation. Additional design changes are being evaluated by PIFSC in an attempt to reduce the potential for such interactions (see section 11 and 13 of this application). In addition, based on a similarity in behavior, several species of “curious” small delphinids have the potential for becoming entangled in gear associated with these instrument deployments. Despite mitigation measures already in place (e.g., no deployment when marine mammals are known to be in the immediate area), there is a remote chance such entanglement may occur when an animal moves into “the wrong place at the wrong time” and investigates such gear. Thus PIFSC requests one take each over the five-year authorization period of each of the following small delphinid species: bottlenose dolphin (all stocks), rough-toothed dolphin (Hawaiʻi stock), spinner dolphin (all stocks), and Pantropical spotted dolphin (all stocks) in “instrument deployment” gears.

Although PIFSC has never taken small delphinids in a pelagic midwater trawl such as an Isaacs-Kidd or Cobb trawl, there is a remote possibility such a take could occur. This research targets very small pelagic species (e.g., micronekton, pelagic larvae) not likely to be attractive to foraging small delphinids. Thus incidental catch of a small delphinid is unlikely in either technique but less so in the Isaacs-Kidd trawl due to the very small opening (about 3 m x 3 m) whereas the mouth of the PIFSC Cobb trawls are about 10 m x 10 m. However, to address a rare situation or event, PIFSC requests one take each of the following small delphinids in trawl gear over the five year period of this application: bottlenose dolphin (all stocks), rough-toothed dolphin (Hawaiʻi stock), spinner dolphin (all stocks), Pantropical spotted dolphin (all stocks), and striped dolphin (Hawaiʻi stock).

Table 6.1 Requested number of potential M&SI/Level A marine mammal takes in PIFSC fisheries and ecosystem research (all areas combined).

This table shows the requested potential takes of marine mammal stocks by Mortality and Serious Injury (M&SI) over a five-year period by gear type. Blank cells reflect that no take is requested.

Common Name - Stock	PIFSC Potential M&SI Level A Take Request (all areas combined)						
	Midwater Trawl		Longline		Instrument Deployments		
	Calculated - average take per year	Total takes over 5-year period	Calculated - average take per year	Total takes over 5-year period	Calculated - average take per year	Total takes over 5-year period	Sum all gears 5-year request
Beaked whale, Blainville's - Hawaiʿi stock			0.2	1			**1**
Beaked whale, Cuvier's - Hawaiʿi pelagic stock			0.2	1			**1**
Bottlenose dolphin - Hawaiʿi pelagic stock	0.2	1	0.2	1	0.2	1	**3**
Bottlenose dolphin - All stocks, except above	0.2	1			0.2	1	**2**
False killer whale, Hawai'i pelagic or unspecified [B]			0.2	1 [C]			**1**
Humpback whale CNP stock [D]			0.2	1	0.2	1	**2**
Kogia spp. (Pygmy and dwarf sperm whale) - Hawaiʿi stocks			0.2	1			**1**
Pantropical spotted dolphin - all stocks	0.2	1	0.2	1	0.2	1	**3**
Pygmy killer whale - Hawai'i stock [E]			0.2	1			**1**
Risso's dolphin - Hawaiʿi stock			0.2	1			**1**
Rough-toothed dolphin - Hawaiʿi stock	0.2	1	0.2	1 [F]	0.2	1	**3**
Rough-toothed dolphin - all stocks except above				1 [F]	0.2	1	**2**
Short-finned pilot whale - Hawai'i stock			0.2	1			**1**
Sperm whale - Hawaiʿi stock [G]			0.2	1			**1**
Spinner dolphin, all stocks	0.2	1			0.2	1	**2**
Striped dolphin, - all stocks	0.2	1	0.2	1			**2**

A. Hawai'i pelagic stock only

B. Strategic stock. "Unspecified stock" occurs on the high seas.

C. Longline research would only occur outside of FKW exclusion zone; potential take not in HARA, only within WCPRA.

D. Listed as "endangered" under the ESA. Request for take in instrument deployment based on Bradford and Lyman (2015).

E. Based on 2014 take in commercial longline fisheries, not yet included in LOF.

F. Hawaiʿi stock only.

G. Listed as "endangered" under the ESA.

6.1.3 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

PIFSC considered the risk of interaction with marine mammals for all the research gears and instruments it uses but does not request incidental takes in research gears other than midwater trawls, longline, and instrument deployments. PIFSC acknowledges that by having hooks, nets, lines, or vessels in the water there is a potential for incidental take of marine mammals during research activities. However, many of the fisheries and ecosystem research activities conducted by PIFSC involve gear or instruments that do not present a large enough risk to be included as part of the mortality, serious injury, or Level A harassment take request. These include gear and instruments that are operated by hand or close enough to the vessel that they can be continuously observed and controlled such as dip nets, scoop nets, handheld gear and instruments used by SCUBA divers or free divers (cameras, transect lines, and spears), environmental data collectors deployed or attached by hand to the reef, marine debris removal tools (knives and float bags), and surface net trawls adjacent to the vessel (bongo nets, IK nets, ring nets, and neuston nets). Other gear or instruments that are used so infrequently, operate so slowly, or carried out with appropriate mitigation measures so as not to present a reasonable risk of interactions with marine mammals include: autonomous vehicles such as gliders, AUV, UAV, UAS, and TOAD; submersibles; towed-divers; troll fishing; larval settlement traps temporarily installed on the reef; XBT; and environmental data collectors temporarily deployed from a vessel to the seafloor and then retrieved remotely such as HARP and EAR. Refer to Table 1.1 for a list of the research projects that use these gears and Appendix A for descriptions of their use.

All the gear and instruments listed above in this section are not considered to have a reasonable potential to take marine mammals given their physical characteristics, how they are fished, and the environments where they are used. There have been no marine mammal mortalities, serious injuries, or other Level A takes associated with any of these gear types. Because of this, PIFSC is not requesting marine mammal take for these gears or instruments, and as such they are not expected to result in take of marine mammal stocks in the PIFSC research areas.

There is evidence that cetaceans and Hawaiian monk seals occasionally pursue fish caught on various hook-and-line gears (depredation of fishing lines) deployed in commercial and non-commercial fisheries across Hawaiʿi (Nitta and Henderson 1993, Kobayashi and Kawamoto 1994). This depredation behavior, which is documented as catch loss from the hook-and-line gear, may be beneficial to the marine mammal in providing prey but it also opens the possibility for the marine mammal to be hooked or entangled in the gear. PIFSC gave careful consideration to the potential for including incidental take requests for marine mammals in bottom handline (bottomfishing) gear because of the planned increase in research effort using that gear in the Insular Fish Abundance Estimation Comparison Survey (from approximately 700 sets per year to over 7000 sets per year). PIFSC has not had any interactions in the past with marine mammals while conducting research with bottomfishing gear in the MHI.

Fisheries in state waters are not observed by independent, trained monitors and therefore few data exist on interactions with marine mammals. A recently published preliminary summary of self-reported catch loss data from the State of Hawaiʿi Commercial Marine License reporting system indicates that the number of catch loss incidents by dolphins and monk seals in the MHI may be increasing, but is still relatively rare (Boggs et al. 2015). The authors of the summary emphasize that the data received only cursory treatment and should not be viewed as comprehensive.

Bottlenose dolphins have been identified as the primary species associated with depredation of catch in the bottomfish fishery and they appear to be adept at pulling hooked fish from the gear without breaking the line or taking hooks off the line (Kobayashi and Kawamoto 1994). It is not known if these interactions result in injury, serious injury, or mortality of bottlenose dolphins (Caretta et al. 2015).

Regarding monk seals, the population in the MHI is relatively small (minimum abundance estimate in 2011 of 138 seals), but it is growing at approximately 6.5% per year (Caretta et al. 2015). No mortality or serious injuries of monk seals have been attributed to the MHI bottomfish handline fishery (Caretta et al. 2015). However, the latest marine mammal stock assessment report (Caretta et al. 2015) notes: “In 2012, 16 Hawaiian monk seals were observed hooked, four of which died as a result of ingesting hooks. The remaining 12 were non-serious hookings, although 5 of these would have been deemed serious had they not been mitigated by capture and hook removal. Several incidents involved hooks used to catch ulua (jacks, *Caranx* spp.).” The hook-and-line rigging used to target ulua are typical of shoreline fisheries that are distinct from the bottomfishing gear and methods used by PIFSC during its fisheries and ecosystem research. Although there are some similarities between the shoreline fishery and the bottomfishing gear used by PIFSC (e.g., circle hooks), the general size and the way the hooks are rigged (e.g., baits, leaders, weights, tackle) are typically different and probably present different risks of incidental hooking to monk seals. Ulua hooks are generally much larger circle hooks than PIFSC uses because the targeted ulua are usually greater than 50 pounds in weight. Shoreline fisheries (deployed from shore with rod and reel) also typically use “slide bait” or “slide rigs” that allow the use of live bait (small fish or octopus) hooked in the middle of the bait. If a monk seal pursued this live bait and targeted the center of the bait or swallowed it whole, it could get hooked in the mouth. PIFSC research with bottomfishing gear uses pieces of fish for bait that attract bottomfish but not monk seals. Monk seals could be attracted to a caught bottomfish but, given the length of the target bottomfish (averaging approximately 14 inches long; Boggs, personal communication), it is unlikely that a monk seal would be physically capable of swallowing the whole fish and therefore bites and tears at the caught fish (i.e., shreds the body of the fish while feeding). The risk of monk seals getting hooked on bottomfishing gear used in PIFSC research is therefore less than the risk of getting hooked on shoreline hook-and-line gears which are identified in the marine mammal stock assessment report (Caretta et al. 2015).

Given the mitigation measures the PIFSC intends to implement for bottomfishing research (see Section 11.7), PIFSC has concluded that the risk of marine mammal interactions with its research bottomfishing gear is not high enough to warrant an incidental take request for marine mammals in that gear. PIFSC intends to document potential depredation of its bottomfish research gear (catch loss) in the future, and increase monitoring efforts when catch loss becomes apparent, in an effort to better understand the potential risks of hooking to monk seals and other marine mammals.

6.1.4 Mitigation and avoidance of takes

Because of the suite of mitigation measures PIFSC has implemented since 2008, it expects the total number of marine mammals taken in these gears to be very low in the future and be substantially less than the estimated level of take when summed across all species. Current mitigation protocols are described in detail in Section 11 of this application, and focus on diligently using visual monitoring by experienced field staff.

6.1.5 Conclusion

PIFSC has not had interactions with marine mammals in fisheries research but has used documented interactions from commercial fisheries, historic and self-reported accounts, and other NMFS Fisheries Science Centers employing analogous gear as a basis for estimating potential takes. PIFSC notes that despite its best efforts to estimate realistic potential marine mammal takes, it believes actual takes will be less than its take estimates. Nevertheless, PIFSC considers the take estimates presented here to be precautionary and to account for the maximum amount of potential take in the future based on the best information available. There is substantial inherent uncertainty in estimating numbers and species that potentially could be taken and the PIFSC take estimates reflect this uncertainty.

Our understanding of the potential effects of PIFSC activities on marine mammals is continually evolving. Reflecting this, PIFSC proposes to include an adaptive management component within the application (see Section 13 of this application). This allows PIFSC, 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.

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

Estimating sound exposures leading to behavioral 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. PIFSC took a dual approach to assess the impacts of high-frequency active acoustic sources used in fisheries research in each of the four different research areas (HARA, MARA, ASRA, WCPRA) and, where appropriate within each area, to appropriately address species occurrence within the geographical areas where it operates these devices and within two depth strata: 0-200 meter depth and >200 meter depth.

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 below) 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 PIFSC 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 and 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 MMPA 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 in this 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). The analysis used characteristics of active acoustic systems, their expected patterns of use in each of the four PIFSC research 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 PIFSC 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 likely 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 of the number of exposures at received levels identified as Level B harassment) are described below (see 6.2.7).

6.2.1 Framework for quantitative estimation of potential acoustic harassment takes

The discussion in section 7.2 considers the differential frequency bands and functional 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 PIFSC operations, in this case acoustic impacts, a quantitative estimate of potential incidents of Level B harassment is 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 considered 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. Sound produced by the fisheries acoustic sources here are very short in duration (typically on the order of milliseconds, [ms]), intermittent, have high rise times, and are operated from moving platforms. They are consequently considered most similar to impulsive sources, which are subject to the 160 dB RMS criterion. A mathematical method for estimating exposures according to this step-function was derived and applied in each of the PIFSC research areas where active acoustic gear is used (HARA, MARA, ASRA, WCPRA).

The assessment paradigm for active acoustic sources used in PIFSC 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 in 6.2.7) very likely lead to an overestimate of the number of exposures to animals that may occur 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 dimensions of the sound exposure footprint 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 acoustic exposures 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 200 meters 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 PIFSC sound source characteristics

An initial characterization of the general source parameters for the primary PIFSC vessels operating active acoustic sources was conducted for each research area (Table 6.3). This process enabled a full assessment of all sound sources, including those within the category 1 sources (identified in section 7.2 below) 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. Many of these sources can be operated in different modes and with different output parameters. In modeling their potential impact areas for NOAA vessels when used and also when they are operated from non-NOAA vessels used for PIFSC survey operations, those features among those given below that would lead to the most precautionary estimate of maximum received level ranges (i.e., largest insonified area) were used (i.e., lowest operating frequency and highest power output utilized). These operating characteristics of each of the predominant sound sources were used in the calculation of effective line km (section 6.2.3) and in modeling effective beam pattern 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 (e.g., standard consumer fishfinders used on small research boats). Among those operating within the audible band of marine mammal hearing, four 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 (Table 6.2). The operating frequencies of these PIFSC sources only go down to 30 kHz, which is above the hearing range of baleen whales (Southall et al. 2007). Therefore, baleen whales would not be expected to perceive signals from PIFSC active acoustic sources and we would not expect any exposures to these signals to result in behavioral harassment.

In determining the effective line km for each of these predominant sources (Appendix A) 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 200 m, 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 simultaneous sources with different spatial profiles. This overall process effectively resulted in three sound sources (EK60, EM300, and ADCP Ocean Surveyor) comprising the total effective line km, their relative proportions depending on the nature of each survey in each region (Table 6.3). A fourth source used in PIFSC research (Netmind) could potentially cause behavioral harassment but has been excluded from the calculations because it was dominated in all cases by the other three sources.

Table 6.2 Output characteristics for PIFSC acoustic sources within hearing range of marine mammals

Note: Calculations of effective exposure areas are made with the lowest frequency from sources with multiple frequencies; the full range of frequencies used is shown in parentheses. Abbreviations: dB re 1 µPa at 1 m = decibels referenced at one micro Pascal at one meter; km^2 = square kilometer

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 attenuated to 160 dB SPL (km^2)
Simrad EK60	38 (70, 120, 200)	224	7	0.0082	0.0413
Simrad EM300	30	237	1	0.112	3.7661

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 attenuated to 160 dB SPL (km^2)
ADCP Ocean Surveyor	75	223.6	4	0.0086	0.0187

6.2.3 Calculating effective line kilometer for each NOAA vessel

An estimated volume of water insonified to the 160 dB RMS received level was determined based on the operating parameters for each source type as described below. 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. Two depth zones were defined for each of the four research areas: 0-200 m and > 200 m. Effective line distance and volume insonified was calculated for each depth strata (0-200 m and > 200 m), where appropriate. In some cases, this resulted in different sources being predominant in each depth strata for all line km when multiple sources were in operation; this was accounted for when 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. The total line km for each vessel, the effective portions associated with each of the dominant sound source, and the effective total km for operation for each sound source is given in Table 6.3.

Table 6.3 Linear survey distance for each NOAA vessel and its dominant sources within two depth strata for each of the four PIFSC Research Areas for the five-year period of this request

Only the sound sources that were the dominant sources of sound during PIFSC research are shown.

Vessel - Survey	Average Line kms per vessel	Dominant Source	% Time Source Dominant (0-200m)	Line km/ Dominant Source (0-200m)	Volume Insonified at 0-200 m Depth (km^3)	% Time Source Dominant (>200m)	Line km/ Dominant Source (>200m)	Volume Insonified at >200 m Depth (km^3)
HAWAIIAN ARCHIPELAGO RESEARCH AREA								
***Hi'ialakai* RAMP**	36000	Simrad EM 300	25	9000	1000.8	25	9000	32894.1
	36000	ADCP Ocean Surveyor	75	27000	232.2	75	27000	272.1
***Hi'ialakai* Coral Reef Benthic Mapping**	17000	Simrad EM 300	100	17000	1890.4	100	17000	62133.3
***Oscar Elton Sette* Kona IEA**	5000	EK60	0	0	0	100	5000	165.5
	5000	ADCP Ocean Surveyor	100	5000	43.0	0	0	0
***Oscar Elton Sette* Insular Fish Abundance Estimation**	3000	EK60	0	0	0	100	3000	99.3
	3000	ADCP Ocean Surveyor	100	3000	28.5	0	0	0
***Hi'ialakai* Deep Coral and Sponge Research**	5500	Simrad EM300	100	5500	611.6	100	5500	20102.0
***Oscar Elton Sette* Sampling Pelagic Stages of Insular Fish Species**	4000	EK60	0	0	0	100	4000	132.4
	4000	ADCP Ocean Surveyor	100	4000	34.4	0	0	0
***Oscar Elton Sette* Cetacean Ecology Assessment**	40000	EK60	0	0	0	100	40000	1324.0
	40000	ADCP Ocean Surveyor	100	40000	344.0	0	0	0
***Hi'ialakai* or *Oscar Elton Sette* RAMP Gear & Instrument Development & Field Trials**	2500	EK60	0	0	0	100	2500	82.8
	2500	ADCP Ocean Surveyor	100	2500	21.5	0	0	0
MARIANA ARCHIPELAGO RESEARCH AREA								
***Hi'ialakai* RAMP**	18000	Simrad EK60	25	4500	500.4	25	4500	16447.1
	18000	ADCP Ocean Surveyor	75	13500	116.1	75	13500	136.4

Vessel - Survey	Average Line kms per vessel	Dominant Source	% Time Source Dominant (0-200m)	Line km/ Dominant Source (0-200m)	Volume Insonified at 0-200 m Depth (km^3)	% Time Source Dominant (>200m)	Line km/ Dominant Source (>200m)	Volume Insonified at >200 m Depth (km^3)
Hi'ialakai **Coral Reef Benthic Mapping**	8600	Simrad EM 300	100	8600	956.3	100	8600	31432.1
Oscar Elton Sette **Insular Fish Abundance Estimation**	2000	EK60	0	0	0	100	2000	66.2
	2000	ADCP Ocean Surveyor	100	2000	17.2	0	0	0
Hi'ialakai **Deep Coral and Sponge**	5500	Simrad EM 300	100	5500	611.6	100	5500	20102.0
Oscar Elton Sette **Sampling Pelagic Stages of Insular Fish**	2000	EK60	0	0	0	100	2000	66.2
	2000	ADCP Ocean Surveyor	100	2000	17.2	0	0	0
Oscar Elton Sette **Cetacean Ecology Assessment**	20000	EK60	0	0	0	100	20000	662.0
	20000	ADCP Ocean Surveyor	100	20000	172.0	0	0	0
Hi'ialakai **Mariana Baseline Surveys**	3000	EK60	0	0	0	100	3000	99.3
	3000	ADCP Ocean Surveyor	100	3000	25.8	0	0	0
AMERICAN SAMOA RESEARCH AREA								
NOAA ship ***Hi'ialakai*** **RAMP**	18000	Simrad EK60	25	4500	500.4	25	4500	16447.1
	18000	ADCP Ocean Surveyor	75	13500	116.1	75	13500	136.4
Hi'ialakai **Coral Reef Benthic Mapping**	8600	Simrad EM 300	100	8600	956.3	100	8600	31432.1
NOAA ship ***Oscar Elton Sette*** **Insular Fish Abundance Estimation**	2000	EK60	0	0	0	100	2000	66.2
		ADCP Ocean Surveyor	100	2000	17.2	0	0	0
Hi'ialakai **Deep Coral and Sponge Research**	500	Simrad EM 300	100	500	55.6	100	500	1827.5
Oscar Elton Sette **Sampling Pelagic Stage of Insular Fish**	2000	EK60	0	0	0	100	2000	66.2
	2000	ADCP Ocean Surveyor	100	2000	17.2	0	0	0
Oscar Elton Sette	20000	EK60	0	0	0	100	20000	662.0

Vessel - Survey	Average Line kms per vessel	Dominant Source	% Time Source Dominant (0-200m)	Line km/ Dominant Source (0-200m)	Volume Insonified at 0-200 m Depth (km^3)	% Time Source Dominant (>200m)	Line km/ Dominant Source (>200m)	Volume Insonified at >200 m Depth (km^3)
Cetacean Ecology Assessment	20000	ADCP Ocean Surveyor	100	20000	172.0	0	0	0
WESTERN AND CENTRAL PACIFIC RESEARCH AREA								
***Hi'ialakai* RAMP**	18000	Simrad EK60	25	4500	500.4	25	4500	16447.1
	18000	ADCP Ocean Surveyor	75	13500	116.1	75	13500	136.4
***Hi'ialakai* Coral Reef Benthic Mapping**	8600	Simrad EM 300	100	8600	956.3	100	8600	31432.1
***Oscar Elton Sette* Oceanographic**	7000	EK60	0	0	0	100	7000	231.7
	7000	ADCP Ocean Surveyor	100	7000	60.2	0	0	0
***Oscar Elton Sette* Insular Fish Abundance Estimation**	2000	EK60	0	0	0	100	2000	66.2
	2000	ADCP Ocean Surveyor	100	2000	17.2	0	0	0
***Hi'ialakai* Deep Coral and Sponge**	500	Simrad EM 300	100	500	55.6	100	500	1827.5
***Oscar Elton Sette* Sampling Pelagic Stages of Insular Fish**	2000	EK60	0	0	0	100	2000	66.2
	2000	ADCP Ocean Surveyor	100	2000	17.2	0	0	0
***Oscar Elton Sette* Cetacean Ecology Assessment**	20000	EK60	0	0	0	100	20000	662.0
	20000	ADCP Ocean Surveyor	100	20000	172.0	0	0	0

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 x log (range) - such that there would be 60 dB of attenuation over 1000 m). This is a reasonable assumption even in relatively shallow waters since, taking into account the beam angle, the reflected energy from the seafloor will be much weaker than the direct source and the volume influenced by the reflected acoustic energy would be much smaller over the relatively short ranges involved. The spherical spreading model accounted for the frequency dependent absorption coefficient and the highly directional beam pattern of most of these sound sources. For absorption coefficients, the most commonly used formulas given by Francios and Garrison (1982) were used. 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 for deep water operations, 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 Table 6.4). A simple visualization of a two-dimensional slice of modeled sound propagation is shown in Figure 6.1 to illustrate the predicted area ensonified to the 160 dB level by an EK-60 operated at 18 kHz. PIFSC does not operate the EK60 at 18 kHz, only between 38 and 200 kHz. These higher frequencies have a higher sound propogation loss, and therefore a smaller volume of ensonified water than Figure 6.1.

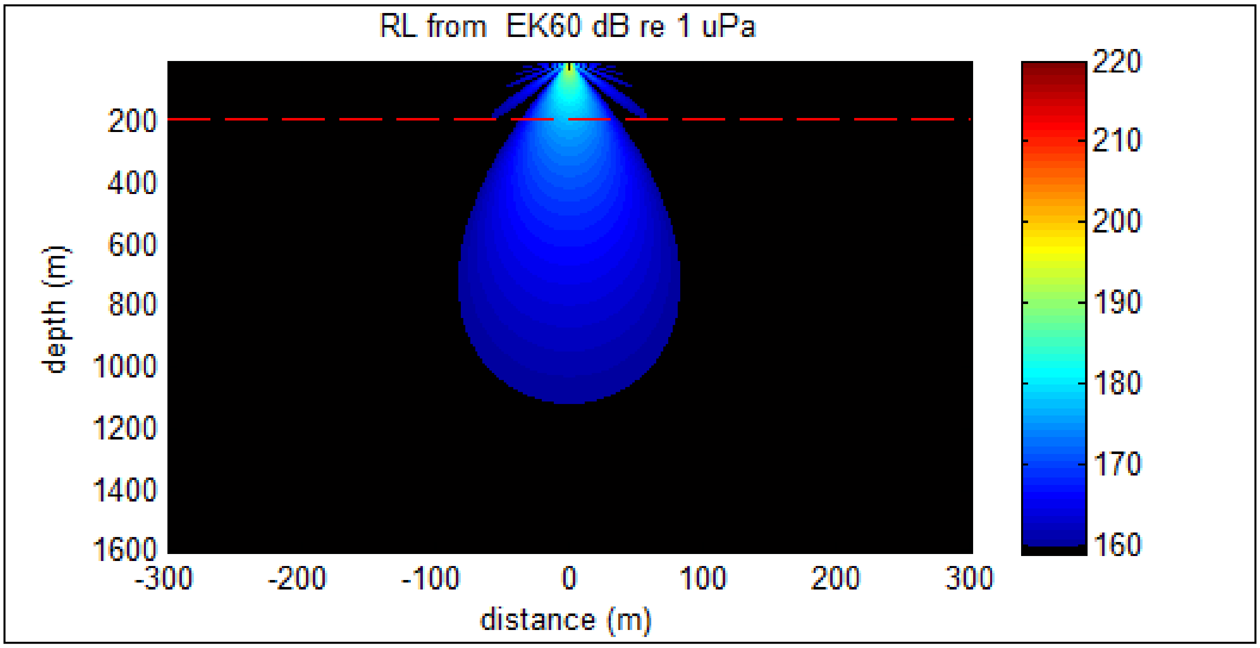


Figure 6.1 Visualization of a two-dimensional slice of modeled sound propagation to illustrate the predicted area ensonified to the 160 dB level by an EK-60 operated at 18 kHz.

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. ADCP and EK60 operating simultaneously in deep water 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 in deeper water 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 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 and other sources for the Pacific and are based on the best scientific information available to PIFSC (see Tables 6.4 and 6.5). There are a number of caveats associated with these estimates:

- 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 PIFSC fisheries surveys.
- 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.
- Marine mammal density information is in many cases based on limited historical surveys and may be incomplete or absent for many regions of the vast geographic area addressed by PIFSC fisheries research. As a result density estimates for some species/stocks in some regions are based on the best available data for other regions and/or similar stocks.

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). The volumetric densities are estimates of the three-dimensional distribution of animals in their typical depth strata. 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. For shallow diving species the volumetric density is the area density divided by 0.2 km (i.e., 200 m). Species in the deeper diving stratum were reasonably estimated to dive deeper than 200 m and spend 25% or more of their lives 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. 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 Table 6.4.

Table 6.4 Volumetric densities calculated for each species in the four PIFSC Research Areas used in take estimation

Note that densities of baleen whales are not provided due to the lack of overlap in their hearing range with the operating frequencies of PIFSC acoustic sources.

Species (common name)	Typical Dive Depth Strata		Area density (#/km²)	Volumetric density (#/km³)
	0-200 m	>200 m		
HAWAIIAN ARCHIPELAGO RESEARCH AREA				
Pantropical spotted dolphin	X		0.02332	0.1166
Striped dolphin	X		0.025	0.125
Spinner dolphin- all insular	X		0.009985	0.0499255
Rough-toothed dolphin	X		0.02963	0.14815
Bottlenose dolphin	X		0.00899	0.04495
Risso's dolphin		X	0.00474	0.00948
Fraser's dolphin	X		0.02104	0.1052
Melon-headed whale	X		0.00354	0.0177
Melon-headed whale- Kohala stock	X		0.001415	0.0070734
Pygmy killer whale	X		0.00435	0.02175
False killer whale- pelagic		X	0.0006	0.0012
False killer whale- MHI insular		X	0.0009	0.0018
False killer whale- NWHI		X	0.0014	0.0028
Short-finned pilot whale		X	0.00797	0.01594
Killer whale	X		0.00006	0.0003
Sperm whale		X	0.00186	0.00372
Pygmy sperm whale		X	0.00291	0.00582
Dwarf sperm whale		X	0.00714	0.01428
Blainville's beaked whale		X	0.00086	0.00172
Cuvier's beaked whale		X	0.0003	0.0006
Longman's beaked whale		X	0.00311	0.00622
Unidentified Mesoplodon		X	0.00189	0.00378
Unidentified beaked whale		X	0.00117	0.00234
Hawaiian monk seal	X		0.003741	0.0187042
MARIANA ARCHIPELAGO RESEARCH AREA				
Pantropical spotted dolphin	X		0.0226	0.113
Striped dolphin	X		0.00616	0.0308
Spinner dolphin	X		0.009985	0.0499255
Rough-toothed dolphin	X		0.00314	0.0157
Bottlenose dolphin	X		0.00029	0.00145
Risso's dolphin		X[1]	0.00021	0.00042

Species (common name)	Typical Dive Depth Strata		Area density (#/km^2)	Volumetric density (#/km^3)
	0-200 m	>200 m		
Fraser's dolphin	X		0.02104	0.1052
Melon-headed whale	X		0.00428	0.0214
Pygmy killer whale	X		0.00014	0.0007
False killer whale- pelagic		X[1]	0.00111	0.00222
Short-finned pilot whale		X	0.00159	0.00318
Killer whale	X		0.00006	0.0003
Sperm whale		X	0.00123	0.00246
Pygmy sperm whale		X	0.00291	0.00582
Dwarf sperm whale		X	0.00714	0.01428
Blainville's beaked whale		X	0.00086	0.00172
Cuvier's beaked whale		X	0.0003	0.0006
Unidentified beaked whale		X	0.00117	0.00234
AMERICAN SAMOA RESEARCH AREA				
Pantropical spotted dolphin	X		0.02332	0.1166
Spinner dolphin	X		0.00475	0.02375
Rough-toothed dolphin	X		0.02963	0.14815
Bottlenose dolphin	X		0.00899	0.04495
False killer whale	X		0.00090	0.0045
Short-finned pilot whale		X	0.00797	0.01594
Killer whale	X		0.00006	0.0003
Sperm whale		X	0.00186	0.00372
Dwarf sperm whale		X	0.00714	0.01428
Cuvier's beaked whale		X	0.00030	0.0006
Unidentified beaked whale		X	0.00117	0.00234
WESTERN AND CENTRAL PACIFIC RESEARCH AREA				
Pantropical spotted dolphin	X		0.02332	0.1166
Striped dolphin	X		0.025	0.125
Spinner dolphin	X		0.011095	0.055475
Rough-toothed dolphin	X		0.02963	0.14815
Bottlenose dolphin	X		0.00899	0.04495
Risso's dolphin		X[1]	0.00474	0.00948
Fraser's dolphin	X		0.02104	0.1052
Melon-headed whale	X		0.00354	0.0177
Pygmy killer whale	X		0.00435	0.02175
False killer whale		X[1]	0.00102	0.00204

Species (common name)	Typical Dive Depth Strata		Area density (#/km^2)	Volumetric density (#/km^3)
	0-200 m	>200 m		
Short-finned pilot whale		X	0.00797	0.01594
Killer whale	X		0.00006	0.0003
Sperm whale		X	0.00186	0.00372
Pygmy sperm whale		X	0.00291	0.00582
Dwarf sperm whale		X	0.00714	0.01428
Blainville's beaked whale		X	0.00086	0.00172
Cuvier's beaked whale		X	0.0003	0.0006
Deraniyagala's beaked whale		X	0.0003	0.0006
Longman's beaked whale		X	0.00311	0.00622
Unidentified beaked whale		X	0.00117	0.00234

[1] PIFSC has classified these species as deep diving in the PIFSCresearch areas, which is different from their classification as shallow-diving species by the other NMFS Fisheries Science Centers. These classifications of deep-diving are based on unpublished data from telemetry studies including depth of dive and stomach contents of deep-diving prey items (E. Oleson, personal commmunication, November 10, 2015).

Table 6.5 Sources of cetacean density information used to develop Table 6.4

The sources used to estimate densities include NMFS SARs as appropriate, references cited below, and the best scientific information available to PIFSC staff. Density estimates in areas where a species is thought to occur (Table 3.1) based on PIFSC expertise, but where published density data is absent (asterisks) were calculated based on values published for the species in adjacent regions. Blank cells represent areas where density was not estimated, as there is no evidence of the species occurring in that research area.

Common Name - stock	Research Area			
	HARA	MARA	ASARA	WCPRA
Blainville's beaked whale	1, 10	*		1
Bottlenose dolphin	1, 10	7		1
Cuvier's beaked whale	1, 10	*	*	1
Deraniyagala's beaked whale				13
Dwarf sperm whale	5, 6, 10	*	*	5
False killer whale	5	7	*	9
False killer whale- MHI insular	5			
False killer whale- NWHI	5			
False killer whale- pelagic	5, 9, 10	7		
Fraser's dolphin	1, 10	*		1
Killer whale	1, 10	*	*	1

Common Name - stock	Research Area			
	HARA	MARA	ASARA	WCPRA
***Kogia* sp.**	10			
Longman's beaked whale	1			1
Melon-headed whale	1, 10	7		1
Melon-headed whale- Kohala stock	3, 11			
Pantropical spotted dolphin	1, 10	7	*	1, 8
Pygmy killer whale	1, 10	7		1
Pygmy sperm whale	5, 6		*	5
Risso's dolphin	1, 10	7		1
Rough-toothed dolphin	1, 10	7	*	1
Short-finned pilot whale	1, 10	7	*	1
Sperm whale	1, 10, 12	7	*	1
Spinner dolphin	2, 5, 10	6	*	9
Spinner dolphin- all insular	2			
Spinner dolphin- pelagic	5, 10			
Striped dolphin	1, 10	7		1
Unidentified beaked whale	1, 10			1
Unidentified *Mesoplodon*	1, 10			

1. Bradford et al. in review. Line-transect abundance estimates of cetaceans in the Hawai‘i EEZ
2. Tyne et al. 2014.
3. Aschettino 2010.
4. Bradford, A.L. et al. 2015. Revised stock boundaries for false killer whales (*Pseudorca crassidens*) in Hawaiian waters
5. Barlow 2006.
6. Calambokidis et al. 2008.
7. Fulling et al. 2011.
8. Forney et al. 2015.
9. Barlow and Rankin 2007.
10. Ferguson and Barlow 2003.
11. Aschettino et al. 2011.
12. Barlow and Taylor 2005.
13. Dalebout et al. 2014.

6.2.6 Using areas insonified and volumetric density to calculate acoustic takes

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 usage and 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). These estimated takes 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 take estimates are given for each of the four PIFSC research areas in Tables 6.6 through 6.9.

Table 6.6 PIFSC estimated acoustic takes (Level B harassment) by sound type for each marine mammal species in the HARA requested by PIFSC for the five-year authorization period

The volume of water insonified to 160 dB by each sound source and depth strata is shown in Table 6.3. The number of Level B takes for each species is derived by multiplying the volume of insonified water for each sound source by the volumetric density for each species. Note that take estimates of baleen whales are not provided due to the lack of overlap in their hearing range with the operating frequencies of PIFSC acoustic sources.

Species	Volumetric density (#/km^3)	Estimated Level B harassment (numbers of animals) in 0-200m depth stratum			Estimated Level B harassment in >200m depth stratum		Total Take
		EK60	EM300	ADCP	EK60	EM300	
HARA CETACEANS							
Pantropical spotted dolphin	0.11660	0	408	82	0	0	**490**
Striped dolphin	0.12500	0	438	88	0	0	**525**
Spinner dolphin- all insular	0.04993	0	175	35	0	0	**210**
Rough-toothed dolphin	0.14815	0	519	104	0	0	**623**
Bottlenose dolphin	0.04495	0	157	32	0	0	**189**
Risso's dolphin	0.00948	0	33	7	17	1091	**1148**
Fraser's dolphin	0.10520	0	368	74	0	0	**442**
Melon-headed whale	0.01770	0	62	12	0	0	**74**
Melon-headed whale- Kohala stock	0.00707	0	25	5	0	0	**30**
Pygmy killer whale	0.02175	0	76	15	0	0	**91**
False killer whale- pelagic	0.00120	0	4	1	2	138	**145**
False killer whale- MHI insular	0.00180	0	6	1	3	207	**218**
False killer whale- NWHI	0.00280	0	10	2	5	322	**339**
Short-finned pilot whale	0.01594	0	56	11	29	1835	**1931**
Killer whale	0.00030	0	1	0	0	0	**1**
Sperm whale	0.00372	0	13	3	7	428	**451**

Species	Volumetric density (#/km^3)	Estimated Level B harassment (numbers of animals) in 0-200m depth stratum			Estimated Level B harassment in >200m depth stratum		Total Take
		EK60	EM300	ADCP	EK60	EM300	
Pygmy sperm whale	0.00582	0	20	4	10	670	**705**
Dwarf sperm whale	0.01428	0	50	10	26	1644	**1730**
Blainville's beaked whale	0.00172	0	6	1	3	198	**208**
Cuvier's beaked whale	0.00060	0	2	0	1	69	**73**
Longman's beaked whale	0.00622	0	22	4	11	716	**753**
Unidentified *Mesoplodon*	0.00378	0	13	3	7	435	**458**
Unidentified beaked whale	0.00234	0	8	2	4	269	**283**
HARA PINNIPEDS							
Hawaiian monk seal	0.01870		66	13	0	0	**79**
						Total	**11,199**

Table 6.7 PIFSC estimated acoustic takes (Level B harassment) by sound type for each marine mammal species in the MARA requested by PIFSC for the five-year authorization period

The volume of water insonified to 160 dB by each sound source and depth strata is shown in Table 6.3. The number of Level B takes for each species is derived by multiplying the volume of insonified water for each sound source by the volumetric density for each species. Note that take estimates of baleen whales are not provided due to the lack of overlap in their hearing range with the operating frequencies of PIFSC acoustic sources.

Species	Volumetric density (#/km^3)	Estimated Level B harassment (numbers of animals) in 0-200m depth stratum			Estimated Level B harassment in >200m depth stratum			Total Take
		EK60	EM300	ADCP	EK60	EM300	ADCP	
MARA CETACEANS								
Pantropical spotted dolphin	0.11300	0	234	37	0	0	0	**271**
Striped dolphin	0.03080	0	64	10	0	0	0	**74**
Spinner dolphin	0.04993	0	103	17	0	0	0	**120**
Rough-toothed dolphin	0.01570	0	32	5	0	0	0	**38**
Bottlenose dolphin	0.00145	0	3	0	0	0	0	**3**
Risso's dolphin	0.00042	0	1	0	0	29	0	**30**
Fraser's dolphin	0.10520	0	218	35	0	0	0	**252**
Melon-headed whale	0.02140	0	44	7	0	0	0	**51**
Pygmy killer whale	0.00070	0	1	0	0	0	0	**2**
False killer whale-	0.00222	0	5	1	2	151	0	**159**

Species	Volumetric density (#/km^3)	Estimated Level B harassment (numbers of animals) in 0-200m depth stratum			Estimated Level B harassment in >200m depth stratum			Total Take
		EK60	EM300	ADCP	EK60	EM300	ADCP	
pelagic								
Short-finned pilot whale	0.00318	0	7	1	3	216	0	**227**
Killer whale	0.00030	0	1	0	0	0	0	**1**
Sperm whale	0.00246	0	5	1	2	167	0	**175**
Pygmy sperm whale	0.00582	0	12	2	5	396	1	**416**
Dwarf sperm whale	0.01428	0	30	5	13	971	2	**1020**
Blainville's beaked whale	0.00172	0	4	1	2	117	0	**123**
Cuvier's beaked whale	0.00060	0	1	0	1	41	0	**43**
Unidentified beaked whale	0.00234	0	5	1	2	159	0	**167**
						Total		**3,172**

Table 6.8 PIFSC estimated acoustic takes (Level B harassment) by sound type for each marine mammal species in the ASARA requested by PIFSC for the five-year authorization period

The volume of water insonified to 160 dB by each sound source and depth strata is shown in Table 6.3. The number of Level B takes for each species is derived by multiplying the volume of insonified water for each sound source by the volumetric density for each species. Note that take estimates of baleen whales are not provided due to the lack of overlap in their hearing range with the operating frequencies of PIFSC acoustic sources.

Species	Volumetric density (#/km^3)	Estimated Level B harassment (numbers of animals) in 0-200m depth stratum			Estimated Level B harassment in >200m depth stratum			Total Take
		EK60	EM300	ADCP	EK60	EM300	ADCP	
ASARA CETACEANS								
Pantropical spotted dolphin	0.11660	0	176	38	0	0	0	**214**
Spinner dolphin	0.02375	0	36	8	0	0	0	**44**
Rough-toothed dolphin	0.14815	0	224	48	0	0	0	**272**
Bottlenose dolphin	0.04495	0	68	14	0	0	0	**82**
False killer whale	0.00450	0	7	1	0	0	0	**8**
Short-finned pilot whale	0.01594	0	24	5	13	792	2	**836**
Killer whale	0.00030	0	0	0	0	0	0	**1**
Sperm whale	0.00372	0	6	1	3	185	1	**195**

Species	Volumetric density (#/km^3)	Estimated Level B harassment (numbers of animals) in 0-200m depth stratum			Estimated Level B harassment in >200m depth stratum			Total Take
		EK60	EM300	ADCP	EK60	EM300	ADCP	
Dwarf sperm whale	0.01428	0	22	5	11	710	2	**749**
Cuvier's beaked whale	0.00060	0	1	0	0	30	0	**31**
Unidentified beaked whale	0.00234	0	4	1	2	116	0	**123**
						Total		**2,556**

Table 6.9 PIFSC estimated acoustic takes (Level B harassment) by sound type for each marine mammal species in the WPCRA requested by PIFSC for the five-year authorization period

The volume of water insonified to 160 dB by each sound source and depth strata is shown in Table 6.3. The number of Level B takes for each species is derived by multiplying the volume of insonified water for each sound source by the volumetric density for each species. Note that take estimates of baleen whales are not provided due to the lack of overlap in their hearing range with the operating frequencies of PIFSC acoustic sources.

Species	Volumetric density (#/km^3)	Estimated Level B harassment (numbers of animals) in 0-200m depth stratum			Estimated Level B harassment in >200m depth stratum			Total Take
		EK60	EM300	ADCP	EK60	EM300	ADCP	
WCPRA CETACEANS								
Pantropical spotted dolphin	0.11660	0	176	45	0	0	0	**221**
Striped dolphin	0.12500	0	189	48	0	0	0	**237**
Spinner dolphin	0.05548	0	84	21	0	0	0	**105**
Rough-toothed dolphin	0.14815	0	224	57	0	0	0	**281**
Bottlenose dolphin	0.04495	0	68	17	0	0	0	**85**
Risso's dolphin	0.00948	0	14	4	10	471	1	**500**
Fraser's dolphin	0.10520	0	159	40	0	0	0	**199**
Melon-headed whale	0.01770	0	27	7	0	0	0	**34**
Pygmy killer whale	0.02175	0	33	8	0	0	0	**41**
False killer whale	0.00204	0	3	1	2	101	0	**107**
Short-finned pilot whale	0.01594	0	24	6	16	792	2	**841**
Killer whale	0.00030	0	0	0	0	0	0	**1**
Sperm whale	0.00372	0	6	1	4	185	1	**197**
Pygmy sperm whale	0.00582	0	9	2	6	289	1	**307**

Species	Volumetric density (#/km^3)	Estimated Level B harassment (numbers of animals) in 0-200m depth stratum			Estimated Level B harassment in >200m depth stratum			Total Take
		EK60	EM300	ADCP	EK60	EM300	ADCP	
Dwarf sperm whale	0.01428	0	22	5	15	710	2	**754**
Blainville's beaked whale	0.00172	0	3	1	2	85	0	**91**
Cuvier's beaked whale	0.00060	0	1	0	1	30	0	**32**
Deraniyagala's beaked whale	0.00060	0	1	0	1	30	0	**32**
Longman's beaked whale	0.00622	0	9	2	6	309	1	**328**
Unidentified beaked whale	0.00234	0	4	1	2	116	0	**123**
						Total		**4,515**

6.2.7 Conclusion regarding total estimates of Level B harassment due to acoustic sources

The results given in Tables 6.7 through 6.10 are based on the approach taken here to estimate marine mammal Level B harassment takes under the MMPA and should be interpreted with caution. This method is prescribed by the current definition of 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, large 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 precautionary estimate of potential impact (e.g., higher estimated "takes" 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:

- While the hearing ranges of the functional hearing groups (see section 7.2 below and Southall et al. 2007) are accounted for in a straightforward manner in these calculations (i.e. sources are considered unlikely to lead to any Level B harassment if they are above or below functional hearing cut-offs), the known differences in hearing sensitivities between different marine mammal species, and within a functional hearing range (e.g., as reflected in auditory weighting functions), are not considered in estimates of Level B harassment by acoustic sources. All species are assumed to be equally sensitive to acoustic systems operating within their functional hearing range.
- 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. All Sound Pressure Levels (SPLs) are calculated by assuming a continuous transmission, without taking into account the duty cycle, i.e., the ratio of pulse duration to ping interval. While some animals may potentially hear these signals well (e.g., odontocete cetaceans), for other animals, the perceived sound loudness may 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. More research is needed, however, in order to be able to quantify any potential reduction in

perceived received level due to the brief nature of the sounds and to determine to which species this applies.

- Several other precautionary assumptions are made, including the use of the lowest frequencies and highest output power levels utilized (with greatest potential propagation leading to higher received levels) in cases where source operational parameters may be varied (Table 6.3).
- It should be recognized that the estimates of take by acoustic sources take into account that more than one animal could be insonified several times and the total estimated take cannot be directly compared to the total number of animals in any particular population stock.

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

6.2.8 Estimated Level B harassment due to physical presence of fisheries research activities

PIFSC research activities in coastal regions and on islands and atolls may interact with marine mammals in the water or pinnipeds hauled out on land. In the MHI and the NWHI, there are numerous sites used by the endangered Hawaiian monk seal to haulout (sandy beaches, rocky outcroppings, exposed reefs) where the physical presence and sounds of researchers walking by or passing nearby in small boats may disturb animals present. For example, during the RAMP coral reef monitoring surveys virtually all of the islands and atolls in the HARA are circumnavigated by small boats (usually with divers in the water) once during the year. This circumnavigation is an approximation because the specific sampling locations are choosen based on a random sampling protocol. In some cases, PIFSC research may involve nearshore diving and shallow water fisheries sampling using rod and reel or other such gear. In addition, nearshore and shore-based research to assess and remove marine debris is conducted at many locations where Hawaiian monk seals may be present. Often, when removing marine debris from shallow-water coral reefs fish hiding in the debris may be flushed out and thus attract monk seals in the vicinity. PIFSC scientists are aware of this situation and take precautions to avoid and minimize the chance of inadvertently disturbing monk seals, including reconnaissance of all beaches before approaching in skiffs or on foot (see mitigation procedures detailed in Section 11). However, there are numerous locations where Hawaiian monk seals may be resting adjacent to vegetation, or just emerging from the water onto the beach, and would not be immediately visible and where the options for alternate passage may be limited. Combined with the fact that this population is expanding in some PIFSC regions and that pinnipeds may haul out in new locations on a regular basis, it is essentially impossible for researchers to completely avoid disturbing monk seals as they travel around to conduct research. Such disturbance would be entirely accidental and unintentional.

Based on the locations of known haulouts (Baker and Johanos 2004, PIFSC 2014 a, b), PIFSC estimates the minimum population estimate for the Hawaiian monk seal population at about 1,182 animals. Not all of these seals haul out at the same time or at the same places, and therefore it is difficult to predict if any monk seals will be present at any particular research location at any point in time. Therfore, the only way to estimate the amount of Level B harassment would be to approximate the number of seals hauled out at any point in time across the HARA and the probability that a researcher would be close enough to actually disturb the seal.

The best estimate for the number of monk seals hauled out at any point in time is approximately one-third of the total population (Parrish et al. 2000). Therfore, assuming that all seals have an equal probability of hauling out anywhere in the archipelago, one-third of 1,182 is approximately 400 individual monk seals. Given that the two surveys with the highest probablility of disturbing monk seals (i.e., RAMP and Marine Debris Research and Removal) systematically circumnavigate all the islands and atolls when they are conducted, we could estimate the annual maximum number of Level B harassment takes as 800 during the years when these are conducted. Over the course of five years, this would be approximately 4000 potential disturbance if all the surveys took place every year at every location across the HARA. However, RAMP surveys occur in the HARA approximately twice every five years and Marine Debris Research and Removal Surveys are rarely funded to a level that would support complete circumnavigation of the HARA each year. In addition, sometimes during RAMP surveys the location of marine debris are identifed (and recorded), thus precluding the need for marine debris identification later (only removal). Therefore, the approximately 4000 potential disturbances over five years could be reduced by two-fifths to approximately 1600 potential disturbances over five years. Futhermore, not all small boat operations during these surveys are close enough to the shoreline to actually cause a disturbance (e.g., a seal may be hauled out on a beach in a bay but the shallow fringing reef may keep the small boat from getting within half of mile from shore) and the researchers implement avoidance and minimization measures while carrying out the surveys. The approximately 1600 potential disturbances could realistically be reduced through avoidance or sheer geographical separation by one-half. Therefore, the PIFSC is requesting 800 Level B disturbances of Hawaiian monk seals due to the physical presence of researchers over the five year authorization period.

It is likely that many of these animals will not be disturbed as research occurs in the vicinity but to date PIFSC fisheries researchers have not recorded numbers of animals actually affected by their presence. Until more accurate data becomes available monitoring and reporting procedures (Section 11.7), it is assumed that these animals may react to PIFSC research activity. PIFSC recognizes these estimated take levels are likely large over-estimates and that actual taking by harassment will be considerably smaller. This level of periodic, highly infrequent, and temporary disturbance is unlikely to affect the use of the region by this species.

7.0 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, Level A (non-serious injury) harassment (through gear interaction), or by causing Level B (behavioral) harassment (through use of active acoustic sources and the physical presence of researchers). These could occur through the following:

- Entanglement or capture in nets or lines;
- Accidental hooking;
- Alterations in behavior caused by acoustics sources and by close approaches to pinnipeds hauled out during research activities either from approaches of nearshore small vessel based research or land based debris research and clean-up 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 effects on marine mammals from ship collision or vessel strike (see 7.4 Collision and Ship Strike for details).

PIFSC does not expect its survey operations or its cooperative surveys with other research entities would cause the marine mammal populations in portions of the Western and Central Pacific Ocean, the waters around the State of Hawaiʻi, the Territories of Guam and American Samoa, PRIA, or the Commonwealth of the Northern Mariana Islands 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. PIFSC 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 short periods throughout the year; however, density information is not available for every season in all the study regions. But PIFSC believes that the direct effects on species or stocks would be minor because over the course of its fisheries research operations no marine mammals have ever been incidentally caught.

While there are different approaches that could be taken to evaluate the adverse impact 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 PIFSC fisheries research activities on affected marine mammal stocks, two assumptions should be noted. First, as described in section 6 of this application, PIFSC has requested a single number of takes in each gear for each stock in a combined category that includes Level A injury, and serious injury and mortality. It is likely that some marine mammals that interact with PIFSC research gears will experience only non-serious injuries. However, for purposes of evaluating the importance of the PIFSC 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 this binning of Level A injury, serious injury and mortality takes is described in greater detail in Section 6 of this application.

Second, PIFSC 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 interactions reported in commercial and other fisheries, and as such PIFSC 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 PIFSC research will need to be evaluated to understand the importance of these activities. As described in Sections 11 and 13 of this application, PIFSC 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 Fishing Gear

Several gear types used during PIFSC fisheries research surveys, including cooperative research, are similar to those used in commercial fishing operations in the central Pacific Ocean. Included are mid-water trawls, pelagic longlines, troll, bottomfishing, and traps. However, it is important to note that even though PIFSC uses similar types of gear as that in commercial fisheries, the size, configuration, effort, and methods of use of this gear during PIFSC research surveys differs substantially than that used in commercial operations thereby reducing or eliminating the likelihood of incidental catch of marine mammals.

Entanglement in fishing gear is not a common occurrence in the PIFSC research area. However, commercial fishing gear such as fixed, bottom-tending fishing gear (i.e., pots and gillnets) is a source of human-caused injury or mortality in marine mammals in other parts of the U.S. and in Hawai‘i (Bradford and Lyman 2013). There were 153 confirmed entanglements of baleen whales along the U.S. eastern seaboard between 2003 and 2007. Twenty-one of these were fatal and 16 caused serious injury (Glass et al. 2009). Although not always as immediately fatal as ship strikes, entanglements in commercial fishing gear can lead to prolonged weakening or deterioration of an animal (Knowlton and Kraus 2001). This is particularly true for large whales; small whales, dolphins, porpoises, and seals are more likely to die when entangled. Commercial fisheries along the U.S. east coast with known bycatch of marine mammals include those using pelagic longlines, sink gillnets, drift gillnets, lobster traps/pots, mixed species traps/pots, bottom trawls, midwater trawls, purse seines, stop seine/weirs, and haul/beach seines (Waring et al. 2011, Zollet 2009).

PIFSC has made a concerted effort to develop and implement mitigation measures to reduce the risk of such takes. These mitigation measures are part of the proposed action (continuing fisheries research program) and are described in Section 11. Most of the mitigation measures rely on visual monitoring and detection of marine mammals near the vessel or fishing gear. There are many variables that influence the effectiveness of visual monitoring at any one time, including the lighting and sea state, and the capabilities of the person(s) assigned to watch, so it is impossible to determine an overall measure of effectiveness, such as how many animals may have been avoided with visual monitoring compared to having no monitors. The value of implementing some mitigation measures is therefore based on general principles and best available information even if their effectiveness at reducing takes has not been scientifically demonstrated or quantified.

Because there have been no historical takes by any gear type used during PIFSC fisheries research surveys, as well as the low level of predicted future takes associated with the use of such gear in research activities in the Pacific Ocean, PIFSC 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.

7.1.1 Anticipated impact of surveys conducted in the Hawaiian Archipelago, Mariana Archipelago, American Samoa Archipelago, and Western and Central Pacific, including the Pacific Remote Islands Research Areas on marine mammal stocks

PIFSC expects to continue its surveys in the HARA, MARA, ASARA, and WCPRA as described in previous sections. PIFSC believes it is likely it will conduct the surveys for named target species as detailed in Table 1.1. No marine mammals have been caught during PIFSC research in the past. For descriptions of various research gears and instruments used by PIFSC, see Appendix A. Mitigation measures include a move-on rule to minimize chances for gear to be deployed with marine mammals nearby and a modified net retrieval procedure if marine mammals are sighted while gear is in the water (see Section 11 for additional information on mitigation and Section 13 for information on monitoring and reporting interactions). Additional modifications are being discussed for gear used to deploy instrumentation to reduce the chance that a surfacing whale, humpback whales in particular, might become entangled.

As described in Section 6, PIFSC relied on historic marine mammal interactions by other NMFS science centers, commercial fisheries and other relevant information in developing its take request. The impact criteria PIFSC used to assess the magnitude of research effects on marine mammals have been developed in the context of two important factors derived from the MMPA. The first factor is the calculation of PBR for each marine mammal stock. The MMPA defined PBR at 16 U.S.C. § 1362(20) as, "the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population." PBR was intended to serve as an upper limit guideline for anthropogenic mortality for each species. Calculations of PBR are stock-specific and include estimates of the minimum population size, reproductive potential of the species, and a recovery factor related to the conservation status of the stock (e.g., whether the stock is listed under the Endangered Species Act (ESA) or depleted under the MMPA). NMFS and USFWS are required to calculate PBR (if possible) for each stock of marine mammals they have jurisdiction over and to report PBR in the annual marine mammal stock assessment reports (SARs) mandated by the MMPA. The PBR metric has been used extensively to assess human impacts on marine mammals in many commercial fisheries involving mortality and serious injury (M&SI) and is a recognized and acceptable metric used by NMFS Office of Protected Resources in the evaluation of commercial fisheries incidental takes of marine mammals in US waters as well as for other sources of mortality such as ship strikes.

The second factor is the categorization of commercial fisheries with respect to their adverse interactions with marine mammals. Under Section 118 of the MMPA, NMFS must classify all U.S. commercial fisheries into one of three categories based on the level of marine mammal M&SI that occurs incidental to each fishery, which it does in the List of Fisheries (LOF) published annually. Category III fisheries are considered to have a remote likelihood of or no known incidental M&SI of marine mammals. Category II fisheries are those that have occasional incidental M&SI of marine mammals. Category I fisheries are those that have frequent incidental M&SI of marine mammals. A two-tiered classification system is used to develop the LOF, with different thresholds of incidental M&SI compared to the PBR of a given marine mammal stock.

However, the LOF criteria is primarily used for managing commercial fisheries based on their actual levels of marine mammal M&SI and is not necessarily designed to assess impacts of projected takes on a given marine mammal stock. Because the analysis of impacts of PIFSC research on marine mammals in this document is based on projected takes rather than actual takes, we use a similar but not identical model to the LOF criteria.

In spite of some fundamental differences between most PIFSC research activities and commercial fishing practices, it is appropriate to assess the impacts of incidental takes due to research in a manner similar to what is done for commercial fisheries for two reasons:

- PIFSC research activities are similar to many commercial fisheries in the fishing gear and types of vessels used, and
- PIFSC research plays a key role in supporting commercial fisheries management.

For the purposes of assessing the impact of requested marine mammal takes (combined Level A Harassment and M&SI) on the respective stocks, if the projected annual M&SI of a marine mammal stock from all PIFSC research activities is less than or equal to 10 percent of PBR for that stock, the effect would be considered minor in magnitude for the marine mammal stock, similar to the LOF's Category III fisheries that have a remote likelihood of M&SI with marine mammals with no measurable population change. Projected annual gear takes from PIFSC research activities between 10 and 50 percent of PBR for that stock would be considered moderate in magnitude for the marine mammal stock, similar to the LOF's Category II fisheries that have occasional M&SI with marine mammals where population effects may be measurable. Projected annual gear takes from PIFSC research activities greater than or equal to 50 percent of PBR would be major in magnitude for the marine mammal stock, similar to the LOF's Category I fisheries that have frequent M&SI with marine mammals which measurably affect a marine mammal stock's population trend.

Table 7.1 compares the PIFSC take request in the collective research regions for all gears used in its fisheries research relative to each stock's PBR. The take request is based on a five-year authorization period, not an annual basis, so the total take request for all gears was divided by five to provide an annual average take for each species with which to compare to the annual PBR values. However, our ability to assess the impacts of the requested taking is limited in many cases by a spatial mismatch between where takes may occur and where stocks have been assessed (i.e., mainly just in the Hawai‘i EEZ).

For all but one stock for which take is requested and PBR has been determined, the average annual take in all gear types combined is well below 10 percent of PBR – (see below for Spinner dolphin discussion). This level of mortality, if it occurred, would be unlikely to affect the survival or reproductive success of any of these species and would be considered minor.

Takes in longline gear are requested from two species, the humpback whale and the sperm whale listed as "Endangered" under the ESA and thus, by definition, as "Depleted" under the MMPA. In both cases the taking is based on interactions with longlines in commercial fisheries. As part of the PIFSC mitigation measures, no longlines would be set where either of these species had been observed to be present prior to line deployment. In addition, PIFSC is requesting take of one humpback whale in gear associated with instrument deployment. In this case research gear is anchored to the bottom within areas where humpback whales may occur in winter. While no gear would be deployed when humpback whales were within sight, this request addresses the potential for a whale to move into the area and became entangled in the mooring line. The requested levels of take are well below 10% of PBR for each of these species.

Two requested stocks, the Dwarf sperm whale and the Pygmy sperm whale have population estimates more than 8 years old and therefore are considered outdated and no longer used, based on NMFS Guidelines for Assessing Marine Mammal Stocks (NMFS 2005). However, the outdated information is still the best available at this time, and is described below.

Baird (2005) reports that dwarf sperm whales are the sixth most commonly sighted odontocete around the MHIs. This species' size and behavior may result in negatively biased relative abundances in this region. A 2002 shipboard line-transect survey of the entire Hawaiian Islands EEZ resulted in an abundance estimate of 17,519 dwarf sperm whales (Barlow 2006), including a correction factor for missed diving animals. The minimum abundance (N_{min}), calculated as the log-normal 20th percentile of that estimate is therefore 10,043 and given these values the PBR is estimated at 100. In this case, the PIFSC request of one animal (total in five years) represents 0.2% of the annual PBR.

A 2002 shipboard line-transect survey of the entire Hawaiian Islands EEZ resulted in an abundance estimate of 7,138 pygmy sperm whales (Barlow 2006), including a correction factor for missed diving animals. The log-normal 20th percentile of that estimate (N_{min}) is 3,341, and the PBR is 33. In this case, the PIFSC request of one animal (total in five years) represents 0.6% of the annual PBR.

Because these species may be difficult to distinguish in the field, available population assessment data is out of date, and the chance of an incidental take is extremely low, the take request of one animal in longline research has been combined into a single complex, *Kogia* sp. Should a single take occur, the level of mortality would be unlikely to affect the survival or reproductive success of either of these species and would be considered minor.

By analogy with takes in commercial longline fisheries, PIFSC has identified several other species of small delphinids that may be taken in longline research conducted throughout the PIFSC region outside of the longline exclusion areas. These include one animal each over the five-year authorization period of: bottlenose dolphin - Hawai‘i pelagic stock, Blainville’s beaked whale - Hawai‘i pelagic stock, Cuvier’s beaked whale, Kogia spp. (dwarf sperm whale and pygmy sperm whale) Hawai‘i stocks, false killer whale - HI pelagic stock, Pantropical spotted dolphin - all stocks, pygmy killer whale, rough toothed dolphin – Hawai‘i stock, Risso's dolphin – Hawai‘i stock, short-finned pilot whale – Hawai‘i stock, and striped dolphin - Hawai‘i stock. The level of requested serious injury and mortality taking is generally less than 2% of PBR, unlikely to affect the survival or reproductive success of any of these species and would be considered minor.

PIFSC is requesting takes of several small delphinids in midwater trawls – one take each over the five-year authorization period of bottlenose dolphin (all stocks), rough-toothed dolphin (Hawaiʿi stock), spinner dolphin (all stocks), Pantropical spotted dolphin (all stocks), and striped dolphin (Hawaiʿi stock). The likely trawl gear in consideration here is the Cobb trawl which operates at slow speeds (3 knots) in research anywhere from 3 nm offshore to over 1000 nm offshore. This level of mortality is generally less than 2% of PBR (where known), unlikely to affect the survival or reproductive success of any of these species and would be considered minor. For bottlenose dolphin, spinner dolphin, and Pantropical spotted dolphin – the request is for “all stocks” because of the spatial extent of the research, the uncertainty of stock boundaries and possibility of encountering individuals from undescribed stocks.

Finally, PIFSC is also requesting a single take of several small delphinds over the five-year authorization period in gear associated with instrument deployments. The species most likely to interact would include “curious species” likely to investigate mooring lines: bottlenose dolphin (all stocks), rough-toothed dolphin (Hawaiʿi stock), spinner dolphin (all stocks), and Pantropical spotted dolphin (all stocks). This level of mortality is generally less than 2% of PBR, unlikely to affect the survival or reproductive success of any of these species and would be considered minor.

The combined take of two spinner dolphins (one in mid-water trawl and one in instrument deployments) would be 12.1% of the Oahu/4-Islands stock’s PBR and would be considered moderate. However, since the request is for all stocks due to the spatial extent of the research, the uncertainty of stock boundaries and possibility of encountering individuals from undescribed stocks, the impact would be more likely to be spread across more than one stock of spinner dolphin.

Table 7.1 Stocks for which PIFSC is requesting combined Level A harassment/M&SI take in the HARA, MARA, ASARA and WPCRA and numbers requested relative to PBR

This table summarizes the PIFSC combined Mortality and Serious Injury (M&SI) and Level A harassment take request of marine mammal stocks by gear type. Instrument deployments involve moorings and floating instruments or other lines that may cause entanglements. All population estimates and Potential Biological Removal (PBR) values are from the most recent stock assessment reports (Carreta et al. 2015, Allen and Angliss 2015). Note that PBR is an annual measure of mortality while the LOA application estimates potential takes for the five-year period. The requested takes are shown as average annual takes that can be compared with PBR.

Common Name - stock	Minimum Population Estimate	PBR	Potential M&SI and Level A Take Average per Year – All Research Areas Combined (total for five-year period)				
			Midwater Trawl Gear	Longline Gear	Instrument Deployment	Total Average Take Request – All Gears and Research Areas Combined	Total Annual Take Request as % of PBR Requested
Beaked whale, Blainville's - Hawaiʿi stock	1,088	11		0.2 (1)		0.2 (1)	**1.8%**
Beaked whale, Cuvier's - Hawaiʿi pelagic stock	1,142	11.4		0.2 (1)		0.2 (1)	**1.8%**
Bottlenose dolphin - Hawaiʿi pelagic stock	3,755	38	0.2 (1)	0.2 (1)	0.2 (1)	0.6 (3)	**1.6%**
Bottlenose dolphin – all stocks except above			0.2 (1)		0.2 (1)	0.4 (2)	**NA**
False killer whale - Hawaiʿi pelagic stock or unspecified [A]	935	9.4		0.2 (1)		0.2 (1)	**2.1%**
Humpback whale – Central North Pacific stock [B]	7,890	82.8		0.2 (1)	0.2 (1)	0.4 (2)	**0.5%**
Kogia spp. (Pygmy and dwarf sperm whale - Hawaiʿi stocks)	Unknown	Undetermined		0.2 (1)		0.2 (1)	**NA**
Pantropical spotted dolphin – all stocks [C]	11, 508	115	0.2 (1)	0.2 (1)	0.2 (1)	0.6 (3)	**0.5%**
Pygmy killer whale	2,274	23		0.2 (1)		0.2 (1)	**0.9%**
Risso's dolphin - Hawaiʿi stock	5,207	42		0.2 (1)		0.2 (1)	**0.5%**
Rough-toothed dolphin – Hawaiʿi stock	4,581	46	0.2 (1)	0.2 (1)	0.2 (1)	0.6 (3)	**1.3%**
Rough-toothed dolphin – all stocks but above			0.2 (1)		0.2 (1)	0.4 (2)	**NA**
Short-finned pilot whale	8,782	70		0.2 (1)		0.2 (1)	**0.3%**
Sperm whale - Hawaiʿi stock [D]	2,539	10.2		0.2 (1)		0.2 (1)	**2.0%**
Spinner dolphin, all stocks [E]	355	3.3	0.2 (1)		0.2 (1)	0.4 (2)	**12.1%**
Striped dolphin, All stocks[E]	15,391	154	0.2 (1)	0.2 (1)		0.4 (2)	**0.3%**

A Strategic stock based on total M&SI exceeding PBR. PIFSC fisheries and ecosystem research would not occur within the ranges of other specified false killer whale stocks. "Unspecified stock" only occurs on the high seas.

B Listed as endangered under the ESA. Request for take by potential entanglement in instrument deployment lines based on Bradford and Lyman (2015).

C Information presented only for Hawaiʻi pelagic stock, which is the only stock with estimates of population and PBR.

D Listed as endangered under the ESA.

E Information presented only for the Oahu/4-Islands stock, which is the smallest stock for which population and PBR estimates are available. This is used to provide the most conservative impact assessment.

Because of the low level of predicted future takes associated with the use of trawl, longline, and other gear in research activities in the PIFSCs research areas, PIFSC believes that its surveys will neither affect annual recruitment or survival nor the health and condition of marine mammal species or stocks.

7.1.2 Synopsis of the anticipated impact of PIFSC fisheries research activities

Our analysis of the effects of research is limited by the extent of knowledge for many of the species and stocks occurring within the vast geographic region served by PIFSC. It is likely that there are as yet to be described stocks for some species and for species to occur within regions where they have yet to be reported. Our knowledge is most complete for the HARA and thus our assessment of the impact of taking is largely based on what is known from, or adjacent to, this region. Using the best scientific information available, PIFSC has integrated the following underlying factors into this evaluation of the area wide impact of PIFSC fisheries research activities:

- There is much remaining to be discovered about marine mammal distribution, abundance and stock structure for the vast area where PIFSC fisheries and ecosystem research activities are conducted. Studies in the area have not been in place for nearly as long as in some other Fisheries Science Center areas. These are time consuming and expensive and will take many years to conduct.
- There are similarities between the HARA and other PIFSC research areas that provide insight into and inform how fisheries research and local stocks are likely to interact.
- No takes in longline fishing are being requested in the HARA, ASARA, MARA, or nearshore areas of the Pacific Remote Island Areas (part of the WCPRA).
- The gear types used by PIFSC are relatively small in scale and scope; areas are visited infrequently.
- Estimates of marine mammal densities in regions other than the HARA are conservative because in many cases HARA data have been used as a proxy.
- For species in regions outside of the HARA, our evaluation of impacts from the requested takes is limited by the fact that there may be undefined stocks in these areas. There may also be instances where a species/stock occur in a given region but has yet to be reported as present. Even so, the levels of take requested for species and stocks outside of the HARA are low (from 1-3 animals/species over the five-year authorization period, Table 7.1) and, if they occurred, would likely be distributed across several research areas over time.
- The geographic regions studied by PIFSC research are vast; therefore, the intensity of the impacts (i.e., "significance") due to the requested takes, if they occurred, needs to be considered in this context as well as relative to the areas explored by other Fishery Science Centers.

Acknowledging these limitations and recognizing the lack of historical interactions, as well as the low level of predicted future takes (mortality, serious injury, and Level A harassment) associated with PIFSC research activities, PIFSC believes that their activities will not affect annual rates of recruitment or survival or the health and condition of the species or stock of the requested species. The average annual human-caused mortality for these species is generally, with few exceptions, estimated to be less than the

PBR, and as discussed above in the species accounts, they are not from stocks classified as "strategic" under the MMPA. Based on this PIFSC believes that its activities:

1. Will have a minimal 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.

7.2 Disturbance and Behavioral Changes (Level B harassment)

7.2.1 Due to physical presence of researchers

As described in section 6.2.8, Hawaiian monk seals hauled out on land are expected to experience occasional close approaches by PIFSC survey vessels during the course of fisheries research activities. In addition, gear studies and clean-up activities are conducted each year on many atolls and islands within the PIFSC areas of operation. PIFSC 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. In spite of procedures and mitigation guidance to avoid interactions with resting Hawaiian monk seals, occasional disturbance events may occur. These events are expected to be infrequent and cause only 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 occurred frequently, 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 frequently appeared within a short time period (e.g., 24 hours), a reduction in the total number of seals present was also observed (Fox 2008). A recent paper suggests that long-term dynamics of Hawaiian monk seal populations may have been driven as much, if not more, by climate–ocean variability as by direct human activity. In recent years, direct human impacts on monk seals have been virtually eliminated from the NWHI (Baker et al. 2012).

Based on these studies, repeated disturbance can 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 PIFSC surveys), PIFSC 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 1999, Nowacek et al. 2007, Southall et al. 2007, Au and Hastings 2008). Several recent studies on hearing in individual species or species groups of odontocetes and pinnipeds also exist (e.g., Kastelein et al. 2009, Kastelein et al. 2013, Ruser et al. 2014).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.

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). NOAA modified the functional hearing groups of Southall et al. (2007) to extend the upper range of low-frequency cetaceans and to divide pinnipeds into Phocids and Otariids (NOAA Fisheries 2013b). Detailed descriptions of marine mammal auditory weighting functions and functional hearing groups are available in NOAA Fisheries (2013b). Based on these functional hearing groupings, 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 30 kHz (NOAA Fisheries 2013b, Southall et al. 2007, Figure 7.2). 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 (Table 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).

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 PIFSC research vessels are operated in water. In the PIFSC research areas, this group includes just one species of true seals (phocids). 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 both otariid and phocid pinnipeds.

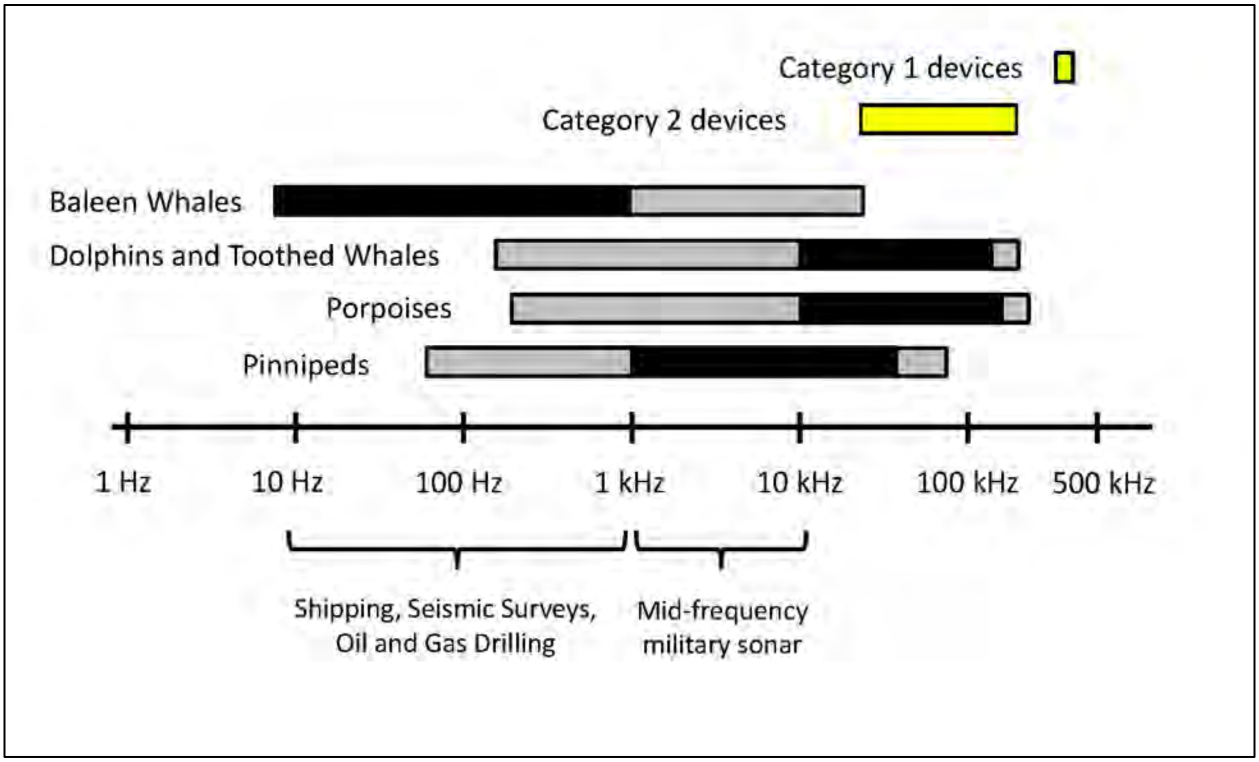


Figure 7.1 Typical frequency ranges of hearing in marine animals

Table 7.1 shows hearing range for different marine mammal groups (gray and black bars) relative to the frequency outputs of the two categories of acoustic devices used in PIFSC fisheries and ecosystem research (yellow bars), as identified in Section 6.2. Black bars indicate the most sensitive hearing ranges of different marine mammals. Brackets indicate frequency ranges of several industrial sound sources as well as U.S. Navy mid-frequency active sonar for comparison. Data on hearing ranges is from Southall et al. (2007) and modified from DON (2008b).

7.2.3 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 PIFSC. 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.

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 cetaceans 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 used by PIFSC, RMS sound pressure levels in the range of approximately 180-220 dB re: 1µPa are required to induce onset TTS levels for most species (Chapter 3 in Southall et al., 2007). 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 (~40dB) 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 10s 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. 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. 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.

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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).

7.2.4 Active acoustic sources used by PIFSC 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 PIFSC 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 PIFSC 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.

Category 1 active acoustic sources

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; Deng et al. 2014, Hastie et al. 2014).

Category 2 active acoustic sources

These acoustic sources, which are present on most PIFSC 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.

7.2.5 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 PIFSC 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. However, recent analysis of potential causes of a mass stranding of 100 typically oceanic melon-headed whales (*Peponocephala electra*) in Madagascar in 2008 implicate a mapping survey using a high-power 12 kHz multi-beam echosounder (MBES) as a likely trigger for this event. Although the cause is equivocal and other environmental, social, or anthropogenic factors may have facilitated the strandings, the authors determined the MBES the most plausible factor initiating the stranding response, suggesting that avoidance behavior may have led the pelagic whales into shallow, unfamiliar waters (Southall et al. 2013).

As a general conclusion, while some of the active acoustic sources used in PIFSC 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 takes of marine mammals from impulse noise sources, a quantitative framework was developed (Section 6.2) for assessing the potential impacts of PIFSC active acoustic sources used in fisheries research.

7.3 Surveys Conducted by PIFSC that May Take Marine Mammals by Level B Harassment Using Category 2 Acoustic Sources

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. NMFS uses these levels as guidelines to estimate when harassment may occur.

Level B harassment take associated with use of active acoustics equipment that may occur in PIFSC fisheries surveys is described at 1.6 and Tables 6.6 to 6.9. PIFSC believes that these 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.

7.4 Collision and Ship Strike

Collisions with vessels, or ship strikes, threaten numerous marine animals and are of great concern for endangered large whales, particularly right whales. Ship strikes with marine mammals can lead to death by massive trauma, hemorrhaging, broken bones, or propeller wounds (Knowlton and Kraus 2001). Large whales, such as fin whales, are occasionally found draped across the bulbous bow of large ships upon arriving in port. Massive propeller wounds can be immediately fatal. If more superficial, the whales may survive the collisions (Silber et al. 2009). 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.

Ship strikes are a major cause of mortality and serious injury in the North Atlantic Ocean to right whales, accounting for 35% of deaths from 1970-1999 (Knowlton and Kraus 2001). Average annual reported mortality and serious injury from ship strikes, 2002-2006, was 2.4 (Waring et al. 2009). Ship strikes occur less frequently with humpbacks (1.4/year, 2002-2006) and fin whales (0.8/year, 2002-2006) (Waring et al. 2009).

No collisions with large whales have been reported during fisheries research activities conducted or sponsored by PIFSC (section 6.1.1). PIFSC has avoidance and mitigation measures in place (see sections 11 and 13) and emphasizes adherence during ship operations. No such future take is requested by this application as it is assumed that such events are very unlikely occur in the next five years. PIFSC has concluded the probability of vessel and marine mammal interactions occurring during PIFSC operations is negligible due to the vessel's slow operational speed, which is typically four knots or less during sampling and average about 10 knots while in transit, 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 PIFSC 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 PIFSC research 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.

Several mitigation measures implemented by the Hawaiian Islands Humpback Whale National Marine Sanctuary, to which NOAA vessels adhere, were implemented to minimize the risk of vessel collisions with humpback whales. Other species that occur within the PIFSC research areas also benefit. The compliance guide for humpback whale protection in Hawaiian waters (CFR Title 15 Chapter XI at 922 Hawaiian Islands Humpback Whale National Marine Sanctuary) states that the following activities are prohibited and thus unlawful for any person to conduct or cause to be conducted.

1. Approaching, or causing a vessel or other object to approach, within the Sanctuary, by any means, within 100 yards of any humpback whale except as authorized under the MMPA and ESA;
2. Operating any aircraft above the Sanctuary within 1,000 feet of any humpback whale except as necessary for takeoff or landing from an airport or runway, or as authorized under the MMPA and the ESA;
3. Taking any humpback whale in the Sanctuary except as authorized under the MMPA and the ESA;
4. Possessing within the Sanctuary (regardless of where taken) any living or dead humpback whale or part thereof taken in violation of the MMPA or the ESA;
5. Discharging or depositing any material or other matter in the Sanctuary; altering the seabed of the Sanctuary; or discharging or depositing any material or other matter outside the Sanctuary if the discharge or deposit subsequently enters and injures a humpback whale or humpback whale habitat.

As a standard operating practice, PIFSC follows item 1 above whenever and wherever it conducts fisheries research activities, not just within the Sanctuary. When research vessels have sampling gear in the water, cruise speeds are less than 5 knots, a speed at which the probability of collision and serious injury of large whales is low. However, when transiting between sampling stations, research vessels travel at speeds up to 10 knots (http://www.moc.noaa.gov/Ships%20Characteristics/NOAA%20Ship%20Oscar%20Elton%20Sette%20-%20Final%2025FEB2014.pdf). PIFSC vessel captains and crew watch for marine mammals while underway during daylight hours and take necessary actions to avoid them, but there are no dedicated Marine Mammal Observers (MMOs) aboard the vessels.

That, combined with adherence to the above mentioned mitigation measures, indicate that vessel collisions are possible, but unlikely to occur, and anticipated impacts to most species would be negligible to minor. Although it is highly unlikely that a PIFSC fisheries research vessel would strike a large whale, particularly a humpback whale, doing so would be considered a serious impact for this population of endangered whales and would result in the initiation of ESA Section 7 consultation.

NOAA vessels are subject to ship strike management measures. Measures apply to vessels 19.8 m (65 ft) in length or greater, including commercial vessels (fishing vessels, tugs and tows, passenger vessels, passenger vessels for hire, large commercial vessels) and recreational vessels (NERO 2004). NMFS based the 19.8 m threshold on analysis of ship strike mortalities and serious injuries that occurred with the research area of the NMFS NEFSC. Most involved vessels there were greater than 80 m long. One right whale calf was, however, struck and killed by a 25 m vessel. Vessels smaller than 19.8 m may also pose a threat for slow moving cetaceans such as humpback and right whales, but the 19.8 m threshold was deemed appropriate since it included most vessels involved in collisions and corresponded with established size criteria used in several other existing regulatory requirements (NERO 2004, NMFS 2008a,).

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%.

Injuries and death to marine mammals resulting from ship collisions caused by vessels during PIFSC research are not likely to occur. The probability of vessel and marine mammal interactions occurring during PIFSC activity is unlikely due to the vessel's slow operational speed, which is typically less than 5 knots. Outside of operations, each vessel's cruising speed would be approximately 8 to 10 knots which is generally below the speed at which studies have noted reported increases of marine mammal injury or death (Laist et al., 2001). Considering this slow speed and the continual observation for marine mammals during all ship transits, PIFSC 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 PIFSC vessel it is unlikely to result in mortality.

There is a potential for vessels to strike cetaceans while traveling at slow speeds. For example, a NOAA contracted survey vessel traveling at slow 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 knots, and exceeded 90 percent at 17 knots. 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 PIFSC 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 designed to maintain the 100 yd buffer between whales and PIFSC vessels.

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

As outlined in this and previous sections, there are several PIFSC fisheries research activities that have the potential to cause Level B harassment, Level A non-serious injury, and serious injury or mortality of marine mammals in the American Samoan, Hawaiian Archipelago, Mariana Archipelago, and the Western and Central Pacific Research Areas. However, because of the absence of historical interactions due to PIFSC fisheries research, and low levels of take in commercial fisheries and other Fisheries Science Centers using analogous gear relative to the abundance of affected populations, as well as the low level of predicted future takes associated with PIFSC surveys, PIFSC 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 PIFSC fisheries research surveys over the five-year authorization period do not exceed any stock's PBR (where determined), and for most affected stocks the PIFSC take request is only a small fraction of PBR. In particular, for known species and stocks outside of the HARA, the requested take is for just 1-3 animals of a requested species/stock spread throughout these vast regions over the five-year authorization period.
- In the coastal study areas of the Hawaiian Archipelago, PIFSC expects due to the number of monk seals hauled out or in the nearshore reef environment some animals will experience Level B harassment when the survey vessel passes during the course of conducting research operations or in the process of conducting gear studies on land during beach clean-up activities. However, these events are expected to be infrequent and temporary. Further, cited studies on pinniped disturbance do not indicate that impacts would be of the magnitude likely to result in population-

level impacts. It is noted that it would be difficult to mitigate this effect if the seals are in the water (i.e., curious animals), but it would be easier to mitigate if they are hauled out (i.e., scan and avoid). Mitigation includes avoiding mother-pup pairs.

- PIFSC 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, exposure to active acoustics used on PIFSC fisheries research surveys is not expected to result in injury to animals and behavioral disturbance is expected to be temporary and not result in population level impacts.

Based on this information PIFSC believes that its fisheries research 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.

8.0 THE ANTICIPATED IMPACT OF THE ACTIVITY ON THE AVAILABILITY OF THE SPECIES OR STOCKS OF MARINE MAMMALS FOR SUBSISTENCE USES.

The proposed activity will take place in the Hawaiian Archipelago, Mariana Archipelago, American Samoa Archipelago, and Western and Central Pacific, including the Pacific Remote Islands Research Areas. There are no relevant subsistence uses of marine mammals implicated by this action in these areas.

9.0 THE ANTICIPATED IMPACT OF THE ACTIVITY UPON THE HABITAT OF THE MARINE MAMMAL POPULATIONS, AND THE LIKELIHOOD OF RESTORATION OF THE AFFECTED HABITAT

The fisheries research activities conducted by PIFSC take place in the Hawaiian Archipelago, Mariana Archipelago, American Samoa Archipelago, and Western and Central Pacific, including the Pacific Remote Islands Research Areas. The proposed activities will not result in any permanent impact on habitats used by marine mammals or to the food resources that they utilize and thus will not affect marine mammal stocks, populations or species within the PIFSC research areas. Modifications to the water column are expected to be short-term in nature while modifications to the sea floor from bottom-contact sampling gear (e.g., traps, pots) may be longer-term. Expected modifications to the sea floor are insignificant relative to current and projected future levels of survey activity. The levels of removals of finfish and invertebrates relative to overall population sizes was evaluated through a separate NEPA Environmental Assessment and found to be insignificant for all common prey items of marine mammals. Potential impacts to marine mammal habitat are not anticipated to alter the function of the habitat and, therefore, will have little to no impact on marine mammal stocks or species.

9.1 Changes in Food Availability

PIFSC fisheries research removals of species commonly utilized by marine mammals are relatively low. Prey of sei whales and blue whales are primarily zooplankton, which are targeted by PIFSC fisheries research with collection only on the order of liters, so the likelihood of research activities changing prey availability is low and impact negligible to none. Humpback whales do not feed within the PIFSC region of fisheries research, so there is no affect. There may be some minor overlap with sperm whale prey (squid), but this is expected to be minor due to the insignificant amount of squid removed through fisheries research (i.e., hundreds of pounds). There may be some minor overlap between the RAMP survey removals of a variety of reef fishes and the Insular Fish Abundance Estimation Comparison Surveys. By example, in the main Hawaiian Islands, the majority of sampling for these surveys is at the periphery of monk seal foraging habitat and is a tiny fraction of what is taken by monk seals or by apex predatory fish or non-commercial fisheries (Sprague et al. 2013, Kobayashi and Kawamoto 1995). In the case of false killer whale consumption of tunas, mahi, and ono, there may be some minor overlap with fisheries research removals in the pelagic longline research. However, here the removal by PIFSC fisheries research, regardless of season and location is minor relative to that taken through commercial fisheries. For example, commercial fisheries catches for most pelagic species typically range from the hundreds to thousands of metric *tons*, whereas the catch in similar fisheries research activities would only occasionally range as high as hundreds to thousands of *pounds* in any particular year (see Draft PEA 4.2.3 – 4.3.3).

In contrast to these minor adverse effects, PIFSC research also provides long-term beneficial effects on managed fish species throughout the Pacific Islands region through its contribution to sustainable fisheries management. Data from PIFSC research provides the scientific basis to reduce bycatch, establish optimal fishing levels, prevent overfishing, and recover overfished stocks. The beneficial effects of the time-series data provided by PIFSC research programs effects are especially valuable for long-term trend analysis for commercially harvested fish and, combined with other oceanographic data collected during fisheries research, provide the basis for monitoring changes to the marine environment important to fish populations.

Therefore, in summary the effects of fisheries research removals are minimal in amount, highly localized, and very short term in effect. The overall impact would be discountable to negligible. The impact of prey removal may be further reduced by spatial dispersion, since the stratification of the midwater trawl surveys disperses catch over the entire region, whereas marine mammals may concentrate feeding in localized areas. Overall, PIFSC fisheries research catch levels are unlikely to affect changes in prey type or quantity available to marine mammals considered by this application, threatened and endangered marine mammal species and their critical habitat included. The resulting impact of the catch level on prey resources would, therefore, be negligible.

9.2 Physical Damage to Benthic (Seafloor) Habitat

The potential effects of PIFSC fishery research activities on the physical environment vary depending on the survey gear and other equipment used but generally includes:

- Physical damage to benthic (seafloor) habitat
- Biological damage to infauna and epifauna
- Removal of organisms which produce structure, and
- Alteration of the turbidity and geochemistry of the water column.

Fishing gear that contacts the seafloor, especially bottom trawling and dredging equipment, can alter and/or physically damage seafloor habitat. It is important to note that surveys conducted by PIFSC are limited to surface and midwater trawls, which do not directly interact with the benthos. Physical damage includes furrowing and smoothing of the seafloor as well as the displacement of rocks and boulders as fishing gear is towed across the bottom (Morgan and Chuenpagdee 2003). Physical damage to the seafloor can increase with multiple tows in the same area (Stevenson et al. 2004).

The Deep Coral and Sponge Research Survey collect small pieces of coral for DNA samples, voucher specimens, and paleoclimate samples. The combined sampling of these studies amounts to about 5.5 pounds/year. Together, these coral samples comprise a small percentage of the total population of coral colonies (see Draft PEA section 4.2.7). The RAMP Survey collects up to 500 samples per year of corals (including ESA-listed species), coral products, algae and algal products, and sessile invertebrates. NMFS has conducted a Section 7 consultation for these surveys and found they are not likely to jeopardize the continued existence of any of the species taken.

Bottom contact fishing gear used in PIFSC fishery research activities and funded fishery research activities include deep-set longline, lobster pots, and settlement traps (Table 1.1). These fishing gears contact the seafloor and may cause physical damage but the impacts are localized and minimal as this type of gear is fixed in position rather than towed across the sea floor.

In general, physical damage to the seafloor recovers within 1.5 years through water currents and natural sedimentation with the exception of rocks and boulders which may be permanently displaced (Stevenson et al. 2004). The majority of the seafloor in the PIFSC research areas is made of a number of sediment types including coral, clay, gravel and boulders. Therefore any minor and highly localized physical damage caused by PIFSC surveys and funded fishery research activities would be expected to recover within 1.5 years.

9.3 Physical Damage to Infauna and Epifauna

The potential effects of research vessels, survey gear, and other associated equipment on invertebrates include:

- Physical damage to infauna and epifauna
- Directed take of coral specimens
- Mortality from Fisheries Research Activities
- Changes in species composition

- Contamination or degradation of habitat

Infauna are animals that live in the seafloor or within structures that are on the seafloor. Infauna usually construct tubes or burrows and are commonly found in deeper and subtidal waters. Clams, tubeworms, and burrowing crabs are infaunal animals. Epifauna live on the surface of the seafloor or on structures on the seafloor such as rocks, pilings, or vegetation. Epifauna may attach themselves to such surfaces or range freely over them, as by crawling or swimming. Mussels, crabs, starfish, and flounder are epifaunal animals. Fishing gear that contact the seafloor can disturb infauna and epifauna by crushing them, burying them or exposing them to predators (Morgan and Chuenpagdee 2003). The level of biological damage to infauna and epifauna can vary from very minimal to more severe particularly with repeated disturbance in the same areas (Stevenson et al. 2004).

The Deep Coral and Sponge Research Survey collect small pieces of coral for DNA samples, voucher specimens, and paleoclimate samples. DNA specimens are comprised of small pieces of coral less than 1 percent of the total colony size and a total weight of approximately 0.02 pounds per year. The RAMP Survey collects up to 500 samples per year of corals (including ESA-listed species), coral products, algae and algal products, and sessile invertebrates. Together, these coral samples comprise a small percentage of the total population of coral colonies.

The recovery time for damage to infauna and epifauna varies based on the type of fishing gear used, the type of seafloor surface (i.e., mud, sand, gravel, mixed substrate), and the level of repeated disturbances. In general, biological damage from a single disturbance is 1-18 months, and up to 3 years from repeated disturbances (Stevenson et al. 2004). Because research surveys are conducted in the same areas but not in the exact same locations each year they are expected to cause single rather than repeated disturbances in any one area. Therefore any physical damage caused by PIFSC surveys and funded fishery research activities would be expected to recover within 1-18 months. Given the small magnitude of area affected by research and the short-term nature of physical damage effects, these impacts are considered minor or negligible.

Mortality from fisheries research activities in the PIFSC research areas would be limited to surveys which perform directed take of corals, and the Northwestern Hawaiian Islands Lobster Survey. Overall, the amounts of invertebrates removed as a result of PIFSC research activities would be small relative to commercial catches and even smaller relative to the estimated populations of these invertebrates. Deployments of the previously discussed stationary bottom-contact gear (e.g. lobster traps and ARMS) are not expected to alter species composition due to the small footprint created by these gear types.

PIFSC fisheries research could have direct and indirect effects on many invertebrate species through physical damage to infauna and epifauna, directed take of coral specimens, mortality, changes in species composition, and contamination or degradation of habitat. For all invertebrate species targeted by commercial fisheries and managed under Fishery Management Plans, mortality due to research surveys and projects is less than two percent of commercial and recreational harvest and is considered to be minor in magnitude for all species. Mortality for all species would be distributed across a wide geographic area rather than concentrated in particular localities and the risk of altering benthic community structure would be minimal. Disturbance of animals and benthic habitats from research activities would be temporary and minor in magnitude for all species. The overall direct and indirect effects of PIFSC fisheries research on invertebrates would be minor in magnitude, dispersed over a large geographic area, and temporary or short-term in duration and would therefore be considered minor.

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

Critical habitat has been established for the following species listed under the ESA addressed by this application: the Hawaiian monk seal. No critical habitat has been designated for any of the stocks of listed blue, fin, sei, humpback, sperm, or false killer (Main Hawaiian Islands Insular distinct population segment) whales within the regions of PIFSC fisheries research. The evaluation of the effects of the actions requested by this application to listed species and their critical habitat will be the subject of a separate Biological Opinion under Section 7 of the ESA conducted by the Protected Resources Division.

As stated in section 9 above, the proposed activities are not anticipated to result in impacts other than very transitory negligible modifications to marine mammal habitats or to the food resources on which the species addressed in this application depend. Modifications to benthic infauna are expected to be short-term in nature while modifications to the sea floor from sampling gear may be moderate in duration but will be highly localized and restricted in dimension. Expected modifications to the sea floor are insignificant relative the current and projected future levels of commercial fishing activity. The levels of removals of finfish and invertebrates relative to overall population sizes was evaluated through a separate NEPA Environmental Assessment and found to be minor for all common prey items of marine mammals. Potential impacts to marine mammal habitat are not anticipated to alter the function of the habitat and, therefore, will have little to no impact on marine mammal species.

11.0 THE AVAILABILITY AND FEASIBILITY (ECONOMIC AND TECHNOLOGICAL) OF EQUIPMENT, 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

The following suite of mitigation measures will be employed by PIFSC during fisheries and ecosystem research. These procedures are the same whether the survey is conducted on board a NOAA vessel or charter vessel. The procedures described are based on protocols used during previous research surveys and/or best practices developed for commercial fisheries using similar gear. PIFSC continually reviews its procedures and investigates options for incorporating new mitigation measures and equipment into its on-going survey programs. Evaluations of new mitigation measures include assessments of their effectiveness in reducing risk to marine mammals but any such measures must also pass safety considerations and allow survey results to remain consistent with previous data sets. Additional mitigation measures may be considered and developed further and may be implemented by PIFSC during the five-year authorization period.

11.1 Mitigation Measures for Marine Mammals during Research with Trawl Gear

11.1.1 Monitoring methods

The officer on watch, Chief Scientist (CS) (or other designated member of the scientific party), and crew standing watch visually scan for marine mammals during all trawl operations. Because midwater trawling is typically conducted at night, sight distance is generally limited to no more than twenty meters beyond the ship. If trawling is conducted during the day, the member of the crew designated to stand watch for marine mammals visually scans the waters surrounding the vessel, usually with binoculars, with an approximately one-kilometer radius.

11.1.2 Operational procedures

PIFSC fisheries research is conducted either on NOAA vessels operated by professional captains and crew from the NOAA Office of Marine and Aviation Operation (OMAO) or on chartered vessels with their own professional vessel captains and crew. The captain of the vessel has the final authority for all decisions regarding operations of the ship. The CS has responsibility for the science mission and works collaboratively with the captain and crew to accomplish that mission. Decisions about when and where to deploy or retrieve research gear, or not deploy or retrieve gear, are made by the CS or other designated science crew for various reasons (including the presence of marine mammals, as described below). However, the captain (or officer on watch) must consider the safety of the vessel and crew and has final authority on whether or not to carry out the decisions of the science crew.

"Move-on" Rule: If any marine mammals are sighted anywhere around the vessel in the 30 minutes before setting the gear, the vessel may be moved away from the animals to a different section of the sampling area if the animals appear to be at risk of interaction with the gear at the discretion of the officer on watch in consultation with the CS. Small moves within the sampling area can be accomplished without leaving the sample station. After moving on, if marine mammals are still visible from the vessel and appear to be at risk, the officer on watch may decide, in consultation with the CS, to move again or to skip the station. The officer on watch will first consult with the CS or other designated scientist and other experienced crew as necessary to determine the best strategy to avoid potential takes of these species based on those encountered, their numbers and behavior, position and vector relative to the vessel, and other factors. For instance, a whale transiting through the area and heading away from the vessel might not require any move or only require a short move from the initial sampling site while a pod of dolphins gathered around the vessel may require a longer move from the initial sampling site or possibly cancellation of the station if they follow the vessel. In most cases, trawl gear is not deployed if marine mammals have been sighted from the ship in the previous 30 minutes unless those animals do not appear to be in danger of interactions with the trawl, as determined by the judgment of the CS and officer on watch. The efficacy of the "move-on" rule is limited during night time or other periods of limited visibility; although operational lighting from the vessel illuminates the water in the immediate vicinity of the vessel during gear setting and retrieval.

Trawl operations are usually 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, CTD casts may immediately precede trawl deployment. The order of gear deployment is determined on a case-by-case basis by the CS based on environmental conditions and other available information at the sampling site. Other activities, such as water sampling or plankton tows, are conducted in conjunction with, or upon completion of, trawl activities.

Once the trawl net is in the water, the officer on watch, CS or other designated scientist, or crew standing watch continue to monitor the waters around the vessel and maintain a lookout for marine mammal presence as far away as environmental conditions allow (as noted previously, visibility is very limited during night trawls). If these species are sighted before the gear is fully retrieved, the most appropriate response to avoid incidental take is determined by the professional judgment of the officer on watch, in consultation with the CS or other designated scientist and other experienced crew as necessary. 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. Generally, if a marine mammal is incidentally caught, it would happen during haul-back operations, especially when the trawl doors have been retrieved and the net is near the surface and no longer under tension. The risk of catching an animal may be reduced if the trawling continues and the haul-back is delayed until after the marine mammal has lost interest in gear, or left the area. In other situations, swift retrieval of the net or cutting the cables may be the best course of action. The appropriate course of action to minimize the risk of incidental take of protected species is determined by the professional judgment of the officer on watch and appropriate crew based on all situation variables, even if the choices compromise the value of the data collected at the station.

If trawling operations have been delayed because of the presence of marine mammals, the vessel resumes trawl operations (when practicable) only when these species have not been sighted within 30 minutes or else otherwise determined to no longer be at risk. This decision is at the discretion of the officer on watch and will depend upon the circumstances of the situation.

Care is taken when emptying the trawl, including opening the cod end, as close to the deck as possible in order to avoid damage to protected species that may be caught in the gear but are not visible upon retrieval. The gear is emptied as quickly as possible after retrieval in order to determine whether or not protected species are present. It may be necessary to cut the net to remove the protected species.

11.1.3 Tow duration

Standard tow durations for midwater Cobb trawls are between two and four hours as target species (e.g., pelagic stage eteline snappers) are relatively rare, and longer haul times are necessary to acquire the appropriate scientific samples. However, trawl hauls will be terminated and the trawl retrieved upon the determination and professional judgment of the officer on watch, in consultation with the CS or other designated scientist and other experienced crew as necessary, that this action is warranted in order to avoid an incidental take of a marine mammal.

11.1.4 Gear modifications

PIFSC currently uses only one type of midwater trawl net; a Cobb trawl. The Cobb trawl used in Hawaiian Archipelago water operations has no history of interactions with marine mammals. There are no marine mammal exclusion devices that have been developed for this type of trawl and no work is being done to develop such devices.

11.1.5 Vessel strike avoidance

Vessel speeds are restricted on research cruises in part to reduce the risk of ship strikes with marine mammals. Transit speeds vary from six to ten knots, but average nine knots. This is slower than marine mammals can swim so the risk of collisions and serious injury or mortality is very low. The vessel's speed while towing the Cobb trawl is typically two to four knots. These much slower speeds greatly reduce the risk of ship strikes while towing gear.

In addition, as a standard operating practice, PIFSC maintains a 100 yard distance between research vessels and large whales whenever and wherever it conducts fisheries research activities. At any time during a survey or while in transit, any crew member that sights marine mammals that may intersect with the vessel course immediately communicates the marine mammal presence to the bridge for appropriate course alteration or speed reduction as possible to avoid incidental collisions, particularly with large whales (e.g., humpback whales).

11.2 Mitigation Measures for Marine Mammals during Research with Longline Gear

The 1994 amendments to the MMPA tasked NMFS with establishing monitoring programs to estimate mortality and serious injury of marine mammals incidental to commercial fishing operations and to develop Take Reduction Plans (TRPs) in order to reduce commercial fishing takes of strategic stocks of marine mammals below Potential Biological Removal (PBR). The False Killer Whale Take Reduction Plan (FKWTRP) was finalized in 2012 to reduce the level of mortality and serious injury of false killer whales in Hawaii-based longline fisheries for tuna and billfish (77 FR 71260). Regulatory measures in the FKWTRP include gear requirements, prohibited areas, training and certification in marine mammal handling and release, and posting of NMFS-approved placards on longline vessels. PIFSC does not conduct fisheries and ecosystem research with longline gear within any of the exclusion zones established by the FKWTRP.

11.2.1 Operational procedures

The "move-on" rule may be implemented if any protected species are present near the vessel and appear to be at risk of interactions with the longline gear; longline sets are not made if marine mammals have been seen from the vessel within the past 30 minutes and represent a potential interaction with the longline gear, as determined by the professional judgment of the CS or officer on watch.

Longline gear is always the first equipment or fishing gear to be deployed when the vessel arrives on station. Longline gear is set immediately upon arrival at each station provided the conditions requiring the move-on rule have not been met.

If marine mammals are detected while longline gear is in the water, the officer on watch exercises similar judgments and discretion to avoid incidental take of these species with longline gear as described for trawl gear. The species, number, and behavior of the protected species are considered along with the status of the ship and gear, weather and sea conditions, and crew safety factors. The officer on watch uses professional judgment and discretion to minimize risk of potentially adverse interactions with protected species during all aspects of longline survey activities.

If marine mammals 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 these species, setting does not resume until no marine mammals have been observed for at least 30 minutes.

If marine mammals are detected while longline gear is in the water and are considered to be at risk, haul-back is postponed until the officer on watch determines that it is safe to proceed. While some marine mammals caught during longline fishing may be hooked at any point during operations, most are typically caught during retrieval, so extra caution must be taken during this phase of sampling.

Because longline research is currently conducted in conjunction with commercial fisheries, operational characteristics (e.g., branchline and floatline length, hook type and size, bait type, number of hooks between floats) of the longline gear in Hawai‘i, America Samoa, Guam, the Commonwealth of the Northern Marianas, or EEZs of the Pacific Insular Areas adhere to the requirements on commercial longline gear based on NMFS regulations as summarized at http://www.fpir.noaa.gov/SFD/SFD_regs_2.html and specified in 50 CFR 229, 300, 404, 600, and 665. PIFSC will adhere to the above regulations and generally follow the below procedures when setting and retrieving longline gear:

- When shallow-setting anywhere and setting longline gear from the stern:
  - Completely thawed and blue-dyed bait will be used (two 1-pound containers of blue-dye will be kept on the boat for backup). Fish parts and spent bait with all hooks removed will be kept for strategic offal discard. Retained swordfish will be cut in half at the head; used heads and livers will also be used for strategic offal discard. Setting will only occur at night and begin 1 hour after local sunset and finish 1 hour before next sunrise, with lighting kept to a minimum.
- When deep-setting north of 23°N and setting longline gear from the stern:
  - 45 g or heavier weights will be attached within 1 m of each hook. A line shooter will be used to set the mainline. Completely thawed and blue-dyed bait will be used (two 1-pound containers of blue-dye will be kept on the boat for backup). Fish parts and spent bait with all hooks removed will be kept for strategic offal discard. Retained swordfish will be cut in half at the head; used heads and livers will also be used for strategic offal discard.
- When shallow-setting anywhere and setting longline gear from the side:
  - Mainline will be deployed from the port or starboard side at least 1 m forward of the stern corner. If a line shooter is used, it will be mounted at least 1 m forward from the stern corner. A specified bird curtain will be used aft of the setting station during the set. Gear will be deployed so that hooks do not resurface. 45 g or heavier weights will be attached within 1 m of each hook.
- When deep-setting north of 23°N and setting longline gear from the side:
  - Mainline will be deployed from the port or starboard side at least 1 m forward of the stern corner. If a line shooter is used, it will be mounted at least 1 m forward from the stern corner. A specified bird curtain will be used aft of the setting station during the set. Gear will be deployed so that hooks do not resurface. 45 g or heavier weights will be attached within 1 m of each hook.

Operational characteristics in non-Western Pacific Regional Fisheries Management Council areas of jurisdiction adhere to the regulations of the applicable management agencies. These agencies include the Western and Central Pacific Fisheries Commission (WCPFC), International Commission for the

Conservation of Atlantic Tunas (ICCAT), and Inter-American Tropical Tuna Commission (IATTC). These operational characteristics include specifications in WCPFC 2008, WCPFC 2007, ICCAT 2010, ICCAT 2011, IATTC 2011, and IATTC 2007.

11.3 Small Boat and Diver Operations

11.3.1 Operational procedures

The following measures are carried out when working in and around shallow water coral reef habitats. These measures are intended to avoid and minimize impacts to marine mammals (and other protected species). These activities generally include small boat operations and divers in the water.

Transit from the open ocean to shallow-reef survey regions (depths of < 35 m) of atolls and islands should be no more than 3 nm, dependent upon prevailing weather conditions and regulations. Each team conducts surveys and in-water operations with at least 2 divers observing for the proximity of marine mammals, a coxswain driving the small boat, and a topside spotter working in tandem. Topside spotters may also work as coxswains, depending on team assignment and boat layout. Spotters and coxswains will be tasked with specifically looking out for divers, marine mammals, and environmental hazards.

Before approaching any shoreline or exposed reef, all observers will examine the beach, shoreline, reef areas, and any other visible land areas within the line of sight for marine mammals. The Pacific RAMP teams typically do not participate during terrestrial surveys and operations as part of their mandate, and, therefore, minimize the potential for disturbances of resting animals along shorelines.

Divers, spotters, and coxswains undertake consistent due diligence and take every precaution during operations to avoid interactions with any marine mammals. Scientists, divers, and coxswains follow the Best Management Practices (BMPs) for boat operations and diving activities. These practices include but are not limited to the following precepts:

- Constant vigilance shall be kept for the presence of marine mammals
- When piloting vessels, vessel operators shall alter course to remain at least 100 m from marine mammals
- Reduce vessel speed to 10 km or less when piloting vessels within 1 km (as visibility permits) of marine mammals
- Marine mammals should not be encircled or trapped between multiple vessels or between vessels and the shore
- If approached by a marine mammal, put the engine in neutral and allow the animal to pass
- Unless specifically covered under a separate permit that allows activity in proximity to marine mammals, all in-water work will be postponed until whales are beyond 100 yards or other marine mammals are beyond 50 yards. Activity will commence only after the animal(s) depart the area
- Should marine mammals enter the area while in-water work is already in progress, the activity may continue only when that activity has no reasonable expectation to adversely affect the animal(s)
- Do not attempt to feed, touch, ride, or otherwise intentionally interact with any marine mammals
- Mechanical equipment will also be monitored to ensure no accidental entanglements occur with protected species (e.g., with PAM float lines, transect lines, and oceanographic equipment stabilization lines). Team members will immediately respond to an entangled animal, halting operations and providing an onsite response assessment (allowing the animal to disentangle itself,

assisting with disentanglement, etc.), unless doing so would put divers, coxswains, or other staff at risk of injury or death.

11.4 Plankton Nets, Small-mesh Towed Nets, Oceanographic Sampling Devices, Active Acoustics, Video Cameras, Autonomous Underwater Vehicle (AUV), and Remotely Operated Vessel (ROV) Deployments

PIFSC deploys a wide variety of gear to sample the marine environment during all of their research cruises, such as plankton nets, oceanographic sampling devices, video cameras, low-power high-frequency active acoustics directed underneath the ship as a beam, AUVs, and ROVs. It is not anticipated that these types of gear or equipment would have adverse interactions with marine mammals and are therefore not subject to specific mitigation measures. However, the officer on watch 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 marine mammals during deployment of all research equipment. Often these types of gear are deployed from small boats, not ships, and therefore visual monitoring and reduced transit speeds are the best measures to avoid interactions with marine mammals.

11.5 Marine Debris Research and Removal Activities

Land vehicle (trucks) operations will occur in areas of marine debris where vehicle access is possible from highways or rural/dirt roads adjacent to coastal resources. Prior to initiating any marine debris removal operations, marine debris personnel (marine ecosystem specialists) will thoroughly examine the beaches and near shore environments/waters for Hawaiian monk seals and humpback whales before approaching marine debris sites and initiating removal activities. Debris will be retrieved by personnel who are knowledgeable of and act in compliance with all federal laws, rules and regulations governing wildlife in the PMNM and MHI. This includes, but is not limited to maintaining a minimum distance of 50 yards from all monk seals and a minimum of 100 yards from female seals with pups (http://www.nmfs.noaa.gov/pr/education/hawaii/).

11.6 Handling Procedures for Incidentally Captured Animals

For the Pacific Islands Region, PIFSC follows the guidance on the identification, handling, and release of marine mammals that has been provided by the Pacific Islands Regional Office at: http://www.fpir.noaa.gov/SFD/pdfs/PSW_Placards_English_2014.pdf

If a marine mammal was captured live or injured, then it would be extracted from the research gear and returned to the water as soon as possible. Animals would be released without removing them from the water if possible. Data collection would be conducted in such a manner as not to delay release of the animal and should include species identification, sex identification if genital region is visible, estimated length, disposition at release (e.g., live, dead, hooked, entangled, amount and description of gear remaining on the animal), and photographs. The CS or crew should collect as much data as possible from hooked or entangled animals, considering the disposition of the animal; if it is in imminent danger of drowning, it should be released as quickly as possible. Biological specimens would not be collected from marine mammals because PIFSC currently does not have an Incidental Take Authorization. If a large whale is alive and entangled in fishing gear, the vessel should immediately call the U.S. Coast Guard (USCG) at VHF Ch. 16 or the appropriate Marine Mammal Health and Stranding Response Network.

11.7 Additional Mitigation Measures that are being Proposed for Further Development and Implementation by PIFSC

The PIFSC considers the current suite of monitoring and operational procedures to be necessary to avoid adverse interactions with protected species and still allow PIFSC to fulfill its scientific missions. However, some mitigation measures such as the move-on rule require judgments about the risk of gear interactions with protected species and the best procedures for minimizing that risk on a case-by-case basis. Ship captains and Chief Scientists are charged with making those judgments at sea. They are all highly experienced professionals but there may be inconsistencies across the range of research surveys conducted and funded by PIFSC in how those judgments are made. In addition, some of the mitigation measures described above could also be considered “best practices” for safe seamanship and avoidance of hazards during fishing (e.g., prior surveillance of a sample site before setting trawl gear). At least for some of the research activities considered, explicit links between the implementation of these best practices and their usefulness as mitigation measures for avoidance of protected species may not have been formalized and clearly communicated with all scientific parties and vessel operators. PIFSC therefore proposes a series of improvements to its protected species training, awareness, and reporting procedures. PIFSC expects these new procedures will facilitate and improve the implementation of the mitigation measures described above.

11.7.1 Training requirements and protocols for marine mammals

- PIFSC will initiate a process for its Chief Scientists and vessel captains to communicate with each other about their experiences with marine mammal interactions during research work with the goal of improving decision-making regarding avoidance of adverse interactions. As noted above, there are many situations where professional judgment is used to decide the best course of action for avoiding marine mammal interactions before and during the time research gear is in the water. The intent of this mitigation measure would be to draw on the collective experience of people who have been making those decisions, provide a forum for the exchange of information about what went right and what went wrong, and try to determine if there are any rules-of-thumb or key factors to consider that would help in future decisions regarding avoidance practices. PIFSC would coordinate not only among its staff and vessel captains but also with those from other fisheries science centers and institutions with similar experience.
- Another new element is the intent of PIFSC to develop a formalized marine mammal training program for all crew members that may be posted on monitoring duty or handle incidentally caught marine mammals, which would be required for all PIFSC research projects. Training programs would be conducted on a regular basis and would include topics such as monitoring and sighting protocols, species identification, decision-making factors for avoiding take, procedures for handling and documenting marine mammals caught in research gear, and reporting requirements. PIFSC will work with the Pacific Islands commercial fisheries Observer Program to customize a new marine mammal training program for researchers and ship crew. The Observer Program currently provides protected species training (and other types of training) for NMFS-certified observers placed on board commercial fishing vessels. PIFSC Chief Scientists and appropriate members of PIFSC research crews will be trained using similar monitoring, data collection, and reporting protocols for marine mammal as is required by the Observer Program. All PIFSC research crew members that may be assigned to monitor for the presence of marine mammals during future surveys will be required to attend an initial training course and refresher courses annually or as necessary. The implementation of this training program would formalize and standardize the information provided to all research crew that might experience marine mammal interactions during research activities.

- For all PIFSC research projects and vessels, written cruise instructions and protocols for avoiding adverse interactions with marine mammals will be reviewed and, if found insufficient, made fully consistent with the Observer Program training materials and any guidance on decision-making that arises out of the two training opportunities described above. In addition, informational placards and reporting procedures will be reviewed and updated as necessary for consistency and accuracy. All PIFSC research cruises already include pre-sail review of marine mammal protocols for affected crew but PIFSC will review its briefing instructions for consistency and accuracy.
- Following the first year of implementation of the LOA, PIFSC will convene a workshop with PIRO Protected Resources, PIFSC fishery scientists, NOAA research vessel personnel, and other NMFS staff as appropriate to review data collection, marine mammal interactions, and refine data collection and mitigation protocols, as required.

11.7.2 Operational procedures

As discussed in Section 6.1.3, PIFSC carefully considered the potential risk of marine mammal interactions with its bottomfishing hook-and-line research gear. PIFSC determined that the risk was not high enough to warrant requesting takes in that gear. However, PIFSC intends to implement the following measures to reduce the risk of potential interactions and to help improve our understanding of what those risks might be for different species. These efforts will help inform the adaptive management process to determine the appropriate type of mitigation needed for research conducted with bottomfishing gear.

- Visual monitoring for marine mammals before gear is set and implementation of the "move-on" rule as described for longline gear.
- To avoid attracting any marine mammals to a bottomfishing operation, dead fish and bait will not be discarded from the vessel while actively fishing. Dead fish and bait may be discarded after gear is retrieved and immediately before the vessel leaves the sampling location for a new area.
- If a monk seal, bottlenose dolphin, or other marine mammal is seen in the vicinity of a bottomfishing operation, then the gear would be retrieved immediately and the vessel would move to another sampling location where marine mammals are not present.
- If a hooked fish is retrieved and it appears to the fisher that it has been damaged by a monk seal, then visual monitoring will be enhanced around the vessel for the next ten minutes. Fishing may continue during this time. If a shark is sighted, then visual monitoring would be returned to normal. If a monk seal, bottlenose dolphin, or other marine mammal is seen in the vicinity of a bottomfishing operation, then the gear would be retrieved immediately and the vessel would be moved to another sampling location where marine mammals are not present. Catch loss would be tallied on the data sheet, as would a "move-on" for a marine mammal.
- If bottomfishing gear is lost while fishing, then visual monitoring will be enhanced around the vessel for the next ten minutes. Fishing may continue during this time. If a shark is sighted, then visual monitoring would be returned to normal. If a monk seal, bottlenose dolphin, or other marine mammal is seen in the vicinity, it would be observed until a determination can be made of whether gear is sighted attached to the animal, gear is suspected to be on the animal (i.e., it demonstrates uncharacteristic behavior such as thrashing), or gear is not observed on the animal and it behaves normally. If a cetacean or monk seal is sighted with the gear attached or suspected to be attached, then the procedures and actions for incidental takes would be initiated (see Section 13). Gear loss would be tallied on the data sheet, as would a "move-on" because of a marine mammal.

11.7.3 Gear modifications

In order to minimize the potential risk of entanglement during instrument deployment, PIFSC is evaluating possible modifications to total line length and the relative length of floating line to sinking line used for stationary gear that is deployed from ships or small boats (e.g., stereo-video data collection). A certain amount of extra line (or scope) is needed whenever deploying gear/instruments to the seafloor to prevent currents from moving the gear/instruments off station. If the line is floating line and there is no current then the scope will be floating on the surface. Alternatively, scope in sinking line may gather below the water surface when currents are slow or absent. Because current speeds vary, there is a need for scope every time that gear is deployed.

Line floating on the surface presents the greatest risk for marine mammal entanglement because: (1) when marine mammals (e.g., humpback whales) come to the surface to breathe, the floating line is more likely to become caught in their mouths or around their fins; and (2) humpback whales tend to spend most of their time near the surface, generally in the upper 150 m of the water column.

Currently, PIFSC uses only floating line to deploy stationary gear from ships or small boats. Floating line is used in order to maintain the vertical orientation of the line immediately above the instrument on the seafloor. The floating line also helps to keep the line off of the seafloor where it could snag or adversely affect benthic organisms or habitat features.

This mitigation measure would involve the use of sinking line for approximately the top 1/3 of the line. The other approximately lower 2/3 would still be floating line. This configuration would allow any excess scope in the line to sink to a depth where it would be below where most whales and dolphins commonly occur. Specific line lengths, and ratios of floating line to sinking line, would vary with actual depth and the total line length. This mitigation measure would not preclude the risk of whales or dolphins swimming into the submerged line, but this risk is believed to be lower relative to line floating on the surface.

12.0 WHERE THE PROPOSED ACTIVITY WOULD TAKE PLACE IN OR NEAR A TRADITIONAL ARCTIC SUBSISTENCE HUNTING AREA AND/OR MAY AFFECT THE AVAILABILITY OF A SPECIES OR STOCK OF MARINE MAMMAL FOR ARCTIC SUBSISTENCE USES, THE APPLICANT MUST SUBMIT EITHER A "PLAN OF COOPERATION" (POC) OR INFORMATION THAT IDENTIFIES WHAT MEASURES HAVE BEEN TAKEN AND/OR WILL BE TAKEN TO MINIMIZE ANY ADVERSE EFFECTS ON THE AVAILABILITY OF MARINE MAMMALS FOR SUBSISTENCE USES.

Not applicable. The proposed activity will take place in the Eastern and Southern Tropical Pacific 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.

13.0 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 midwater 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 and monitoring occur for 30 minutes prior to deployment of gear, and they continue until gear is brought back on board. This is the standard operating practice for longline and trawl work. However, PIFSC has no information that suggests capture/entanglement in PIFSC trawl or longline surveys are an issue. If marine mammals are sighted in the area then the sampling station is either moved or canceled. When marine mammal researchers are on board (distinct from marine mammal observers dedicated to monitoring for potential gear interactions) they record the estimated species and number of animals present and their behavior. If marine mammal researchers are not on board or available (due to vessel size limits and bunk space) then PIFSC will develop protocols and provide training (see section 11.7.1) to bridge crew and other marine mammal observer crew to record such information. This information can be valuable in understanding whether some species may be attracted to vessels or gears. NOAA vessels are required to monitor interactions with protected species (and report interactions to the PIFSC Director) but in reality are limited to direct interactions and reporting floaters or entangled whales. Similarly, there is a condition of grant and contract awards for monitoring of marine mammal takes.

13.2 Reporting

PIFSC will coordinate with the local Pacific Islands 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 PIFSC leadership by event, survey leg and cruise. However, the Cruise Leader is not generally on the bridge during fishing operations and will need to rely on forms completed by either scientists or crew. As a result, if any incidental capture or entanglement of a marine mammal occurs, or when animals are present and no takes occur, a report provided by the Cruise Leader will summarize the behavior and species of animals present, weather and viewing conditions, and other important circumstances of these events that will allow PIFSC 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.

NMFS has established a formal incidental take reporting system, the Protected Species Incidental Take (PSIT) database, requiring that incidental takes of MMPA and ESA listed 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 represents not only a valuable real-time reporting and information dissemination tool, but also an archive of information that could be mined at later points in time to study why takes occur, by species, gear, etc. Ultimately, PIFSC 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, PIFSC will input data both into the PSIT database and submit detailed event reports.

A final and equally important component of reporting being implemented by PIFSC will facilitate serious injury (SI) determinations for marine mammals that are released alive. As discussed in Section 11.7.1, PIFSC will require 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. PIFSC 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. In addition, PIFSC fisheries research personnel working in nearshore or onshore locations in proximity to Hawaiian monk seals will document any disturbances to seals. Such documentation will include date, location, number and reaction of seals, type of disturbance and nature of fisheries research activity being conducted. Reports from such events will be compiled and reviewed on an annual basis for review by PIFSC leadership in order to devise alternative strategies for reducing any future take. Take events will be reported annually to the Office of Protected Resources as required by authorization.

14.0 COORDINATING RESEARCH TO REDUCE AND EVALUATE INCIDENTAL TAKE

NOAA Fisheries and PIFSC provide a substantial amount of funding and support to marine research. Specifically, NOAA Fisheries provides funding annually to universities, research institutions, Federal laboratories, private companies, and independent researchers around the world to study marine mammals. PIFSC 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, PIFSC has an active conservation engineering program designed to reduce takes of marine mammals, turtles, and other listed species in fisheries around the world. PIFSC 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.

As noted in section 11.7, following the first year of implementation of the LOA PIFSC will convene a workshop with PIRO Protected Resources, PIFSC fishery scientists, NOAA research vessel personnel, and other NMFS staff as appropriate to review data collection, marine mammal interactions, and refine data collection and mitigation protocols, as required.

PIFSC has a keen awareness that an increase in fisheries research effort could result in more marine mammal takes over time. For this reason and because of resource limitations, PIFSC maximizes efficient use of the charter and NOAA ship time it can attain. We also engage in operational plans with the SWFSC in order to clearly delineate our respective research responsibilities and to ensure we avoid research gaps and duplication of effort between Centers. In short, PIFSC is on the water conducting fisheries research activities no more often than is necessary to fulfill its responsibilities to provide scientific advice to the Pacific Islands Regional Office and other relevant domestic and international management bodies.

15.0 LITERATURE CITED

Acevedo-Gutierrez, A. and M.A. Smultea. 1995. First records of humpback whales including calves at Golfo Dulce and Isla del Coco, Costa Rica, suggesting geographical overlap of northern and southern Hemisphere populations. Marine Mammal Science 11: 554-560.

Allen, B.M. and R.P. Angliss. 2011. Alaska marine mammal stock assessments, 2010. U. S. Dept. Comm., NOAA Tech. Memo. NMFS-AFSC-223. 292 pages.

Allen, B.M. and R.P. Angliss. 2012. Alaska marine mammal stock assessments, 2011. U.S. Dept. Comm., NOAA Tech. Memo. NMFS-AFSC-234, 288 p.

Allen, B.M. and R.P. Angliss. 2015. Alaska Marine Mammal Stock Assessments, 2014. U.S. Dept. Comm., NOAA Tech. Memo. NMFS-AFSC-301.

Aguillar, A. 2009. Fin whale, *Balaenoptera physalus*. Pages 433-437, in W.F. Perrin, B. Würsig, and H.G.M. Thewissen (eds.), Encyclopedia of Marine Mammals, Academic Press, San Diego, CA. 1316 pages.

Archer, F. I. II. 2009. Striped dolphin, *Stenella coeruleoalba*. Pages 1127-1129, in W.F. Perrin, B. Würsig, and H.G.M. Thewissen (eds.), Encyclopedia of Marine Mammals, Academic Press, San Diego, CA. 1316 pages.

Aschettino, J.M., R.W. Baird, D.J. McSweeney, D.L. Webster, et.al. 2011. Population size and structure of melon-headed whales (*Peponocephala electra*) around the main Hawaiian Islands: evidence of multiple populations based on photographic data. Marine Mammal Science 28(4): 666-689.

Aschettino, J.M. 2010. Population size and structure of melon-headed whales (*Peponocephala electra*) around the main Hawaiian Islands: evidence of multiple populations based on photographic data. Master's Thesis. Hawai'i Pacific University.

Aschettino, J.M., R.W. Baird, D.J. McSweeney, D.L. Webster, G.S. Schorr, J.L. Higgins, K.K. Martien, S.D. Mahaffy, and K.L. West. 2012. Population structure of melon-headed whales (*Peponocephala electra*) in the Hawaiian Archipelago: evidence of multiple populations based on photo identification. Marine Mammal Science 28(4): 666-689. doi: 10.1111/j.1748-7692.2011.00517.x

Au, D.W.K. and W.L. Perryman. 1985. Dolphin habitats in the eastern tropical Pacific. Fishery Bulletin, U.S. 83: 623–643.

Au, W.W.L. 2000. Hearing in whales and dolphins: An overview. Pages 1-42, in W.W.L. Au, A.N. Popper, and R.R. Fay (eds.), Hearing by whales and dolphins. Springer-Verlag, New York.

Au, W.W.L. and M.C. Hastings. 2008. Principles of Marine Bioacoustics. New York: Springer.

Au, W.W.L., A.A. Pack, M.O. Lammers, L.M. Herman, M.H. Deakos, and K. Andrews. 2006. Acoustic properties of humpback whale songs. Journal of the Acoustical Society of America 120: 1103-1110.

Auster, P.J., and R.W. Langton. 1999. The effects of fishing on fish habitat. In: Benaka, L., ed. Fish habitat: essential fish habitat and rehabilitation. Am. Fish. Soc. Symp. 22:150-187.

Baird, R.W. 2009a. Risso's dolphin, *Grampus griseus*. Pages 975-976, in W.F. Perrin, B. Würsig, and H.G.M. Thewissen (eds.), Encyclopedia of Marine Mammals, Academic Press, San Diego, CA. 1316 pages.

Baird, R.W. 2009b. False killer whale, *Pseudorca crassidens*. Pages 405-406 in W.F. Perrin, B. Würsig, and H.G.M. Thewissen (eds.), Encyclopedia of Marine Mammals, Academic Press, San Diego, CA. 1316pp.

Baird, R.W., P.A. Abram, and L.M. Dill. 1992. Possible indirect interactions between transient and resident killer whales: implications for the evolution of foraging specialization in the genus Orcinus. Oecologia 89:125-132.

Baird, R.W., J. Borsani, M.B. Hanson, and P.L. Tyack. 2002. Diving and night-time behavior of long-finned pilot whales in the Ligurian Sea. Marine Ecology Progress Series 237:301-305.

Baird, R.W., D.L. Webster, S.D. Mahaffy, D.J. McSweeney, G.S. Schorr, and A.D. Ligon. 2008. Site fidelity and association patterns in a deep-water dolphin: Rough-toothed dolphins (*Steno bredanensis*) in the Hawaiian Archipelago. Marine Mammal Science 24(3): 535-553.

Baird, R.W., A.M. Gorgone, D.J. McSweeney, A.D. Ligon, M.H. Deakos, D.L. Webster, G.S. Schorr, K.K. Martien, D.R. Salden, and S.D. Mahaffy. 2009. Population structure of island-associated dolphins: Evidence from photo-identification of common bottlenose dolphins (*Tursiops truncatus*) in the main Hawaiian Islands. Mar. Mamm. Sci. 25:251-274.

Baird, R.W., A.M. Gorgone, D.L. Webster, D.J. McSweeney, J.W. Durban, A.D. Ligon, D.R. Salden, and M.H. Deakos. 2005. False killer whales around the main Hawaiian Islands: An assessment of inter-island movements and population size using individual photo-identification. Contract Report JJ133F04SE0120 prepared for the Pacific Islands Fisheries Science Center, National Marine Fisheries Service, 2570 Dole Street, Honolulu, Hawaii, 96822. 24pp

Baird, R.W., M.B. Hanson, E.A. Ashe, M.R. Heithaus, and G.J. Marshall. 2003. Studies of foraging in ‘southern resident’ killer whales during July 2002: Dive depths, bursts in speed, and the use of a ‘crittercam’ system for examining sub-surface behavior. Unpublished contract report, available National Marine Mammal Laboratory, 7600 Sand Point Way, NE, Seattle, WA 98115.

Baird, R.W., A.D. Ligon, and S.K. Hooker. 2000. Sub-surface and night-time behavior of humpback whales off Maui, Hawai‘i: A preliminary report. Contract number 40ABNC050729. Prepared for the Hawaiian Islands Humpback Whale National Marine Sanctuary, Kihei, Hawai‘i by the Hawai‘i Wildlife Fund, Paia, Hawai‘i.

Baird, R.W., D.J. McSweeney, C. Bane, J. Barlow, D.R. Salden, L’R.K. Antoine, R.G. LeDuc, and D.L. Webster. 2006. Killer Whales in Hawaiian Waters: Information on Population Identity and Feeding Habits. Pacific Science 60 (4):523–530.

Baird, R.W., D.L. Webster, J.M. Aschettino, G.S. Schorr, and D.J. McSweeney. 2013. Odontocete Cetaceans Around the Main Hawaiian Islands: Habitat Use and Relative Abundance from Small-Boat Sighting Surveys. Aquatic Mammals 39(3): 253-269.

Baird, R.W., D.L. Webster, D.J. McSweeney, A.D. Ligon, G.S. Schorr and J. Barlow. 2006. Diving behaviour of Cuvier's (*Ziphius cavirostris*) and Blainville's (*Mesoplodon densirostris*) beaked whales in Hawai'i. Canadian Journal of Zoology 84:1120-1128.

Baker J.D., A.L. Harting, T.A. Wurth, and T.C. Johanos. 2010. Dramatic shifts in Hawaiian monk seal distribution predicted from divergent regional trends. Marine Mammal Science Published Online: May 26 2010 2:27AM DOI: 10.1111/j.1748-7692.2010.00395.x.

Baker J.D., E.A. Howell, and J.J. Polovina. 2012. Relative influence of climate variability and direct anthropogenic impact on a sub-tropical Pacific top predator, the Hawaiian monk seal. Mar. Ecol. Prog. Ser. 469:175-189.

Ballance, L.T., P.C. Fiedler, T. Gerrodette, R.L. Pitman, and S.B. Reilly. 2002. An overview of eastern tropical Pacific ecosystem studies within the context of International Dolphin Conservation Program Act research. Administrative Report LJ-02-14. Southwest Fisheries Science Center, NMFS, NOAA, La Jolla, CA. 9 pp.

Ballance, L.T., R.L. Pitman, and P.C. Fiedler. 2006. Oceanographic influences on seabirds and cetaceans of the eastern tropical Pacific: A review. Progress in Oceanography 69:360-390.

Barlow, J. 2006. Cetacean abundance in Hawaiian waters estimated from a summer/fall survey in 2002. Marine Mammal Science 22: 446-464.

Barlow, J. 2010. Cetacean abundance in the California Current from a 2008 ship-based line-transect survey. NOAA Tech. Memo., NMFS, NOAA-TM-NMFS-SWFSC-456.

Barlow, J. and G.A. Cameron. 2003. Field experiments show that acoustic pingers reduce marine mammal bycatch in the California drift gill net fishery. Marine Mammal Science 19(2):265-283.

Barlow, J., M.C. Ferguson, E.A. Becker, J.V. Redfern, K.A. Forney, I.L. Vilchis, P.C. Fiedler, T. Gerrodette, and L.T. Ballance. 2009. Predictive modeling of cetacean densities in the eastern Pacific Ocean. U.S. Department of Commerce, NOAA Tech. Memo. NOAA-TM-NMFS-SWFSC-444. 206 pp.

Barlow, J., M.C. Ferguson, W.F. Perrin, L.T. Ballance, T. Gerrodette, G. Joyce, C.D. MacLeod, K. Mullin, D.L. Palka, and G. Waring. 2006. Abundance and densities of beaked and bottlenose whales (family Ziphiidae). Journal of Cetacean Research and Management 7: 263-270

Barlow, J. and R. Gisiner. 2006. Mitigating, monitoring, and assessing the effects of anthropogenic sound on beaked whales. J. Cet. Res. Manage. 7(3):239-249.

Barlow, J. and K.A. Forney. 2007. Abundance and population density of cetaceans in the California Current ecosystem. Fishery Bulletin, U.S. 105:509-526.

Barlow, J. and S. Rankin. 2007. False killer whale abundance and density: Preliminary estimates for the PICEAS study area south of Hawai‘i and new estimates for the US EEZ around Hawaii. Administrative Report LJ-07-02. Southwest Fisheries Science Center, National Marine Fisheries Service, 8604 La Jolla Shores Drive, La Jolla, CA 92037.

Barlow, J. and B.L. Taylor. 2005. Estimates of sperm whale abundance in the northeastern temperate Pacific from a combined acoustic and visual survey. Marine Mammal Science 21(3): 429-445.

Baumann-Pickering, S., M.A. Roch, R.L. Brownell Jr., A.E. Simonis, M.A. McDonald, A. Solsona-Berga, and J.A. Hildebrand. 2014. Spatio-Temporal Patterns of Beaked Whale Echolocation Signals in the North Pacific.*PLoS ONE*, *9*(1), e86072. http://doi.org/10.1371/journal.pone.0086072.

Baumann-Pickering, S., A.E. Simonis, E.M. Oleson, R.W. Baird, M.A. Roch, and, S.M.Wiggins. 2015. False killer whale and short-finned pilot whale acoustic identification. End. Sp. Res. 28: 97-108.

Berzin, A.A. and A.A. Rovnin. 1966. Distribution and migration of whales in the northeastern part of the Pacific Ocean, Bering and Chukchi Seas. Izv. Tikhookean. Nauchno-issled, Inst. Rybn. Khoz. Okeanogr. (TINRO) 58:179-207. {In Russian}. (Translated by U.S. Dep. Inter., Bur. Commer. Fish., Seattle, Washington, 1966, pp. 103-106 In: Panin, K. I. (ed) Soviet Research on marine mammals of the Far East).

Boggs, C.H., D.P. Gonzales, and R.M. Kokubun. 2015. Marine Mammals Reported under Catch Lost to Predators on Fishermen’s Commercial Catch Reports to the State of Hawaii, 2003-2014. PIFSC Data Report DR-15-006

Bograd, S.J., W.J. Sydeman, J. Barlow, A. Booth, R.D. Brodeur, J. Calambokidis, F. Chavez, W.R. Crawford, E. Di Lorenzo, R. Durazo, R. Emmett, J. Field, G. Gaxiola-Castro, R. Gilly, R. Goericke, J. Hildebrand, J.E. Irvine, M. Kahru, J.A. Koslow, B. Lavaniegos, M. Lowry, D.L. Mackas, M. Manzano-Sarabia, S.M. McKinnell, B.G. Mitchell, L. Munger, R.I. Perry, W.T. Peterson, S. Ralston, J. Schweigert, A. Suntsov, R. Tanasichuk, A.C. Thomas, F. Whitney. 2010.

Status and trends of the California Current region, 2003-2008, pp. 106-141 In S.M. McKinnell and M.J. Dagg (eds.). Marine Ecosystems of the North Pacific Ocean, 2003-2008. PICES Special Publication 4. 393 pp.

Bradford, A.L. and K.A. Forney. 2013. Injury determinations for cetaceans observed interacting with Hawai‘i and American Samoa longline fisheries during 2007-2011. Pacific Islands Fishery Science Center Working Paper WP- 13-002. Issued 25 March 2013. 24 pp.

Bradford, A.L., E.M. Oleson, R.W. Baird, C.H. Boggs, K.A. Foorney, and N.C. Young. 2015. Revised stock boundaries for false killer whales (*Pseudorca crassidens*) in Hawaiian waters. NOAA Tech. Memo. NMFS-PIFSC-47; 29pp.

Bradford, A.L., K.A. Forney, E.M. Oleson, and J. Barlow. 2014. Accounting for subgroup structure in line-transect abundance estimates of false killer whales (*Pseudorca crassidens*) in Hawaiian waters. PLoS ONE 9(2): e90464. doi:10.1371/journal.pone.0090464.

Bradford, A.L., K.A. Forney, E.M. Oleson, and J. Barlow. 2013. Line-transect abundance estimates of cetaceans in the Hawaiian EEZ. PIFSC Working Paper WP-13-004. 16 pp. Issued 29 March 2013.

Bradford, A.L. and E. Lyman. 2015. Injury determinations of humpback whales and other cetaceans reported to the Pacific Islands region Marine Mammal Response network during 2007-2011. U.S. Dep. Commer., NOAA Tech. Memo, NOAA-TM-NMFS-PIFSC-45; 29p.

Branch, T., K.M. Stafford, D.M. Palacios, C. Allison, et al. 2007. Past and present distribution, densities and movements of blue whales *Balaenoptera musculus* in the southern hemisphere and northern Indian Ocean. Mammal Review 37:116-175.

Brownell Jr., R.L, K. Ralls, S. Baumann-Pickering, and M.M. Poole. 2009. Behavior of melon-headed whales, *Peponocephala electra*, near oceanic islands. Marine Mammal Science 25(3):639-658.

Buckstaff, K.C. 2004. Effects of watercraft noise on the acoustic behavior of bottlenose dolphins, *Tursiops truncatus*, in Sarasota Bay, Florida. Marine Mammal Science 204:709-725.

Calambokidis, J., E.A. Falcone, T.J. Quinn, A.M. Burdin, et al. 2008. SPLASH: Structure of Populations. Levels of Abundance and Status of Humpback Whales in the North Pacific. Final report for Contract AB133F-03-RP-00078

Calambokidis, J., E. Oleson, M. McDonald, B. Burgess, J. Francis, G. Marshall, M. Bakhtiari, and J. Hildebrand. 2003. Feeding and vocal behavior of blue whales determined through simultaneous visual-acoustic monitoring and deployment of suction-cap attached tags. Page 27 in Abstracts, Fifteenth Biennial Conference on the Biology of Marine Mammals. 14–19 December 2003. Greensboro, North Carolina.

Calambokidis, J., G.H. Steiger, J.R. Evenson and S.J. Jeffries. 1991. Censuses and disturbance of harbor seals at Woodard Bay and recommendations for protection. Final Report to Washington Department of Fish and Game, Olympia, WA. 45p.

Calambokidis, J., G.H. Steiger, Rasmussen, K. Urbán, J.R. Balcomb, K.C. Ladrón de Guevara, P. Salinas, M. Jacobsen J.K. Herman, L.M. Cerchio, and J.D. Darling. 2000. Migratory destinations of humpback whales that feed off California, Oregon and Washington. Marine Ecology Progress Series 192: 295-304

Carretta, J.V. and J. Barlow. 2011. Long-term effectiveness, failure rates, and "dinner bell" properties of acoustic pingers in a gillnet fishery. Marine Technology Society Journal 45(5):7-19.

Carretta, J.V., J. Barlow, and L. Enriquez. 2008. Acoustic pingers eliminate beaked whale bycatch in a gill net fishery. Marine Mammal Science 24:956-961.

Carretta, J.V., K.A. Forney, M.S. Lowry, J. Barlow, J. Baker, B. Hanson, and M.M. Muto. 2007. U.S. Pacific Marine Mammal Stock Assessments: 2007. U.S. Dept. Comm., NOAA Tech. Memo., NMFS-SWFSC-414. 316p.

Carretta, J.V., K.A. Forney, E.M. Oleson, K. Martien, M.M. Muto, M.S. Lowry, J. Barlow, J. Baker, B. Hanson, D. Lynch, L. Carswell, R.L. Brownell Jr., J. Robbins, D.K. Mattila, K. Ralls, and M.C. Hill. 2012. U.S. Pacific Marine Mammal Stock Assessments: 2011. U.S. Dept. Comm., NOAA Tech. Memo., NMFS-SWFSC-488. 360 pages.

Caretta, J.V., E.M. Oleson, D.W. Weller, A.R. Lang, K.A. Forney, J. Baker, B. Hanson, K. Martien, M.M. Muto, A.J. Orr, H. Huber, M.S. Lowry, J. Barlow, D. Lynch, L. Carswell, R.L. Brownwell Jr., and D.K. Mattila. 2014. U.S. Pacific Marine Mammal Stock Assessments: 2013. U.S. Dept. Comm., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-532. 414 pages.

Carretta, J.V., E.M. Oleson, D.W. Weller, A.R. Lang, K.A. Forney, J. Baker, M.M. Muto, B. Hanson, A.J. Orr, H. Huber. M.S. Lowry, J. Barlow, J.E. Moore, D. Lynch, L. Carswell, and R.L. Brownell Jr. 2015. U.S. Pacific marine mammal stock assessments: 2014. U.S. Dept. Comm., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-549.

Clapham, P.J. 2009. Humpback whale, *Megaptera novaeangliae*. Pages 582-585, in W.F. Perrin, B. Würsig, and H.G.M. Thewissen (eds.), Encyclopedia of Marine Mammals, Academic Press, San Diego, CA. 1316 pages.

Clark, C.W., and W.T. Ellison. 2004. Potential use of low-frequency sound by baleen whales for probing the environment: Evidence from models and empirical measurements. Pages 564-581 in J.A. Thomas, C.F. Moss, and M. Vater (eds.), Echolocation in Bats and Dolphins. Chicago: University of Chicago Press.

Clark, C.W., W.T. Ellison, B.L. Southall, L. Hatch, S.M. Van Parijs, A. Frankel, and D. Ponirakis. 2009. Acoustic masking in marine ecosystems: intuitions, analysis, and implication. Marine Ecology Progress Series 395:201-222.

Clyne, H. 1999. Computer simulations of interactions between the North Atlantic right whale (*Eubalaena glacialis*) and shipping. Masters thesis in Software Technology, Napier University (Scotland), 53 pp.

Col, L.A., J.S. Link, S.X. Cadrin, and D.L. Palka. 2012. Marine mammal consumption on the northeast US continental shelf. IWC Annual Science Conference SC/64/WP/EM/2 52 pp.

Cox, T.M., T.J. Ragen, A.J. Read, E. Vos, R.W. Baird, K. Balcomb, J. Barlow, J. Caldwell, T. Cranford, L. Crum, A. D'Amico, G. D'Spain, A. Fernandez, J. Finneran, R. Gentry, W. Gerth, F. Gulland, J.A. Hildebrand, D. Houser, T. Hullar, P.D. Jepson, D. Ketten, C.D. Macleod, P. Miller, S. Moore, D. Mountain, D. Palka, P. Ponganis, S. Rommel, T. Rowles, B. Taylor, P. Tyack, D. Wartzok, R. Gisiner, J. Mead, and L. Brenner. 2006. Understanding the impacts of anthropogenic sound on beaked whales. J. Cetacean Res. Manag. 7:177-187.

Courbis, S. and G. Timmel. 2009. Effects of vessels and swimmers on behavior of Hawaiian spinner dolphins (*Stenella longirostris*) in Kealake'akua, Honaunau, and Kauhako bays, Hawai'i. Marine Mammal Science 25:430-440.Cox, T.M., et al. 2006. Understanding the impacts of anthropogenic sound on beaked whales. Journal of Cetacean Research and Management 7:177-187.

Croll D.A., C.W. Clark., J. Calambokidis., W.T. Ellison., and B.R. Tershy. 2001. Effect of anthropogenic low-frequency noise on the foraging ecology of *Balaenoptera* whales. Animal Conservation 4:13-27.

D'Amico A., R.C. Gisiner, D.R. Ketten, J.A. Hammock, C. Johnson, et al. 2009. Beaked whale strandings and naval exercises. Aquat. Mamm. 34: 452–472.

Dalebout, M.L., G.J.B. Ross, C.S. Baker, R.C. Anderson, P.B. Bestm V.G. Cockroft, H.L. Hinsz, V. Peddemors, and R.L. Pitman. 2003. Appearance, distribution and genetic distinctiveness of Longman's beaked whale, *Indopacetus pacificus*. Marine Mammal Science 19:421-461.

Danil, K., D. Maldini, and K. Marten. 2005. Patterns of use of Maku'a Beach, O'ahu, Hawai'i, by spinner dolphins (*Stenella longirostris*) and potential effects of swimmers on their behavior. Aquatic Mammals 31:403-412.

Dawson, S.M. 2009. *Cephalorhynchus* dolphins *C. heavisidii, C. eutropia, C. hectori, and C. commersonii.* Pages 191-196, in W.F. Perrin, B. Würsig, and H.G.M. Thewissen (eds.), Encyclopedia of Marine Mammals, Academic Press, San Diego, CA. 1316 pages.

Deecke, V.B., J.K.B. Ford, and P.J.B. Slater. 2002. The vocal behavior of mammal-eating killer whales: communicating with costly calls. Animal Behaviour 69:395-404.

Department of the Navy (DON). 2008a. Final Atlantic fleet active sonar training environmental impact statement/overseas environmental impact statement. Submitted December 12, 2008 876 pages.

DON. 2008b. Request for Letter of Authorization for the incidental harassment of marine mammals resulting from Navy training activities conducted within the northwest training range complex. September 2008. 323 pages.

Dizon, A.E., W.F. Perrin, and P.A. Akin. 1994. Stocks of dolphins (*Stenella* spp. and *Delphinus delphis*) in the Eastern Tropical Pacific: A phylogeographic classification. U.S. Dept. Comm., NOAA Technical Report NMFS 119. 20 pp.

Dolar, M.L.L. 2009. Fraser's dolphin, *Lagenodelphis hosei*. Pages 469-471 in W.F. Perrin, B. Würsig, and H.G.M. Thewissen (eds.), Encyclopedia of Marine Mammals, Academic Press, San Diego, CA. 1316 pp.

Donohue, M.A. and W.L. Perryman. 2009. Pygmy killer whale, *Feresa attenuata*. Pages 938-939 in W.F. Perrin, B. Würsig, and H.G.M. Thewissen (eds.), Encyclopedia of Marine Mammals, Academic Press, San Diego, CA. 1316 pp.

Douglas, A.B., J. Calambokidis, S. Raverty, S.J. Jeffries, D.M. Lambourn, and S.A. Norman. 2008. Incidence of ship strikes of large whales in Washington State. Journal of the Marine Biological Association of the United Kingdom 88:1121-1132.

Edds-Walton, P.L. 1997. Acoustic communication signals of mysticete whales. Bioacoustics 8:47–60.

Erbe, C. 2002. Underwater noise of whale-watching boats and potential effects on killer whales (*Orcinus orca*), based on an acoustic impact model. Marine Mammal Science 18:394-418.

Federal Register. 2014. Endangered and Threatened Wildlife and Plants; Technical Corrections for the Hawaiian monk seal; Direct final rule. 50 CFR Parts 224 and 226. Vol. 79, No. 221 (November 17, 2014), pp. 68371-68373.

Félix, F. and N. Botero-Acosta. 2011. Distribution and behavior of humpback whale mother-calf pairs during the breeding season off Ecuador. Marine Ecology Progress Series 426: 277-287.

Ferguson, M.C., J. Barlow, S.B. Reilly, and T. Gerrodette. 2006. Predicting Cuvier's (*Ziphius cavirostris*) and *Mesoplodon* beaked whale population density from habitat characteristics in the eastern tropical Pacific Ocean. Journal of Cetacean Research and Management 7(3):287-299.

Ferguson, M.C., and J. Barlow. 2003. Addendum: Spatial distribution and density of cetaceans in the eastern tropical Pacific Ocean based on summer/fall research vessel surveys in 1986-96. Administrative Report LJ- 01-04 (addendum), Southwest Fisheries Science Center, National Marine Fisheries Service, 8604 La Jolla Shores Drive, La Jolla, CA 92037.

Fiedler, P.C. and M.F. Lavin. 2006. Introduction: A review of eastern tropical Pacific oceanography. Progress in Oceanography 69(2-4): 94-100.

Finneran, J.J. and C.E. Schlundt. 2010. Frequency-dependent and longitudinal changes in noise-induced hearing loss in a bottlenose dolphin (*Tursiops truncatus*). Journal of the Acoustical Society of America 127:3267-3272.

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

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

Finneran, J.J., H.R. London, and D.S. Houser. 2007a. Modulation rate transfer functions in bottlenose dolphins (*Tursiops truncatus*) with normal hearing and high-frequency hearing loss. Journal of Comparative Physiology, Part A 193:835–843.

Finneran, J.J., C.E. Schlundt, B. Branstetter, and R.L. Dear. 2007b. Assessing temporary threshold shift in a bottlenose dolphin (*Tursiops truncatus*) using multiple simultaneous auditory evoked potentials. Journal of the Acoustical Society of America 122:1249–1264.

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

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

Ford, J.K.B. 2009. Killer whale *Orcinus orca*. Pages 650-657, in W.F. Perrin, B. Würsig, and H.G.M. Thewissen (eds.), Encyclopedia of Marine Mammals, Academic Press, San Diego, CA. 1316 pp.

Ford, J.K.B., G.M. Ellis, and K.C. Balcomb. 2000. Killer whales: the natural history and geneology of *Orcinus orca* in British Columbia and Washington, 2nd Edition. University of British Columbia Press, Vancouver, B.C. and University of Washington Press, Seattle, WA.

Forney, K.A., E.A. Becker, D.G. Foley, J. Barlow, and E.M. Oleson. 2015. Habitat-based models of cetacean denesity and distribution in the central North Pacific. Endangered Species Research 27:1-20.

Fox, K.S. 2008. Harbor seal behavioral response to boaters at Bair Island refuge. Master's Thesis. San jose State University. 76p.

Frankel, A.S. 2005. Gray whales hear and respond to a 21-25 kHz high-frequency whale-finding sonar. Page 97 in 16th Biennial Conference on the Biology of Marine Mammals, San Diego, California, 12-16 December.

Freiwald, A., J.H. Fossa, A. Grehan, T. Koslow, and M. Roberts. 2004. Cold-water coral reefs, out of sight – no longer out of mind. UNEP World Conservation Monitoring Centre. pp. 86.

Fulling, G.L., P.H. Thorson, and J. Rivers. 2011. Distribution and abundance estimates for cetaceans in the waters off Guam and the Commonwealth of the Northern Mariana Islands. Pacific Science 65(3): 321-343.

Gerrodette, T. 2009. The tuna-dolphin issue. Pages 1192-1195 in W.F. Perrin, B. Würsig, and H.G.M. Thewissen (eds.), Encyclopedia of Marine Mammals, Academic Press, San Diego, CA. 1316 pp.

Gerrodette, T., G. Watters, W. Perryman, and L. Balance. 2008. Estimate of 2006 dolphin abundance in the eastern tropical Pacific, with revised estimates from 1986-2003. U.S. Dept. Comm., NOAA Tech. Memo.,NOAA-TM-NMFS-SWFSC-422. 39 pp.

Gerrodette, T. and J. Forcada. 2005. Non-recovery of two spotted and spinner dolphin populations in the eastern tropical Pacific Ocean. Marine Ecology Progress Series 291:1-21.

Gerrodette, T. and J. Forcada. 2002. Estimates of abundance of western/southern spotted, whitebelly spinner, striped and common dolphins, and pilot, sperm and Bryde's whales in the eastern tropical Pacific Ocean. SWFSC Administrative Report LJ-02-20. 24 pp.

Gilmartin, W.G. and J., Forcada. 2009. Monk seals *Monachus monachus, M. tropicalis, and M. schauinslandi*. Pages 741-744 in W.F. Perrin, B. Würsig, and H.G.M. Thewissen (eds.), Encyclopedia of Marine Mammals, Academic Press, San Diego, CA. 1316 pp.

Glass, A.H., T.V.N. Cole, and M. Garron. 2009. Mortality and serious injury determinations for baleen whale stocks along the United States eastern seaboard and adjacent Canadian maritimes, 2003-2007 (2nd Edition). US Dept. Comm., NEFSC Ref Doc. 09-04; 19 p. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole MA 02543-1026, or online at http://www.nefsc.noaa.gov/nefsc/publications

Goldbogen, J.A., J. Calambokidis, R.E. Shadwick, E.M. Oleson, M.A. McDonald, and J.A. Hildebrand. 2006. Kinematics of foraging dives and lunge-feeding in fin whales. The Journal of Experimental Biology 209:1231-1244.

Goldbogen, J.A., B.L. Southall, S.L. DeRuiter, J. Calambokidis, A.S. Friedlaender, E.L.Hazen, E.A. Falcone, G.S. Schorr, A. Douglas, D.J. Moretti, C. Kyburg, M.F. McKenna, and P.L.Tyack. 2013. Blue whales respond to simulated mid-frequency military sonar. Proc. R. Soc. London, B 280:0657.

Hall, J.D. and C.S. Johnson. 1972. Auditory thresholds of a killer whale *Orcinus orca* Linnaeus. Journal of the Acoustical Society of America 51:515-517.

Hamilton, T.A., J.V. Redfern, J. Barlow, L.T. Ballance, T. Gerrodette, R.S. Holt, K.A. Forney, and B.L. Taylor. 2009. Atlas of cetacean sightings for Southwest Fisheries Science Center cetacean and ecosystem surveys: 1986-2005. U.S. Dept. Comm., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-440. 70 pp

Hatch, L., C. Clark, R. Merrick, S. Van Parijs, D. Ponirakis, K. Schwehr, M. Thompson, and D. Wiley. 2008. Characterizing the relative contributions of large vessels to total ocean noise fields: A case study using the Gerry E. Studds Stellwagen Bank National Marine Sanctuary. Environmental Management 42:735-752.

Henderson, J.R. 1990. Recent entanglements of Hawaiian monk seals in marine debris. In R.S. Shomura and M.L.Godfrey (eds.), Proceedings of the Second International Conference on Marine Debris, April 2-7, 1989,Honolulu, HI p. 540-553. U.S. Dept. Comm., NOAA Tech. Memo., NMFS-SWFSC-154.

Heyning, J.E. and J.G. Mead. 1996. Suction feeding in beaked whales: Morphological and observational evidence. Contributions in Science, Natural History Museum of Los Angeles County 464:1-12.

Heyning, J.E. and J.G. Mead. 2009. Cuvier's beaked whale *Ziphius cavirostris*. Pages 294-295, in W.F. Perrin, B. Würsig, and H.G.M. Thewissen (eds.), Encyclopedia of Marine Mammals, Academic Press, San Diego, CA. 1316 pp.

Heyning, J.E., and W.F. Perrin. 1994. Evidence for two species of common dolphins (genus *Delphinus*) from the eastern north Pacific. Contributions in Science 442: 1-35.

Heimlich-Boran, J. R. 1988. Behavioral ecology of killer whales (*Orcinus orca*) in the Pacific Northwest. Canadian Journal of Zoology 66:565-578.

Henderson, J.R. 2001. A Pre- and Post- MARPOL Annex V Summary of Hawaiian monk seal entanglements and marine debris accumulation in the Northwestern Hawaiian Islands, 1982-1998. Marine Pollution Bulletin 42:584-589.

Hewitt, R. 2009. SWFSC interim guidelines for mitigating protected species interactions with fisheries survey gear. SWFSC Admin. Rep., La Jolla, LJ-09-07, 12 p.

Hildebrand J.A. 2005. Impacts of anthropogenic sound. Pages 101–123 in Reynolds III, J.E., W.F. Perrin, R.R. Reeves, S. Montgomery, and T.J. Ragen (eds.). Marine mammal research: conservation beyond crisis. Baltimore: Johns Hopkins University.

Hildebrand, J.A. 2009. Anthropogenic and natural sources of ambient noise in the ocean. Marine Ecology Progress Series 139:5-20.

Holt, M.M. 2008. Sound exposure and southern resident killer whales (*Orcinus orca*): A review of current knowledge and data gaps. U.S. Dept. Comm., NOAA Tech. Memo., NMFS-SWFSC-89. 59 pp.

Horwood, J. 2009. Sei whale *Balaenoptera borealis*. Pages 1001-1003 in W.F. Perrin, B. Würsig, and H.G.M. Thewissen (eds.), Encyclopedia of Marine Mammals, Academic Press, San Diego, CA. 1316 pp.

Houser, D.S., D.A. Helweg, and P.W.B Moore. 2001. A bandpass filter-bank model of auditory sensitivity in the humpback whale. Aquatic Mammals 27:82-91.

Jacob, J.M. 2012. Screening and characterization of morbillivirus in Hawaiian cetaceans. M.S. Marine Science Thesis. Hawai‘i Pacific University, Kaneohe, HI.

Jackson, A., T. Gerrodette, S. Chivers, M. Lynn, P. Olson, S. Rankin. 2004. Marine mammal data collected during a survey in the eastern tropical Pacific Ocean aboard the NOAA ships *McArthur II* and *David Starr Jordan* July 29 - December 10, 2003. NOAA TM- NMFS-SWFSC-366. 98 pp.

Jackson, A., T. Gerrodette, S. Chivers, M. Lynn, S. Rankin, and S. Mesnick. 2008. Marine mammal data collected during a survey in the Eastern Tropical Pacific Ocean aboard the NOAA ships *David Starr Jordan* and *MacArthur II*, July 28–December 7, 2006. NOAA Tech. Memo. TM-NMFS-SWFSC-421. 45pp.

Jefferson, T. A. 2009b. Rough-toothed dolphin *Steno bredanensis*. Pages 990-992 in W.F. Perrin, B. Würsig, and H.G.M. Thewissen (eds.), Encyclopedia of Marine Mammals, Academic Press, San Diego, CA. 1316 pp.

Jefferson, T.A., S. Leatherwood, and M.A. Webber. 1993. FAO species identification guide. Marine mammals of the world. Rome: Food and Agriculture Organization of the United Nations.

Jefferson, T.A., M.A. Webber, and R.L. Pitman. 2008. Marine mammals of the world: A comprehensive guide to their identification. Academic Press: San Diego, California.

Jensen, A.S. and G.K. Silber. 2003. Large whale ship strike database. U.S. Dept. Comm., NOAA Tech. Memo., NMFS-F/OPR-25. 37 pages.

Jérémie, S., A. Gannier, S. Bourreau, and J.-C. Nicolas. 2006. Acoustic monitoring of cetaceans in territorial waters off La Martinique (FWI), Lesser Antilles: Global abundance and first description of *Kogia simus* vocalisations (November-December 2004). Presented at the Abstracts, Twentieth Annual Conference of the European Cetacean Society, Gdynia, Poland

Johnston, D.W. 2002. The effect of acoustic harassment devices on harbour porpoises (*Phocoena phocoena*) in the Bay of Fundy, Canada. Biological Conservation 108, 113-118.

Johnston, D.W., J. Robbins, M.E. Chapla, D.K. Mattila, and K.R. Andrews. 2008. Diversity, habitat associations, and stock structure of odontocete cetaceans in the waters of American Samoa, 2003-2006. Journal of Cetacean Research and Management 10:59-66.

Karczmarski, L., B. Würsig and B. Winning. 1998. Socio-ecology and population biology of spinner dolphins *Stenella longirostris* in Midway Atoll, Northwest Hawaiian Chain, Central Pacific. Unpublished report to U.S. Fish and Wildlife Service and National Marine Fisheries Service. 41 pp.

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

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

Kastak, D., C. Reichmuth, M.M. Holt, J. Mulsow, B.L. Southall, and R.J. Schusterman. 2007. Onset, growth, and recovery of in-air temporary threshold shift in a California sea lion (*Zalophus californianus*). Journal of the Acoustical Society of America 122:2916-2924.

Kastelein, R.A., P. Bunskoek, M. Hagedoorn, W.L. Au, and D. Haan. 2002. Audiogram of a harbor porpoise (*Phocoena phocoena*) measured with narrow-band frequency-modulated signals. Journal of the Acoustical Society of America 112:334-344.

Kastelein, R.A., N. Jennings, W.C. Verboom, D. de Haan, and N.M. Schooneman. 2006. Differences in the response of a striped dolphin (*Stenella coeruleoalba*) and a harbour porpoise (*Phocoena phocoena*) to an acoustic alarm. Marine Environmental Research 61, 363–378.

Kastelein, R.A., H.T. Rippe, N. Vaughn, N.M. Schooneman, W.C. Verboom, and D. DeHaan. 2000. The effects of acoustic alarms on the behavior of harbor porpoises (*Phocoena phocoena*) in a floating pen. Marine Mammal Science 16:46–64.

Kastelein, R.A., W.C. Verboom, M. Muijsers, N.V. Jennings, and S. van der Heul. 2005. The influence of acoustic emissions for underwater data transmission on the behaviour of harbor porpoises (*Phocoena phocoena*) in a floating pen. Marine Environmental Research 59:287–307.

Kastelein, R.A., W.C. Verboom, N. Jennings, and D. de Haan. 2008a. Behavioral avoidance threshold level of a harbor porpoise (*Phocoena phocoena*) for a continuous 50 kHz pure tone. Journal of the Acoustical Society of America 123:1858-1861.

Kastelein, R.A., W.C. Verboom, N. Jennings, D. de Haan, S. van der Huel. 2008b. The influence of 70 and 120 kHz tonal signals on the behavior of harbor porpoises (*Phocoena phocoena*) in a floating pen. Marine Environmental Research 66:319-326.

Kato, H. and W.F. Perrin. 2009. Bryde's whales *Balaenoptera edeni/brydei*. Pages 158-163 in W.F. Perrin, B. Würsig, and H.G.M. Thewissen (eds.), Encyclopedia of Marine Mammals, Academic Press, San Diego, CA. 1316 pp.

Ketten, D.R. 1997. Structure and function in whale ears. Bioacoustics - International Journal of Animal Sound and its Recording 8:103-135.

Kinzey, D., T. Gerrodette, J. Barlow, A. Dizon, W. Perryman, P. Olson, and A. Von Saunder. 1999. Marine mammal data collected during a survey in the eastern tropical Pacific Ocean aboard the NOAA ships *McArthur* and *David Starr Jordan* and the UNOLS ship *Endeavor* July 31 - December 9, 1998. NOAA-TM-NMFS-SWFSC-283. 113 pp.

Kinzey, D., T. Gerrodette, J. Barlow, A. Dizon, W. Perryman, and P. Olson. 2000. Marine mammal data collected during a survey in the eastern tropical Pacific Ocean aboard the NOAA ships *McArthur* and *David Starr Jordan* July 28 - December 9, 1999. NOAA-TM- NMFS-SWFSC-293. 90 pp.

Kinzey, D., T. Gerrodette, A. Dizon, W. Perryman, P. Olson, and S. Rankin. 2001. Marine mammal data collected during a survey in the eastern tropical Pacific Ocean aboard the NOAA ships *McArthur* and *David Starr Jordan* July 28 - December 9, 2000. NOAA-TM- NMFS-SWFSC-303. 100 pp

Knowlton, A.R. and S.D. Kraus. 2001. Mortality and serious injury of northern right whales (*Eubalaena glacialis*) in the western North Atlantic Ocean. J. Cetacean Res. Manage. (Special Issue) 2:193-208.

Knowlton, A.R., F.T. Korsmeyer, J.E. Kerwin, H.Y. Wu and B. Hynes. 1995. The hydrodynamic effects of large vessels on right whales. Final Report to the National Marine Fisheries Service. Northeast Fisheries Science Center, Woods Hole, MA. Contract No. 40EANFF400534. 31p.

Kobayashi, D.R. and K.E. Kawamoto. 1995. Interaction with Northwestern Hawaiian Island bottomfishing activity: a comparison of two time periods and an estimate of economic impacts. Fisheries Res. 23: 11-22.

Krahn, M.M., M.J. Ford, W.F. Perrin, P.R. Wade, R.P. Angliss, M.B. Hanson, B.L. Taylor, G.M. Ylitalo, M.E. Dahlheim, J.E. Stein, and R.S. Waples. 2004. 2004 Status review of southern resident killer whales (*Orcinus orca*) under the Endangered Species Act. U.S. Dept. Comm., NOAA Tech. Memo., NMFS-NWFSC-62. 73 pages.

Laist, D.W., A.R. Knowlton, J.G. Mead, A.S. Collet, and M. Podesta. 2001. Collisions between ships and whales. Marine Mammal Science 17:35-75.

Leatherwood, S. and R. R. Reeves. 1986. Porpoises and dolphins. Pages 110-131, in D. Haley (ed.), Marine mammals of eastern North Pacific and Arctic waters. 2nd edition. Pacific Search Press, Seattle, WA. 295 pages.

Leatherwood, S., R.R. Reeves, W.F. Perrin and W.E. Evans. 1982. Whales, dolphins, and porpoises of the eastern North Pacific and adjacent Arctic Waters, a guide to their identification. U.S. Dept. Comm., NOAA Technical Report NMFS Circular 444.

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

Lurton, X., and S. DeRuiter. 2011. Sound radiation of seafloor-mapping echosounders in the water column, in relation to the risks posed to marine mammals. International Hydrographic Review, (November):7-17.

Martien, K.K. and R.W. Baird. 2009. A proposal for new stock boundaries for bottlenose dolphins in Hawaii. Document PSRG-13 presented to the Pacific Scientific Review Group, November 3-5, 2009. Available from Southwest Fisheries Science Center, National Marine Fisheries Service, 8604 La Jolla Shores Drive, La Jolla, CA 92037.

Matteson, R.S. 2009. The Costa Rica Dome: A study of physics, zooplankton, and blue whales. M.S. thesis submitted to Oregon State University. 36pp

Maldini, D., L. Mazzuca, and S. Atkinson. 2005. Odontocete stranding patterns in the Main Hawaiian Islands (1937-2002): How do they compare with live animal surveys? Pacific Science 59(1):55-67.

Mattila, D.K. and J. Robbins. 2008. Incidence of raised and depressed ovoid skin lesions on humpback whales of American Samoa. Paper SC/60/DW3 presented to the Scientific Committee of the International Whaling Commission, Santiago, Chile.

May-Collado, L., T. Gerrodette, J. Calambokidis, K. Rasmussen, and I. Sereg. 2005. Patterns of cetacean sighting distribution in the Pacific Exclusive Economic Zone of Costa Rica based on data collected from 1979-2001. Rev. Biol. Trop. 53(1-2): 249-263.

McAlpine, D.F. 2009. Pygmy and dwarf sperm whales *Kogia breviceps* and *K. sima*. Pages 936-938 in W.F. Perrin, B. Würsig, and H.G.M. Thewissen (eds.), Encyclopedia of Marine Mammals, Academic Press, San Diego, CA. 1316 pp.

McCracken, M. 2013. Preliminary assessment of incidental interactions with marine mammals in the Hawaiʻi longline deep and shallow set fisheries from 2007 to 2011. PIFSC Working Paper WP-13.

McSweeney, D.J., R.W. Baird and S.D. Mahaffy. 2007. Site fidelity, associations and movements of Cuvier's (*Ziphius cavirostris*) and Blainville's (*Mesoplodon densirostris*) beaked whales off the island of Hawaiʻi. Marine Mammal Science 23: 666-687.

MacLeod, C.D., and A. D'Amico. 2006. A review of beaked whale behaviour and ecology in relation to assessing and mitigating impacts of anthropogenic noise. Journal of Cetacean Research and Management 7: 211–221.

Mead, J.G. 1989. Beaked whales of the genus *Mesoplodon*. Pages 349-430 in S.H. Ridgway and R. Harrison (eds.), Handbook of Marine Mammals, Vol. 4: The River Dolphins and Larger Toothed Whales,. Academic Press, 442 pp.

Mesnick, S.L., B.L. Taylor, F.I. Archer, K.K. Martien, et al. 2011. Sperm whale population structure in the eastern and central North Pacific inferred by the use of single-nucleotide polymorphisms, microsatellites and mitochondrial DNA. Molecular Ecology Resources (2011) 11 (Suppl. 1): 278–298

Miller, P.J.O. 2006. Diversity in sound pressure levels and estimated active space of resident killer whale vocalizations. Journal of Comparative Physiology A 192:449-459.

Miyashita, T. 1993. Abundance of dolphin stocks in the western North Pacific taken by the Japanese drive fishery. Rep. Int. Whal. Commn. 43:417-437.

Mizroch, S. A., D. W. Rice, and J. M. Breiwick. 1984. The fin whale, Balaenoptera physalus. Marine Fishery Review 46:20-24.

Mobley Jr., J.R., S.S. Spitz, K.A. Forney, R.A. Grotefendt, and P.H. Forestall. 2000. Distribution and abundance of odontocete species in Hawaiian waters: preliminary results of 1993-98 aerial surveys Admin. Rep. LJ-00-14C. Southwest Fisheries Science Center, National Marine Fisheries Service, P.O. Box 271, La Jolla, CA 92038. 26 pages.

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

Morgan, L.E., and R. Chuenpagdee. 2003. Shifting gears addressing the collateral impacts of fishing methods in U.S. waters. PEW Science Series on conservation and the environment. 52 pp.

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

Nachtigall, P.E., A. Ya, Supin, J.L. Pawloski, and W.W.L. Au. 2004. Temporary threshold shifts after noise exposure in the bottlenose dolphin (*Tursiops truncatus*) measured using auditory evoked potentials. Marine Mammal Science 20:673-687.

NMFS Northeast Regional Office (NERO). 2004. Vessels to which operational measures apply. http://www.nero.noaa.gov/shipstrike/news/vesselsize_July_2004.pdf.

Nitta, E. 1991. The marine mammal stranding network for Hawaii: an overview. Pages 56-62 in J.E. Reynolds III, D.K. Odell (eds.), Marine Mammal Strandings in the United States. NOAA Tech. Rep. NMFS 98, 157 pages.

Nitta, E. and J.R. Henderson. 1993. A review of interactions between Hawaii's fisheries and protected species. Mar. Fish. Rev. 55:83-92.

National Marine Fisheries Service (NMFS). 2004. Federal Register 69:43338. Authorization for commercial fisheries under the Marine Mammal Protection Act of 1972: Zero Mortality Rate Goal. Available at: www.nmfs.noaa.gov/pr/pdfs/fr/fr69-43338.pdf.

NMFS. 2005. Revisions to Guidelines for Assessing Marine Mammal Stocks. 24 pp. Available at: http://www.nmfs.noaa.gov/pr/pdfs/sars/gamms2005.pdf

NMFS. 2008a – killer whale web page: http://www.nwfsc.noaa.gov/research/divisions/cbd/marine_mammal/marinemammal.cfm.

NMFS 2008b. Compliance guide for right whale ship strike reduction rule (50 CFR 224.105). http://www.nero.noaa.gov/shipstrike/doc/compliance_guide.pdf

NMFS. 2011. Final Recovery Plan for the Sei Whale (*Balaenoptera borealis*). NMFS, Office of Protected Resources, Silver Spring, MD. 108 pp.

National Oceanic and Atmospheric Administration (NOAA). 2015. Draft Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing, Underwater Acoustic Threshold Levels for Onset of Permanent and Temporary Threshold Shifts.

National Research Council (NRC). 1994. Low-Frequency Sound and Marine Mammals: Current Knowledge and Research Needs. Washington, D.C.: National Academy Press.

NRC (National Research Council). 2000. Marine mammals and low-frequency sound. National Academy Press, Washington, DC.

NRC. 2003. Ocean Noise and Marine Mammals. National Academy Press, Washington, DC.

NRC. 2005. Marine mammal populations and ocean noise: Determining when noise causes biologically significant effects. National Academy Press, Washington, DC.

Nowacek, D.P., L.H. Thorne, D.W. Johnston, and P.L. Tyack. 2007. Responses of cetaceans to anthropogenic noise. Mammal Review 37:81-115.

Oleson, E.M. 2009. Assessment of American Samoa longline fishery and estimates of cetacean bycatch, 2006-2008. NMFS, PIFSC Working Paper WP-09-006, 12p.

Oleson, E.M., J. Barlow, J. Gordon, S. Rankin, and J.A. Hildebrand. 2003. Low frequency calls of Bryde’s whales. Marine Mammal Science 19:407-419.

Oleson, E.M., C.H. Boggs, K.A. Forney, M.B. Hanson, D.R. Kobayashi, B.L. Taylor, P.R. Wade, and G.M. Ylitalo. 2010. Status Review of Hawaiian Insular False Killer Whales (*Pseudorca crassidens*) under the Endangered Species Act. U.S Dept. Comm., NOAA Tech. Memo., NOAA-TM-NMFS-PIFSC-22. 140 pages.

Olson, P.A. 2009. Pilot whales *Globicephala melas* and *G. macrorhynchus*. Pages 847-852 in W.F. Perrin, B. Würsig, and H.G.M. Thewissen (eds.), Encyclopedia of Marine Mammals, Academic Press, San Diego, CA. 1316 pages.

Olson, P.A. and T. Gerrodette. 2008. Killer whales of the eastern tropical Pacific: A catalog of photo-identified individuals. U.S Dept. Comm., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-428. 120 pages.

Osborne, R., J. Calambokidis, and E.M. Dorsey. 1988. A guide to marine mammals of greater Puget Sound. Island Publishers, Anacortes, WA. 191 pp.

Pace, R.M. and G. Silber. 2005. Simple analyses of ship and large whale collisions: does speed kill? Poster. Sixteenth Biennial Conference on the Biology of Marine Mammals, San Diego, December 2005.

Parks, S., D.R. Ketten, J.T. O'Malley, and J. Arruda. 2007. Anatomical Predictions of Hearing in the North Atlantic Right Whale. The Anatomical Record 290:734-744.

Parrish, F.A., M.P. Craig, T.J. Ragen, G.J. Marshall, and B.M. Buhleier. 2000. Identifying diurnal foraging habitat of endangered Hawaiian monk seal using a seal-mounted video camera. Marine Mammal Science 16, 392–412.

Perrin, W.F., B. Würsig, and J.G.M. Thewissen. 2009. Encyclopedia of Marine Mammals. Second Edition. Academic Press, San Diego, CA. 1316 pp.

Perrin, W.F. and R.L. Brownell, Jr. 2009. Minke whales *Balaenoptera acutorostrata* and *B. bonaerensis*. Pages 733-735 in W.F. Perrin, B. Würsig, and H.G.M. Thewissen (eds.), Encyclopedia of Marine Mammals, Academic Press, San Diego, CA. 1316 pp.

Perrin, W.F., K.M. Robertson, and W.A. Walker. 2008. Diet of the striped dolphin, Stenella coeruleoalba, in the Eastern Tropical Pacific Ocean. U.S Dept. Comm., NOAA Tech. Memo., NOAA-TM-NMFS-SWFSC-418. 30 pages.

Perrin, W.F, B. Wursig, and J.G.M. Thewissen. 2008. Encyclopedia of Marine Mammals. Academic Press, San Diego, CA. 1316 pp.

Perry, S.L., D.P. DeMaster, and G.K. Silber. 1999. The great whales: History and status of six species listed as endangered under the U.S. Endangered Species Act of 1973. Marine Fisheries Review 61:1-74.

Perryman, W.L. 2009. Melon-headed whale *Peponocephala electra*. Pages 719-721 in W.F. Perrin, B. Würsig, and H.G.M. Thewissen (eds.), Encyclopedia of Marine Mammals, Academic Press, San Diego, CA. 1316 pp.

Pitman, R. 2009. Mesoplodont beaked whales (*Mesoplodon* spp.). Pages 721-726 in W.F. Perrin, B. Würsig, and H.G.M. Thewissen (eds.), Encyclopedia of Marine Mammals, Academic Press, San Diego, CA. 1316 pp.

Pitman, R., H. Fearnbach, R. LeDuc, J.W. Gilpatrick, Jr., and J.K.B. Ford. 2007. Killer whales preying on a blue whale calf on the Costa Rica Dome: genetics, morphometrics, vocalisations and composition of the group. Journal of Cetacean Research and. Management 9:151-157.

Pitman, R. and M.S. Lynn. 2001. Biological observations of an unidentified *Mesoplodont* whale in the eastern tropical Pacific and probable identity: *Mesoplodon peruvianus*. Marine Mammal Science 17: 648-657.

Popper, A. and M. Hastings. 2009. The effects of human-generated sound on fish. Integrative Zoology 4:43-52.

Pryor, T., K. Pryor, and K.S. Norris. 1965. Observations on a pygmy killer whale (*Feresa attenuata* Gray) from Hawaii. J. Mamm. 46:450-461.

Rasmussen, K., J. Calambokidis, and G.H. Steiger. 2004. Humpback whales and other marine mammals off Costa Rica and surrounding waters, 1996-2003. Report of the Oceanic Society 2003 field season in cooperation with Elderhostel volunteers. April 2004. 24 pp.

Rasmussen, K., D.M. Palacios, J. Calambokidis, M.T. Saborıo, L. Dalla Rosa, E.R. Secchi, G.H. Steiger, J.M. Allen, and G.S. Stone. 2007. Southern Hemisphere humpback whales wintering off Central America: insights from water temperature into the longest mammalian migration. Biol. Lett. doi:10.1098/rsbl.2007.0067

Reeves, R.R., P.J. Clapham, R.L. Brownell, Jr., and G.K. Silber. 1998. Recovery plan for the blue whale (*Balaenoptera musculus*). Office of Protected Resources, NMFS, NOAA, Silver Spring, Maryland. 30 pp.

Reilly, S.B., P.C. Fiedler, T. Gerrodette, L.T. Ballance, R.L. Pitman, J.M. Borberg, and R.C. Holland. 2002. Eastern tropical Pacific dolphin habitats – Interannual variability 1986–2000. SWFSC Administrative Report LJ-02-21. Available from: Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, CA 92037, and at http://swfsc.nmfs.noaa.gov/IDCPA/TunaDol_rep/

Reilly, S., S. Hedley, J. Borberg, R. Hewitt, D. Thiele, J. Watkins, and M. Naganobu. 2004. Biomass and energy transfer to baleen whales in the South Atlantic sector of the Southern Ocean. Deep-Sea Research II 51:1397–1409.

Reilly, S.B. and V.G. Thayer. 1990. Blue whale (*Balaenoptera musculus*) distribution in the eastern tropical Pacific. Marine Mammal Science 6:265-277.

Reynolds III, J.E. and S.A. Rommel. 1999. Biology of marine mammals. Smithsonian Institute Press. Washington, D.C.

Rice, D.W. 1998. Marine mammals of the world: systematics and distribution. Special Publication 4. The Society for Marine Mammalogy, Lawrence, KS, USA.

Richardson, W.J., C.R.J. Green, C.I. Malme, and D.H. Thomson. 1995. Marine Mammals and Noise. San Diego, CA, Academic Press.

Romano, T.A., M.J. Keogh, C. Kelly, P. Feng, L. Berk, C.E. Schlundt, D.A. Carder, and J.J. Finneran. 2004. Anthropogenic sound and marine mammal health: Measures of the nervous and immune systems before and after intense sound exposure. Canadian Journal of Fisheries and Aquatic Sciences 61:1124-1134.

Santora, J.A., M.P. Force., K. Ampela, and A. Van Cise. 2009. Distribution, abundance and behavior of seabirds and marine mammals at sea. Pages 44-48 in A.M. Van Cise (ed.), AMLR 2008/2009 report: Objectives, accomplishments, and tentative conclusions. U.S. Dept. Comm., NOAA Tech. Memo., NMFS-SWFSC-445.

Martin-Scheel D., Slater G.J., Kolokotronis S-O, Potter C.W., Rotstein D.S., Tsangaras K., Greenwood A.D., Helgen K.M. 2014. Biogeography and taxonomy of extinct and endangered monk seals illuminated by ancient DNA and skull morphology. ZooKeys 409: 1–33. doi: 10.3897/zookeys.409.6244

Schlundt, C.E., J.J. Finneran, D.A. Carder, and S.H. Ridgway. 2000. Temporary shift in masked hearing thresholds of bottlenose dolphins, *Tursiops truncatus*, and white whales, *Delphinapterus leucas*, after exposure to intense tones. Journal of the Acoustical Society of America 107:3496-3508.

Schlundt, C.E., R.L. Dear, D.A. Carder, and J.J. Finneran. 2006. Growth and recovery of temporary threshold shifts in a dolphin exposed to midfrequency tones with durations up to 128 s. Journal of the Acoustical Society of America 120:3227.

Schultz, J.K., J.D. Baker, R.J. Toonen, and B.W. Bowen. 2009. Extremely Low Genetic Diversity in the Endangered Hawaiian Monk Seal (*Monachus schauinslandi*). Journal of Heredity 100 (1): 25-33.

Schusterman, R.J., D. Kastak, D.H. Levenson, C.J. Reichmuth, and B.L. Southall. 2000. Why pinnipeds don't echolocate. Journal of the Acoustical Society of America, 107:2256-2264.

Scott, M.D., A.A. Hohn, A.J. Westgate, J.R. Nicolas, B.R. Whitaker, and W.B. Campbell. 2001. A note on the release and tracking of a rehabilitated pygmy sperm whale (*Kogia breviceps*). Journal of Cetacean Research and Management 3:87-94.

Seagars, D.J. and J.R. Henderson. 1985. Cephalopod remains from the stomach of a short-finned pilot whale collected near Santa Catalina Island. Journal of Mammalogy 66(4):777-779.

Sears, R. and W.F. Perrin. 2009. Blue whale *Balaenoptera musculus*. Pages 120-124, in W.F. Perrin, B. Würsig, and H.G.M. Thewissen (eds.), Encyclopedia of Marine Mammals, Academic Press, San Diego, CA. 1316 pp.

Sekiguchi, K., C. Olavarria, L. Morse, P. Olson, P. Ensor, K. Matsuoka, R. Pitman, and K. Findlay. 2006. The spectacled porpoise *Phocoena dioptrica* in Antarctic waters. Journal of Cetacean Research and Management 8:265-271.

Shallenberger, E.W. 1981. The status of Hawaiian cetaceans. Final report to U.S. Marine Mammal Commission. MMC-77/23. 79 pages.

Sherman, K. and Hempel, G. (eds.) 2009. The UNEP Large Marine Ecosystem Report: A perspective on changing conditions in LMEs of the world's Regional Seas. UNEP Regional Seas Report and Studies No. 182. United Nations Environment Programme. Nairobi, Kenya.

Silber, G.K., S. Bettridge, and D. Cottingham. 2009. Report of a workshop to identify and assess technologies to reduce ship strikes of large whales, 8-10 July, 2008,Providence, Rhode Island. U.S. Dept. Comm., NOAA Tech. Memo. NMFS-OPR-42. 55 pp. Available online at: http://www.nmfs.noaa.gov/pr

South Pacific Whale Research Consortium. 2008. Report of the Annual Meeting of the South Pacific Whale Research Consortium, Auckland, 5-8 February 2008. South Pacific Whale Research Consortium, P.O. Box 3069, Avarua, Rarotonga, Cook Islands. 36 pp.

Southall, B.L., T. Rowles, F. Gulland, R.W. Baird, and P.D. Jepson. 2013. Final report of the Independent Scientific Review Panel investigating potential contributing factors to a 2008 mass stranding of melon-headed whales (*Peponocephala electra*) in Antsohihy, Madagascar

Southall, B.L., A.E. Bowles, W.T. Ellison, J.J. Finneran, R.L. Gentry, C.R. Greene Jr., D. Kastak, D.R. Ketten, J.H. Miller, P.E. Nachtigall, W.J. Richardson, J.A. Thomas, and P.L. Tyack. 2007. Marine mammal noise exposure criteria: Initial scientific recommendations. Aquatic Mammals 33:411-521.

Southall, B.L., R. Braun, F.M.D. Gulland, A.D. Heard, R.W. Baird, S.M. Wilkin, and T.K. Rowles. 2006. Hawaiian melonheaded whale (*Peponocephala electra*) mass stranding event of July 3-4, 2004. U.S. Dept. Comm., NOAA Tech. Memo., NMFS-OPR-31. 73 pp.

Sprague, R., C. Littnan, and J. Walters. 2013. Estimation of Hawaiian monk seal consumption in relation to ecosystem biomass and overlap with fisheries in the main Hawaiian Islands. U.S. Dept. Comm., NOAA Tech. Memo., NOAA-TM-NMFS-PIFSC-37, 42 p.

Stafford, K.M. 2003. Two types of blue whale calls recorded in the Gulf of Alaska. Marine Mammal Science.

Stafford, K.M., S.L. Nieukirk, and C.G. Fox. 2001. Geographic and seasonal variation of blue whale calls in the North Pacific. Journal Cetacean Research and Management. 3:65-76. 19(4):682-693.

Stafford, K.M., S.L. Nieukirk, and C.G. Fox. 1999. An acoustic link between blue whales in the Eastern Tropical Pacific and the Northeast Pacific. Marine Mammal Science 15:1258-1268.

Stevenson, D., L. Chiarella, D. Stephan, R. Reid, K. Wilhem, J. McCarthy, and M. Pentony. 2004. Characterization of the fishing practices and marine benthic ecosystems of the Northeast U.S. Shelf, and an evaluation of the potential effects of fishing on essential fish habitat. U.S. Dept. Comm., NOAA Tech. Memo., NMFS-NE-181.

Szymanski, M.D., D.E. Bain, K. Kiehl, S. Pennington, S. Wong, and K.R. Henry. 1999. Killer whale (*Orcinus orca*) hearing: Auditory brainstem response and behavioral audiograms. Journal of the Acoustical Society of America 106:1134-1141.

Thompson, P.O. and W.A. Friedl. 1982. A long term study of low frequency sound from several species of whales off Oahu, Hawaii. Cetology 45:1-19.

Tyack, P.L., M.P. Johnson, M.A. de Soto, A. Sturlese, and P.T. Madsen. 2006. Extreme diving of beaked whales. Journal of Experimental Biology 209:4238-4253.

Tyne J.A., K.H. Pollock, D.W. Johnston, and L. Bejder. 2014. Abundance and Survival Rates of the Hawai'i Island Associated Spinner Dolphin (*Stenella longirostris*) Stock. PLoS ONE 9(1): e86132. oi:10.1371/journal.pone.0086132.

Van Bressem, M., J.A. Raga, G. Di Guardo, D.P. Jepson, P. J. Duignan, U. Siebert, T. Barrett, M.C. de Oliveira Santos, I.B. Moreno, S. Siciliano, A. Aguilar, and K. Van Waerebeer. 2009. Emerging infectious diseases in cetaceans worldwide and the possible role of environmental stressors. Diseases of Aquatic Organisms. 85:143-157.

Vanderlaan, A.S.M. and C.T. Taggart. 2007. Vessel collisions with whales: The probability of lethal injury based on vessel speed. Marine Mammal Science 23:144-156.

Wade, P.R. and T. Gerrodette. 1993. Estimates of cetacean abundance and distribution in the Eastern Tropical Pacific. Reports of the International Whaling Commission 43:477-494.

Wang, J.Y., and S.-C. Yang. 2006. Unusual cetacean stranding events in Chinese waters in early 2004 and 2005. J. Cetacean Res. and Manag. 8:283-292.

Wartzok, D., A.N. Popper, J. Gordon, and J. Merrill. 2004. Factors affecting the responses of marine mammals to acoustic disturbance. Marine Technology Society Journal 37:4-13.

Wartzok, D., and D.R. Ketten. 1999. Marine mammal sensory systems. Pages 117-175 in J.E. Reynolds III and S.A. Rommel (eds.), Biology of Marine Mammals. Washington, D.C.: Smithsonian Institution Press.

Walker, W.A., J.G. Mead, and R.L. Brownell. 2002. Diets of Baird's beaked whales *Berardius bairdii*, in the southern Sea of Okhotsk and off the Pacific Coast of Honshu, Japan. Marine Mammal Science 18:902-919.

Waring, G.T., E. Josephson, C.P. Fairfield, and K. Maze-Foley. 2009. U.S. Atlantic and Gulf of Mexico marine mammal stock assessments - 2008. U.S. Dept. Comm., NOAA Tech. Memo., NMFS-NE-210, 429 pp.

Waring, G.T., E. Josephson, K. Maze-Foley, and P.E. Rosel. 2011. U.S. Atlantic and Gulf of Mexico marine mammal stock assessments - 2011. draft U.S. Dept. Comm., NOAA Tech. Memo., NMFS-NE, 325 pp

Watkins, W.A. 1986. Whale reactions to human activities in Cape Cod waters. Marine Mammal Science 2:251-262.

Watkins, W.A., M.A. Daher, N.A. DiMarzio, A. Samuels, D. Wartzok, K.M. Fristrup, P.W. Howey, and R.R. Maiefski. 2002. Sperm whale dives tracked by radio tag telemetry. Marine Mammal Science 18:55-68.

Wartzok, D., and D.R. Ketten. 1999. Marine mammal sensory systems. Pages 117-175 in Reynolds III, J.E. and S.A. Rommel (eds.), Biology of Marine Mammals. Smithsonian Institution Press, Washington, D.C.

Weilgart, L.S. 2007. The impacts of anthropogenic ocean noise on cetaceans and implications for management. Canadian Journal of Zoology 85:1091-1116.

Wells, R.S. and M.D. Scott 2009. Common bottlenose dolphin *Tursiops truncatus*. Pages 249-255, in W.F. Perrin, B. Würsig, and H.G.M. Thewissen (eds.), Encyclopedia of Marine Mammals, Academic Press, San Diego, CA. 1316 pp.

West, K.L, S. Sanchez, D. Rothstein, K.M. Robertson, S. Dennison, G. Levine, N. Davis, D. Schoffield, C.W. Potter, and B. Jensen. 2012. A Longman's beaked whale (*Indopacetus pacificus*) strands in Maui, Hawaii, with the first case of morbillivirus in the central Pacific. Marine Mammal Science. 29(4): 767-776.

Whitehead, H. 2002. Estimates of the current global population size and historical trajectory for sperm whales. Marine Ecology Progress Series 242:295-304.

Whitehead, H. 2009. Sperm whale *Physeter macrocephalus*. Pages 1093-1097 in W.F. Perrin, B. Würsig, and H.G.M. Thewissen (eds.), Encyclopedia of Marine Mammals, Academic Press, San Diego, CA. 1316 pp.

Whitehead, H., A. Coakes, N. Jaquet, and S. Lusseau. 2008. Movements of sperm whales in the tropical Pacific. Marine Ecology Progress Series 361:291– 300.

Williams, A.J., K. Loeun, S.J. Nicol, P. Chavance, M. DucrocQ, S.J. Harley, G.M. Pilling, V. Allain, C. Mellin, and C.J.A. Bradshaw. 2013. Population biology and vulnerability to fishing of deep-water Eteline snappers. Journal of Applied Ichthyology 29:395-403.

Williams, R. and P. O'Hara. 2009. Modelling ship strike risk to fin, humpback, and killer whales in British Columbia, Canada. J. Cetacean Res. Manage. On line PDF

Würsig, B., and W.J. Richardson. 2009. Noise, effects of. Pages 765-773 in W.F. Perrin, B. Würsig, and H.G.M. Thewissen (eds.), Encyclopedia of Marine Mammals, Academic Press, San Diego, CA. 1316 pp.

Zollett, E.A. 2009. Bycatch of protected species and other species of concern in US east coast commercial fisheries. Endangered Species Research 9: 49-59. Supplement 1 (Tables) is available at: www.int-res.com/articles/suppl/n009p049_app.pdf

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APPENDIX A

PIFSC Research Gear And Vessel Descriptions

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1. Trawl Nets

A trawl is a funnel-shaped net towed behind a boat to capture fish. The codend, or 'bag,' is the fine-meshed portion of the net most distant from the towing vessel where fish and other organisms larger than the mesh size are retained. In contrast to commercial fishery operations, which generally use larger mesh to capture marketable fish, research trawls often use smaller mesh to enable estimates of the size and age distributions of fish in a particular area. The body of a trawl net is generally constructed of relatively coarse mesh that functions to gather schooling fish so that they can be collected in the codend. The opening of the net, called the 'mouth', is extended horizontally by large panels of wide mesh called 'wings' (Figure A-1). The mouth of the net is held open by hydrodynamic force exerted on the trawl doors attached to the wings of the net. As the net is towed through the water, the force of the water spreads the trawl doors horizontally apart.

The trawl net is usually deployed over the stern of the vessel, and attached with two cables, or 'warps,' to winches on the deck of the vessel. The cables are played out until the net reaches the fishing depth. Commercial trawl vessels travel at speeds between two and five knots while towing the net for time periods up to several hours. The duration of the tow depends on the purpose of the trawl, the catch rate, and the target species. At the end of the tow the net is retrieved and the contents of the codend are emptied onto the deck. For research purposes, the speed and duration of the tow and the characteristics of the net must be standardized to allow meaningful comparisons of data collected at different times and locations. Active acoustic devices incorporated into the research vessel and the trawl gear monitor the position and status of the net, speed of the tow, and other variables important to the research design.

Most PIFSC research trawling activities utilize 'pelagic' trawls, which are designed to operate at various depths within the water column. Because pelagic trawl nets are not designed to contact the seafloor, they do not have bobbins or roller gear, which are often used to protect the foot rope of a 'bottom' trawl net as it is dragged along the bottom.

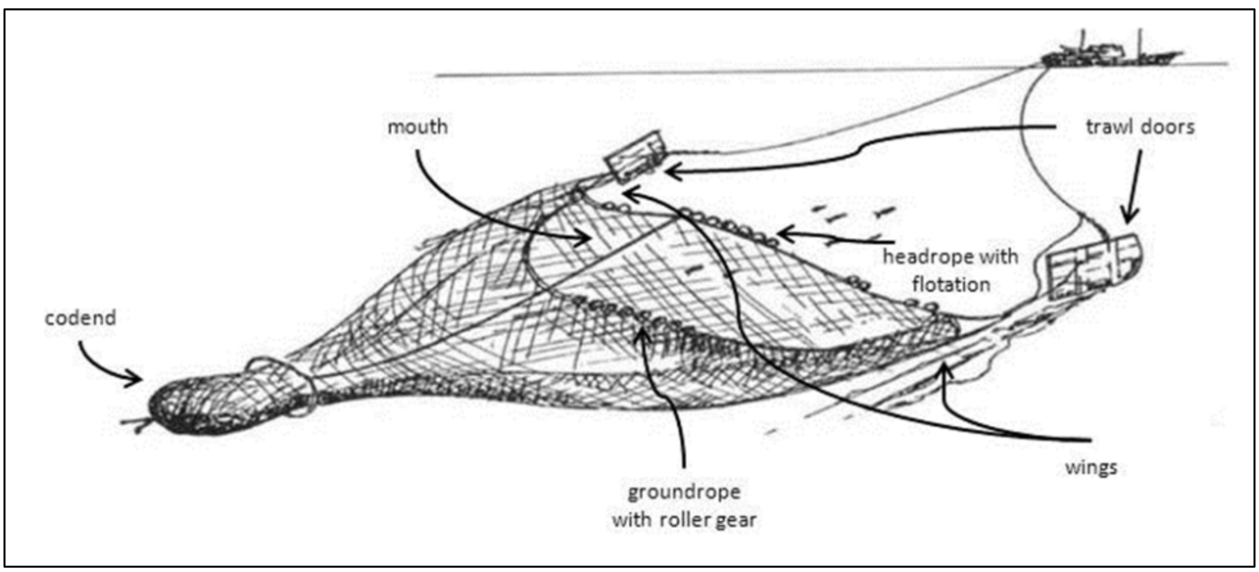


Figure A-1 General schematic of a trawl net

Cobb Trawl: The PIFSC uses a "Stauffer" modified Cobb midwater trawl (Cobb trawl) to sample pelagic species as well as pelagic stages of insular fish species in the Hawaiian Archipelago. Target species are snapper and, grouper species within the 0-175 m depth range. Sampling of pelagic species is conducted using a Cobb trawl with a mouth opening of about 686 m^2 (Figure A-2). For the codend, a 1 m diameter stainless steel ring and 1mm Nitex mesh plankton net is sewn to the rear-most portion of the outer net body near where the inner liner terminates. The plankton net terminates into a zipper-attached ~10 liter capacity canvas bag which serves as the codend and holds the catch contents of the trawl.

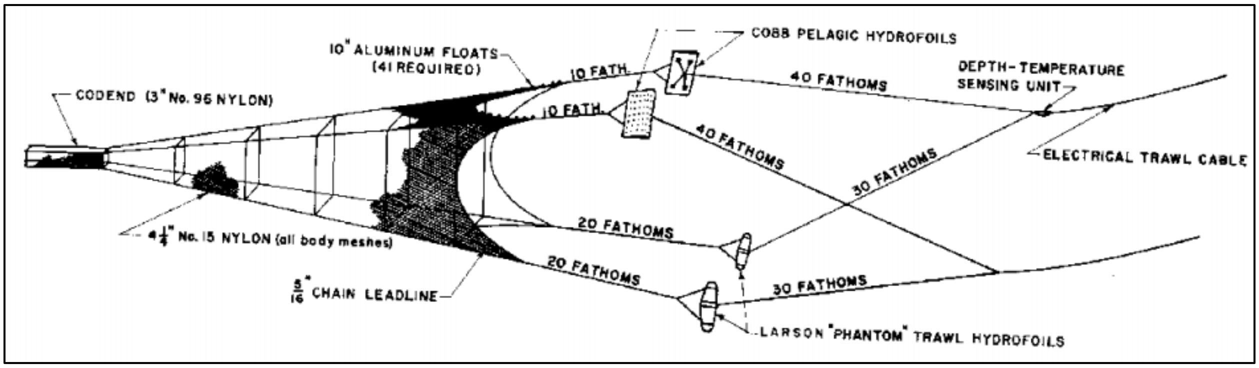


Figure A-2 Cobb trawl

2. Plankton Nets

PIFSC research activities include the use of plankton sampling nets that employ very fine mesh to sample plankton and fish eggs from various parts of the water column. Plankton net mesh sizes generally range from 20 to 500 micrometers. Plankton sampling nets usually consist of fine mesh attached to a rigid frame. The frame spreads the mouth of the net to cover a known surface area. Many plankton nets have a removable collection container at the codend where the sample is concentrated. When the net is retrieved, the collecting bucket can be detached and easily transported to a laboratory. Plankton nets may be towed through the water horizontally, vertically, or at an oblique angle. Often, plankton nets are equipped with instruments such as flow meters or pitch sensors to provide researchers with additional information about the tow or to ensure plankton nets are deployed consistently.

Isaacs-Kidd Trawl: The Isaacs-Kidd trawl is used to collect midwater or surface biological specimens larger than those taken by standard plankton nets. The net is attached to a wide, V-shaped, rigid diving vane that keeps the mouth of the net open and maintains the net at depth for extended periods (Yasook et al. 2007) (Figure A-3). The Isaacs-Kidd trawl is a long, round net approximately 6.5 m (21.3 ft) long, with a series of hoops decreasing in size from the mouth of the net to the codend, which maintain the shape of the net during towing (Yasook et al. 2007). The PIFSC uses two sizes of Isaacs-Kidd trawls for various research purposes, a 6-ft wide model and a 10-ft wide model. These nets may be towed either at the surface of the water or at various midwater depths depending on research protocols or where acoustic signals indicate the presence of study organisms.

Figure A-3 Isaacs-Kidd 6-ft trawl

<u>Neuston Net</u>: Neuston nets are used to collect zooplankton that live in the top few centimeters of the sea surface (the neuston layer). This specialized net has a rectangular mouth opening usually 2 or 3 times as wide as deep (e.g., 1 meter by 1/2 meter, or 60 cm by 20 cm) (Figure A-4). Neuston nets sometimes use hollow piping for construction of the net frame to aid in flotation. They are generally towed half submerged at 1-2 knots from the side of the vessel on a boom to avoid the ship's wake.

Figure A-4 Neuston net

Bongo Net: A bongo net looks like two ring nets whose frames are yoked together and allows replicate samples to be collected concurrently (Figure A-5). Bongo nets are towed through the water to sample plankton over a range of depths. During each plankton tow, the bongo net is deployed to the desired depth and is then retrieved at a controlled rate so that the volume of water sampled is uniform across the range of depths. In shallow areas, sampling protocol is adjusted to prevent contact between the bongo nets and the seafloor. A collecting bucket, attached to the codend of the net, is used to contain the plankton sample. Some bongo nets can be opened and closed with remote control to enable the collection of samples from particular depth ranges. A group of depth-specific bongo net samples can be used to establish the vertical distribution of zooplankton species in the water column at a site.

Credit: Morgan Busby, Alaska Fisheries Science Center

Figure A-5 Bongo net

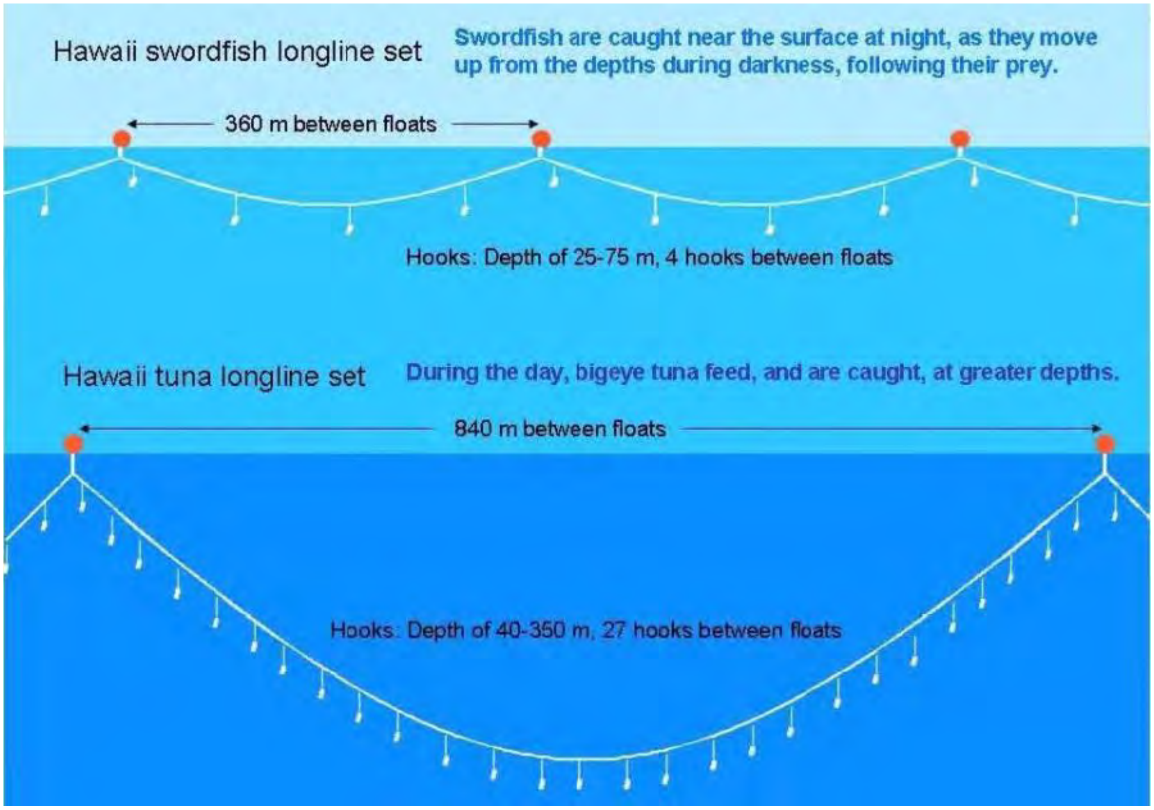
Plankton Drop Net: Plankton drop nets are small hand held nets made up of fine mesh attached to a metal hoop with a long rope attached for retrieval (Figure A-6). These nets are used for stationary surface sampling of the surrounding water.

Figure A-6 Plankton drop net

<u>One Meter Ring Net</u>: A ring net is generic plankton net, made by attaching a net of any mesh size to a metal ring of any diameter. There are 1 m, .75 meter, .25 meter and .5 meter nets that are used regularly. The most common zooplankton ring net is 1 meter in diameter and of mesh size .333mm, also known as a 'meter net'

3. Longline

Longline vessels fish with baited hooks attached to a mainline or 'groundline'. The length of the longline and the number of hooks depend on the species targeted, the size of the vessel, and the purpose of the fishing activity. The PIFSC uses pelagic longline gear deployed at various depths to target different species and to avoid non-target species. Deep-set gear is deployed at depths greater than 100 m and is used to target tunas, e.g., bigeye tuna. Shallow-set gear is deployed at depths less than 100 m and is used to target swordfish. Both types of gear are used to test bycatch mitigation technology to reduce interaction and mortality of marine mammals, seabirds, and sea turtles in pelagic longline fisheries. The longline gear used by the PIFSC for research typically has 600 to 2000 hooks attached to a mainline of up to 60 miles in length. Hooks are attached to the mainline by another thinner line called a 'branchline'. The length of the branchline and the distance between branchlines depends on the purpose of the fishing activity. Buoys are used to keep pelagic longline gear suspended near the surface of the water, and flag buoys (or 'high flyers') equipped with radar reflectors, radio transmitters, and/or flashing lights are attached to each end of the mainline to enable the crew to find the line for retrieval (Figure A-7).



Credit: USFWS 2012

Figure A-7 Schematic example of shallow-set and deep-set pelagic longline gear

4. Trolling

Trolling is a type of hook-and-line fishing method where multiple lines are towed behind a boat to catch species such as salmon, mahi mahi and albacore tuna (Figure A-8). Gear used by the PIFSC have four troll lines each with 1-2 baited hooks towed at 4-6 knots.

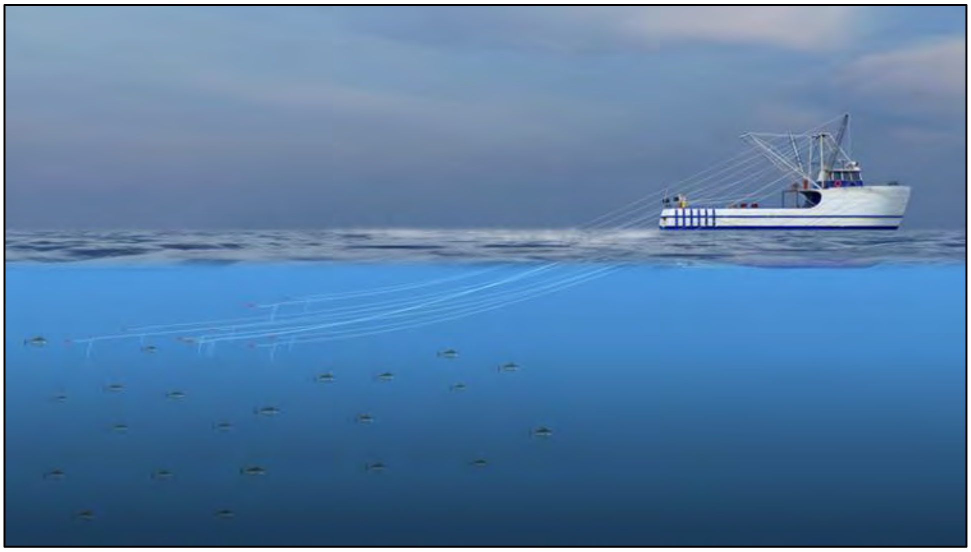


**Figure A-8	Trolling**

5. Hook-and-Line

The PIFSC uses various types of hook-and-line gear that include standard handlines, rods and reels with lures or bait, as well as electric or hydraulic reels (Figures A-9) with multiple lines and hooks. These set-ups may be used while stationary or mobile. The gear used in PIFSC bottomfish surveys consists of a main line constructed of dacron or monofilament with a 2–4 kg weight attached to the end (Figure A-10). Several 40–60 cm sidelines with circle hooks are attached above the weight at 0.5–1 m intervals. A chum bag containing chopped fish or squid may be suspended above the highest of these hooks. The gear is retrieved using hydraulic or electric reels after several fish are hooked.

**Figure A-9	Example of an electric reel used for bottomfishing**

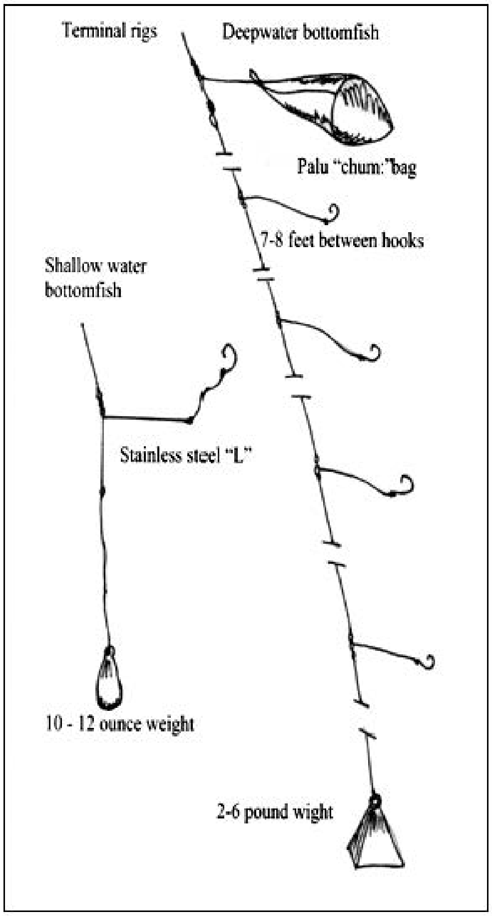


Figure A-10 Typical set-up for bottomfishing hook-and-line gear

6. Lobster Traps

Lobster traps are deployed in the Northwestern Hawaiian Islands to study the life history and population dynamics of lobster. The lobster traps consist of one string per site, with 8 or 20 traps per string, separated by 20 fathoms of ground line (Figure A-11). The traps are deployed within two separate depth regimes: 10-20 or 21-35 fathoms.

Figure A-11 Lobster traps being deployed

7. Miscellaneous Fishing Gear

Spear Gun: Spear guns are used by scuba divers to collect specimens for ecosystem surveys. There are two different types of spear guns, band powered and air powered. The band powered gun consists of a spear a stock and a handle with a trigger (Figure A-12). The air powered gun holds the spear inside of the barrel that contains air which is at ambient pressure until activated by a hand pump that increases the pressure.

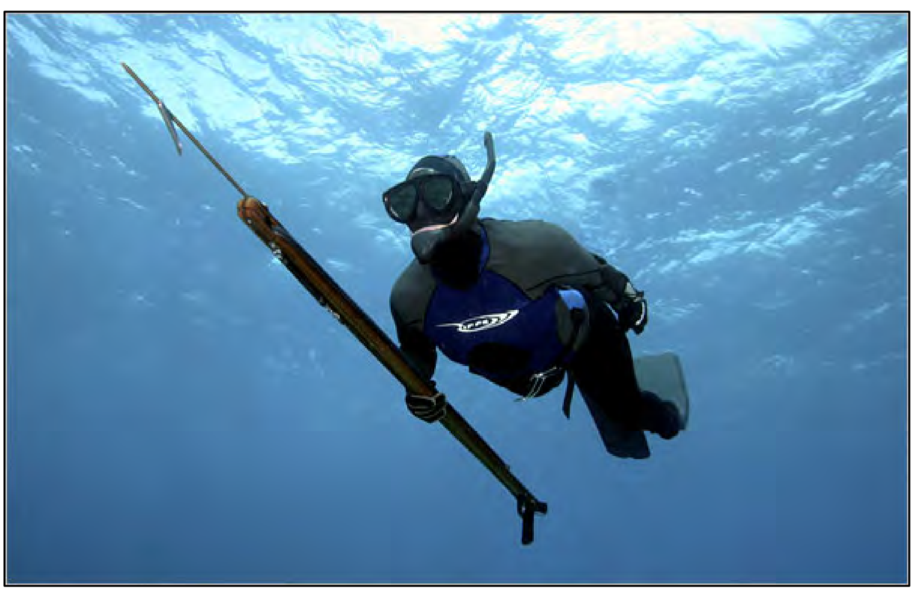


Figure A-12 SCUBA diver with band powered spear gun

<u>Slurp Gun</u>: Slurp guns are clear plastic tubes designed to catch small fish by sliding a plunger backwards out of the tube (Figure A-13). The plunging action causes seawater, and hopefully the fish you are trying to catch, to be sucked into the tube via displacement. The diver caps the tube or covers it with a dip net and places the fish into a containment device (net bag, plastic bucket with holes, etc.).

Figure A-13 Slurp gun

<u>Hand Net</u>: A mesh bag attached to a hoop that is constructed of wood or metal. A hand net is used during the Pacific Reef Assessment and Monitoring Program to collect samples of coral, algae, and sessile invertebrates. During the PIFSC Lagoon Ecosystem Characterization a 12-in diameter small mesh hand net is also used to sample fish species.

<u>Dip Net</u>: A dip net is a bag net attached to a long rod that is used by hand to scoop fish or other organisms of interest from the water (Figure A-14). Dip nets come in various sizes, including a commonly utilized dip net with a diameter of 19 in and ¼ in mesh size.

Figure A-14 Dip net

<u>Barbless Circle Hooks</u>: The PIFSC began a barbless hook awareness program in 2004 in order to increase awareness about the benefits of reducing injury and mortality of non-target species using barbless hooks over barbed hooks. Figure A-15 shows a series of different sized circle hooks that are used in different fisheries, all of which have depressed barbs (barbless) except the top middle hook. On the top row, left to right, are size Mustad 20, 18, and 16. The bottom row, left to right, has hooks size Mustad 12 and 11. The PIFSC donations of barbless circle hooks are made primarily at shore-based fishing tournaments or other outreach events. Under this program the PIFSC donates up to 35,000 barbless hooks per year.

Figure A-15 Circle hooks of various sizes: all but the top center hook have depressed barbs

8. Reef Monitoring Devices

Pneumatic/Hydraulic drill for coral coring: The PIFSC uses two different types of drills to obtain core samples: pneumatic and hydraulic drills. The pneumatic drill is powered by air and is smaller and hand held (Figure A-16). The hydraulic drill is considerably larger, requiring two people to operate. The core samples collected by the PIFSC are approximately 4 cm in diameter and no more than 100 cm long. The samples are processed in the lab to study structure and biological properties of the coral (Figure A-17).

Source: http://pipa.neaq.org/2012/06/studying-climate-change-with-coral.html

Figure A-16 A CRED diver collects a coral core during a Pacific Reef Assessment and Monitoring Program cruise

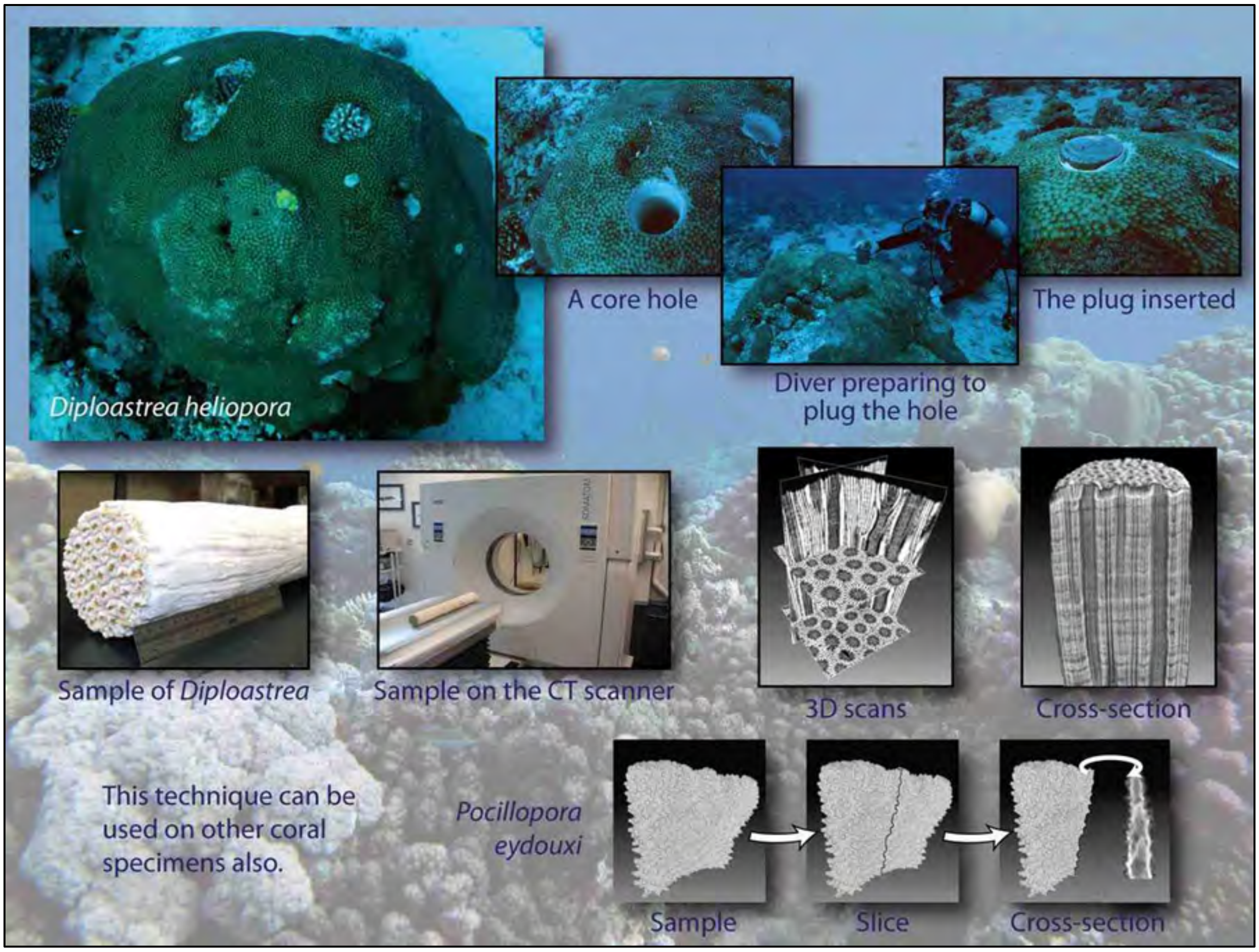


Photo courtesy of the Cohen Lab, Woods Hole Oceanographic Institution

Figure A-17 Diagram illustrating coral-coring process and core analysis

Calcification Acidification Units (CAU's): Rates of net calcium carbonate accretion are monitored with calcification accretion units (CAUs), which allow for recruitment and colonization of crustose coralline algae and hard corals. Each CAU consists of 2 gray PVC plates (10 x 10 cm) separated by a 1 cm spacer and mounted on a stainless steel rod which is installed by divers into the bottom (avoiding corals) (Figure A-18).

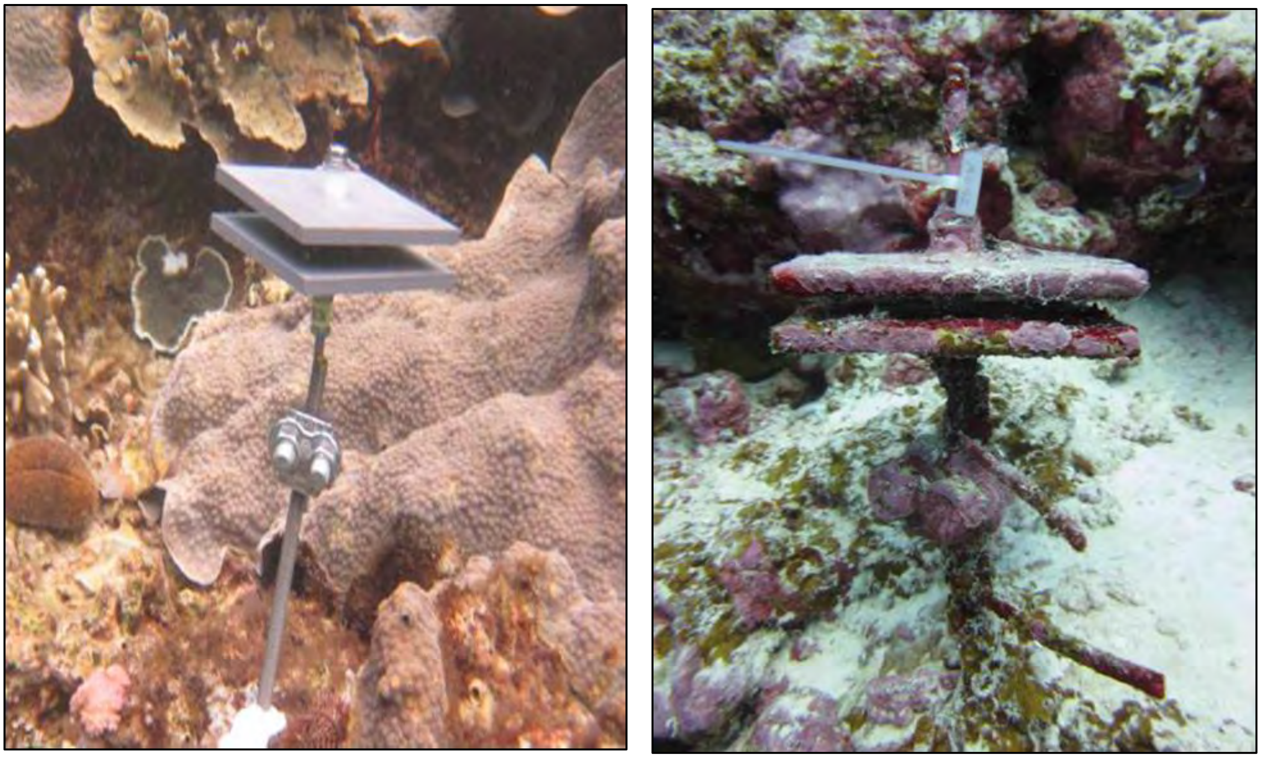


Figure A-18 Calcium acidification unit pre-deployment and two years after deployment

<u>Autonomous Reef Monitoring Structures (ARMS)</u>: ARMS are used to examine the biodiversity and community structure of the cryptobiota community. The cryptobiota community is targeted for biodiversity and community composition measurements because it is the most numerically abundant and diverse community on a reef system (Ginsburg 1983). The ARMS used by the PIFSC for Pacific Reef Monitoring Assessments are 36 x 46 x 20 cm structures placed on pavement or rubble, secured to the bottom by stainless steel stakes and weights in proximity to coral reef structures (Figure A-19).

Figure A-19 ARMS structure three years after deployment

Bioerosion Monitoring Unit (BMU): Bioerosion monitoring units are small blocks made up of coral structures which are layers of calcium carbonate. These units are frequently attached to CAUs for the measurement of coral erosion due to ocean acidification. The PIFSC uses 1 x 2 x 5 cm pieces of relic calcium carbonate and deploys them near reef structures for a period of 1-3 years (Figure A-20).

Figure A-20 Bioerosion monitoring block with CAU unit

9. Submersibles Pisces IV and Pisces V

The Pi*s*ces IV and Pi*s*ces V are three-person, battery-powered, submersibles with a maximum operating depth of 2000m (6,500 ft) (Figure A-21). The submersibles are equipped with HD and SD video cameras on a pan and tilt that allow the science observer to record detailed images of bottom terrain, sea life and sample collecting. Each of the submersibles is equipped with two mechanical arms that give the submersibles the ability perform very fine sampling of fragile marine organisms or operating samplers or scientific instruments. The submersibles have a hydraulically operated "sample tray" that can be configured with a variety of sample collecting boxes or instruments. The submersibles are equipped with a pinger receiver system that enables them to track a signal from 8 to 80Khz. This allows the submersibles to track each other or to locate lost instruments or relocate bottom monitoring sites marked with a pinger or transponder. The submersibles are launched and recovered with a specialized A-frame on the aft deck of their support vessel, the *Ka'imikai-o-Kanaloa*.

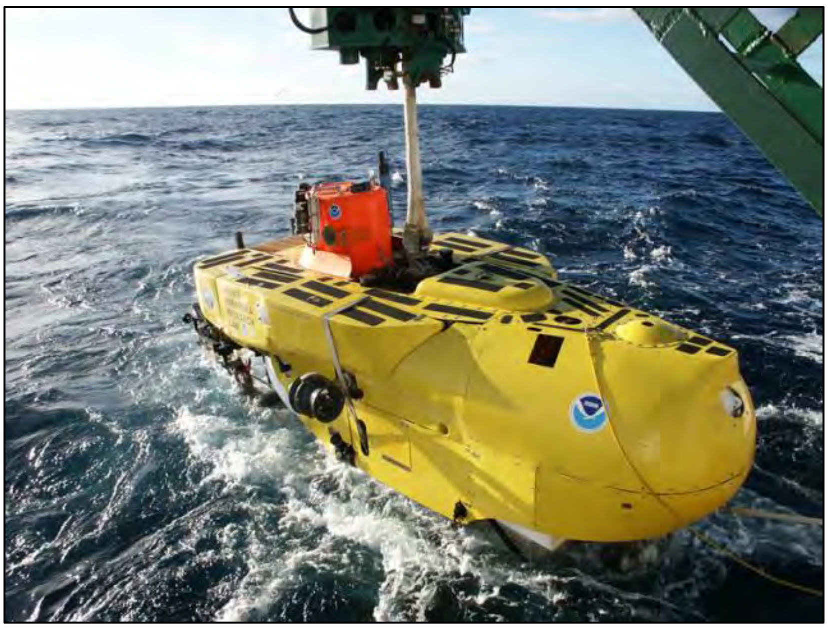


Figure A-21 Submersible

10. Remote Operated Vehicles (ROV), and Autonomous Underwater Vehicle (AUV)

Super Phantom S2 ROV: The Super Phantom S2 is a powerful, versatile, remotely operated vehicle (ROV) with high reliability and mobility (Figure A-22). This light weight system can be deployed by two operators and is designed as an underwater platform which provides support services including color video, digital still photography, navigation instruments, lights and a powered tilt platform. A wide array of specialty tools and sampling devices are available. The basic configuration of the ROV provides color video, digital still photos, laser scaling device, position information of the ROV and support ship, vehicle heading, and vehicle depth.

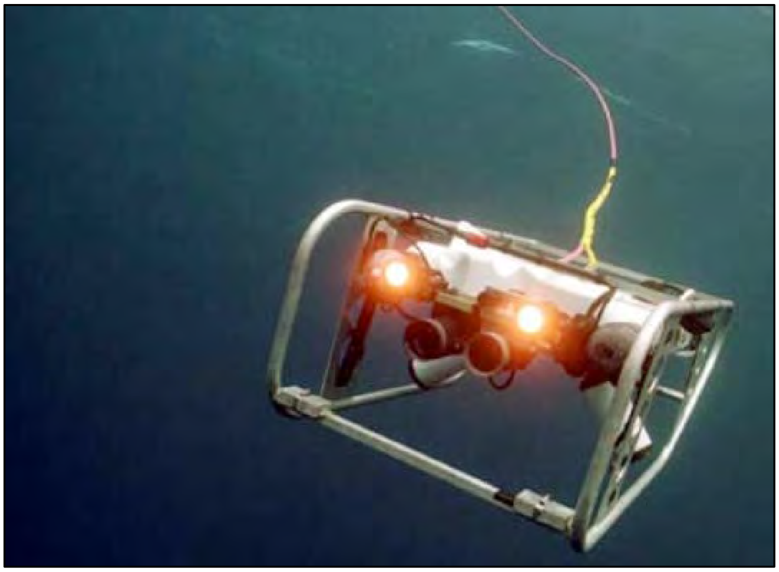
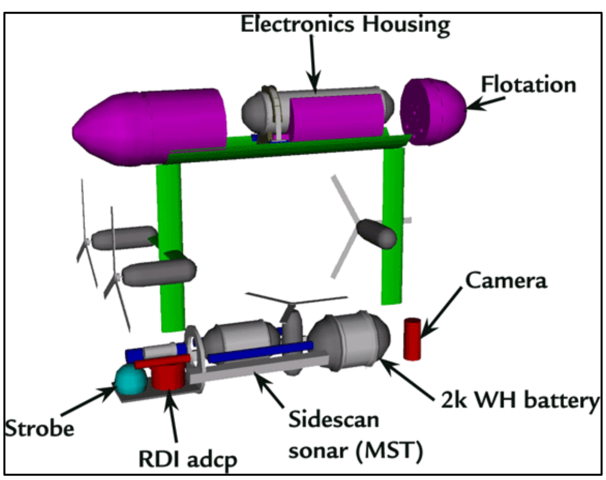


Figure A-22 ROV Super Phantom

The SeaBED-class AUV: Unlike other more traditional AUV's, the SeaBED employs a twin-hull design that provides enhanced stability for low-speed photographic surveys (Figure A-23). SeaBED is designed to autonomously follow the terrain approximately 3 to 4 m above the sea floor, collecting high resolution color and black-and-white imagery while maintaining a forward speed of .25 - .5 m/sec. For this mission, SeaBed is also outfitted with a forward-looking stereo video camera system as well as a forward-looking imaging SONAR unit. The stereo-video system is similar to that used on the BRUVS and allows for accurate measures of fish abundance and size structure. The imaging SONAR unit is being tested as a means to assess fish assemblage outside the visual range of the cameras and in zero light situations including nocturnal or operations in depths to which light does not reach.



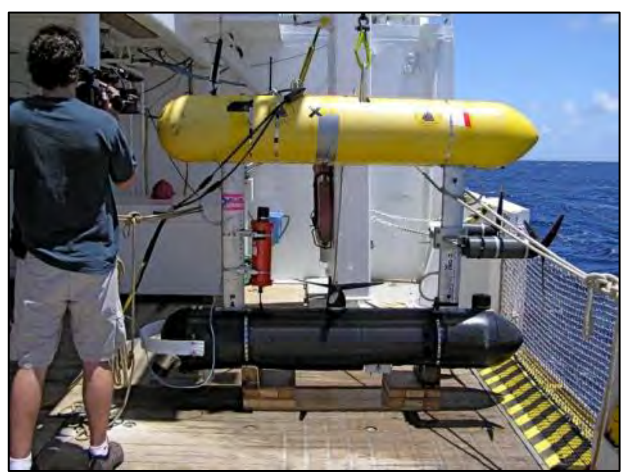


Figure A-23 The SeaBED-class AUV

SeaBED is approximately two meters long and weighs nearly 200 kg. It has two main pressure housings, a top hull and a bottom hull. The CPU electronics are located in the top hull, and the batteries, cameras, and sensors are located in the bottom hull, and all are connected by wet cabling that is routed through vertical struts. With a maximum depth range of 2,000 m, and maximum single-dive time of 6 - 8 hours, SeaBED can be used to survey habitats ranging from shallow coral reefs to deep groundfish environments.

The AUV is programmed while still aboard the ship. Programming parameters include navigational waypoints, speed, altitude to maintain above the seafloor, and frequency of photographs. Once submerged, the AUV does not resurface until the end of its mission. The AUV reports its position to the ship periodically in telemetry messages via acoustic MODEM. If any of these telemetry messages indicate an unexpected change in the AUV's planned mission, the mission can be aborted via acoustic MODEM message, resulting in the AUV returning to the surface for recovery.

The SeaBED AUV carries a forward-facing ROS Navigator black-and-white, low-light stereo-video camera system, two 5 megapixel, 12 bit dynamic range Prosilica GigE strobe-lighted cameras, one perpendicularly downward-looking and one forward looking (~35°). Imagery from the downward-looking camera can be analyzed to characterize the benthic communities while the forward-looking cameras are used to collect species-specific abundance and length information. Combined, these 2 imagery data sets can be used to create spatial species-specific abundance, biomass, and length-frequency distributions, along with the benthic communities around which they associate. An onboard Seabird model 49 FastCat CTD records temperature and salinity data along the AUV track, providing further environmental insight.

11. SeaGlider, or WaveGlider

Also known as Acoustic or Oceanographic Gliders (Figure A-24), these are autonomous underwater vehicles used for sub-surface profiling and other sampling over broad areas and long time periods. Passive acoustic device integrated into the vehicle provide measure of cetacean occurrence and background noise. CTD, pH, fluorometer, and other sensors provide semi-continuous measurements for up to several months.

Photo credit: D'Spain, G.

Figure A-24 Oceanographic glider

12. Underwater Video Cameras

BotCam: The Bottom Camera or ("BotCam") system includes programmable control functions which allow for the activation of imaging systems, bait release mechanisms, image scaling indicators, and acoustic release to enable recovery of the camera (Figure A-25). The camera bait station can be deployed repetitively during a survey of a site or can sit dormant on the seafloor ready for activation at a preset time. Further, the stereo-video configuration of the camera system allows for the sizing and ranging of both fish and benthic features. Development of a field-tested deep-water camera bait station, coupled with a standard method to analyze the collected image data, will provide a cost-effective and non-extractive alternative method to assess the abundance and size composition of bottomfish populations in deepwater habitats.

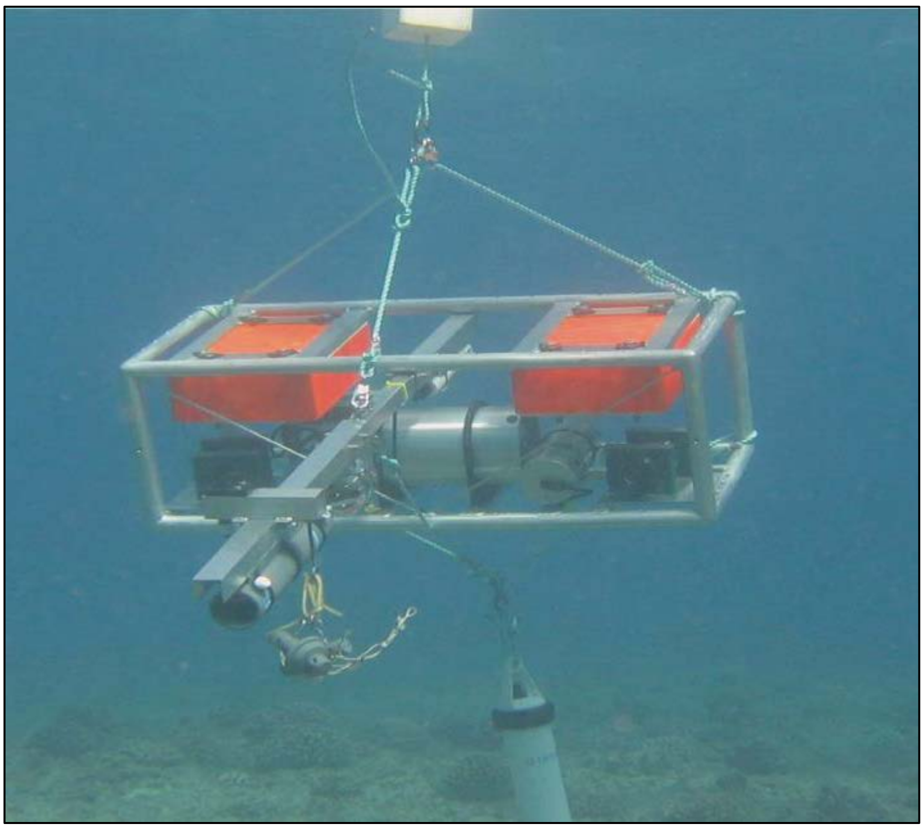


Figure A-25 BotCam

MOUSS: The MOUSS, or Modular Underwater Survey System, is a next generation BotCam that is currently under development (Figure A-26). MOUSS is rated to 500 m and uses highly light sensitive stereo-vision cameras that allow for the identification, enumeration, and sizing of individual fish at a range of 0-10 m from the system. In Hawaiian waters, the system can effectively identify individuals to a depth of 250 m using only ambient light. MOUSS is an evolution of the existing remote camera bait station (BotCam) developed in 2005 by PIFSC. MOUSS is an improvement over the older analogue because it is three times lighter (92 lbs versus 310 lbs), able to attach to different deployment platforms, and captures high-resolution digital footage. The size and weight reduction allows for hand deployment from cooperative research vessels and small boats while the use of high-resolution digital video allows for more accurate and precise fish identifications and measurements

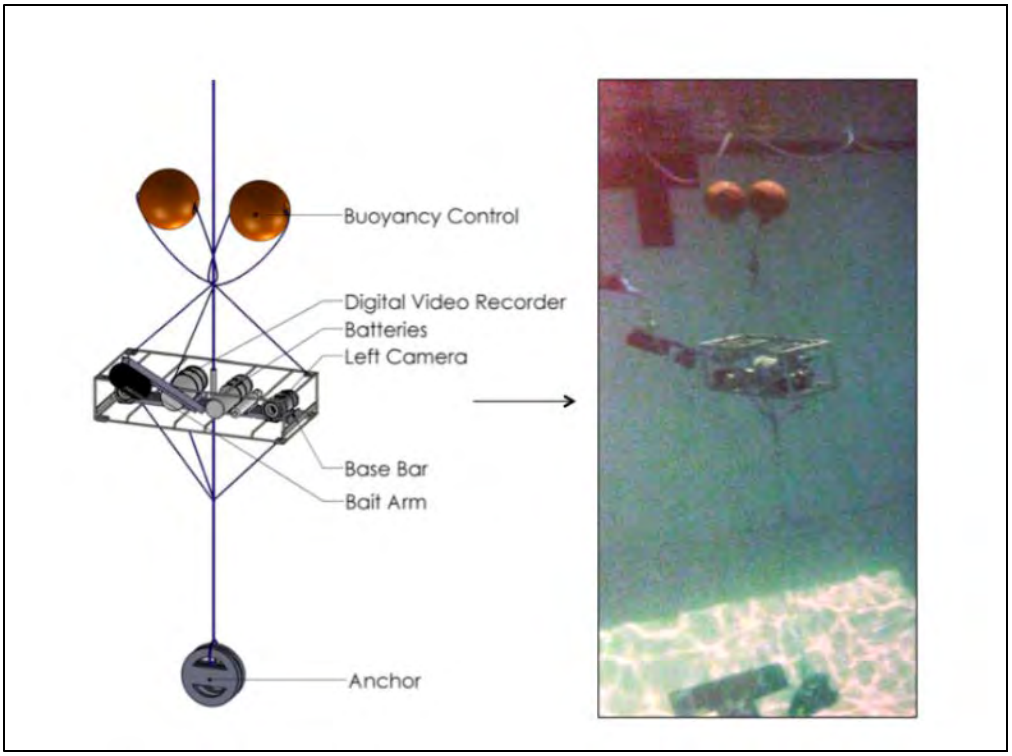


Figure A-26 MOUSS model (left) and prototype during pool test (right)

<u>Baited Remote Underwater Video System (BRUVS)</u>: BRUVS are similar to the existing BotCam technology but are more suitable for deployment on coral reef systems because they are smaller, lighter, and can be deployed closer to a substrate (Figure A-27). Coral Reef Ecosystem Division (CRED) uses BRUVS for reef surveys to depths of ~100 m. Each BRUVS uses high-definition video cameras mounted 0.7 m apart on a base bar that is inwardly converged at 8°. This stereo-video system allows us to identify fish species and to accurately and precisely determine fish sizes and their distances from the camera when the video images from these cameras are subsequently analyzed. The use of bait attracts a wide diversity of fish species into the field of view of the cameras, but CRED is also experimenting with unbaited deployments.

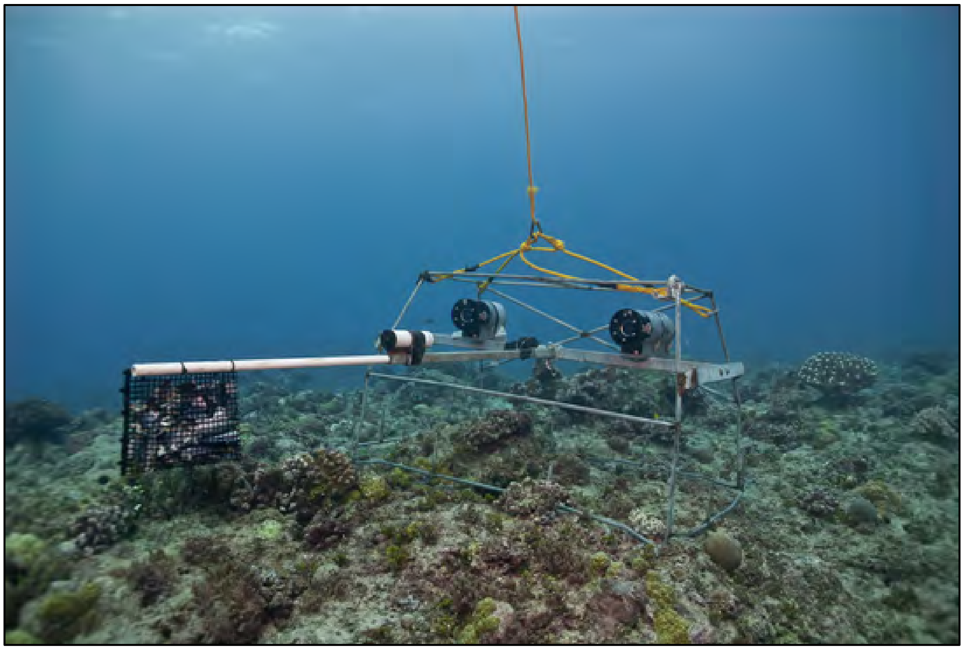
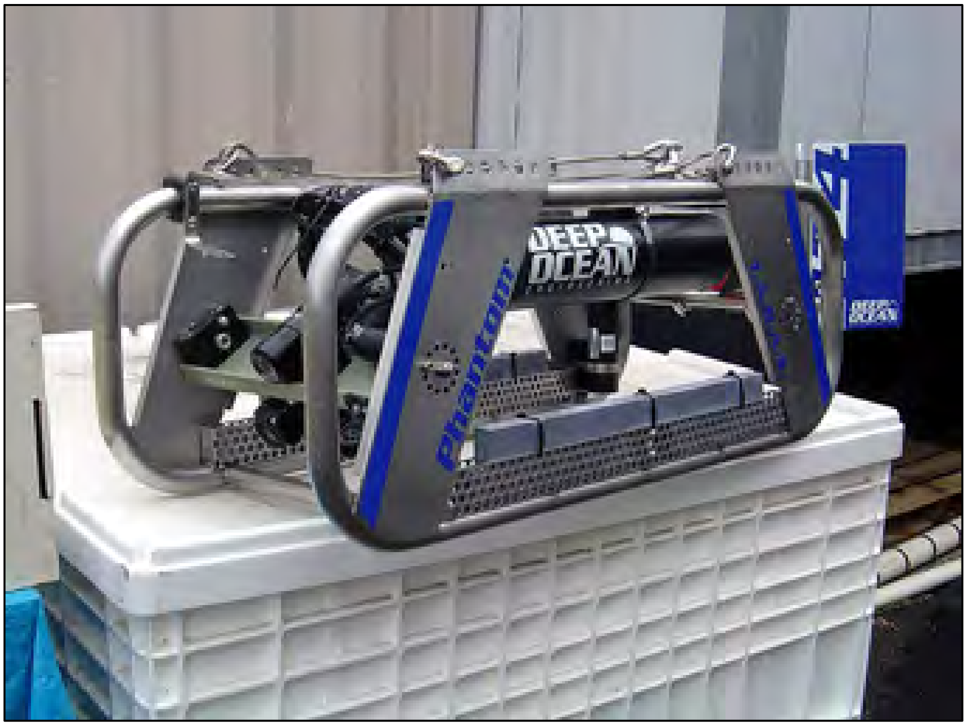


Figure A-27 BRUVS

<u>Towed Optical Assessment Device (TOAD)</u>: The Towed Optical Assessment Device (TOAD) is a camera sled built around a stainless steel tubing frame (Figure A-28). It is equipped with a Deep Sea Power & Light (DSP&L) Multi SeaCam 2060 low-light color video camera angled downwards to provide imagery of the seabed while allowing some view of upcoming obstacles, and a downward-facing Ocean Imaging System 12000 digital still camera (consisting of a Nikon D90 digital SLR camera within an aluminum housing). Illumination is provided by two forward-facing 50 watt DSP&L LED Multi SeaLites for the video camera and a downward-facing strobe for the still camera. A pair of downward-facing DSP&L SeaLaser 100 parallel lasers provide scale for still imagery. The sled also has a Tritech PA200 altimeter to detect the height of the camera sled above the seafloor, and a pressure (depth) sensor and fluxgate compass, all installed inside an electronics bottle. The 75-lb camera sled is attached to a control console via umbilical cable that provides a real time feed from the video camera to an electronics console installed on the towing vessel. The TOAD is generally deployed from the vessel while it is drifting or slowly (≤ 1.5 knots) motoring above the seafloor. Operators manning the console adjust the length of cable out to keep the sled at an altitude of approximately 2 m above the seafloor to maximize imagery quality. Dives typically last from 5 to 20 minutes in duration but can run for several hours depending on the mission. Dive depths are most commonly between 20 – 100 m but have exceeded 200 m in depth in a few instances. Still imagery is the primary data recovered by the TOAD and enable PIFSC scientists to quantitatively characterize benthic communities and substrates. Images are typically taken at 15 second intervals and generally only every other photograph is classified.



Source: http://www.pifsc.noaa.gov/cred/survey_methods.php

Figure A-28 TOAD

13. Underwater Sound Playback System (Lubell LL916 piezoelectric)

The Lubell LL916 piezoelectric underwater sound playback system (Figure A-29) has a frequency response of 200Hz to 20kHz and comes with an underwater amplifier and projector. The PIFSC utilized the underwater speaker during their Cetacean Ecology studies to assist in calibration of the passive acoustic equipment. The speaker was suspended from a small boat or ship to a depth of about 100 meters and was set to transmit sound to passive acoustic recording devices in order to understand the detection distances and frequency–dependent variations in the device performances.

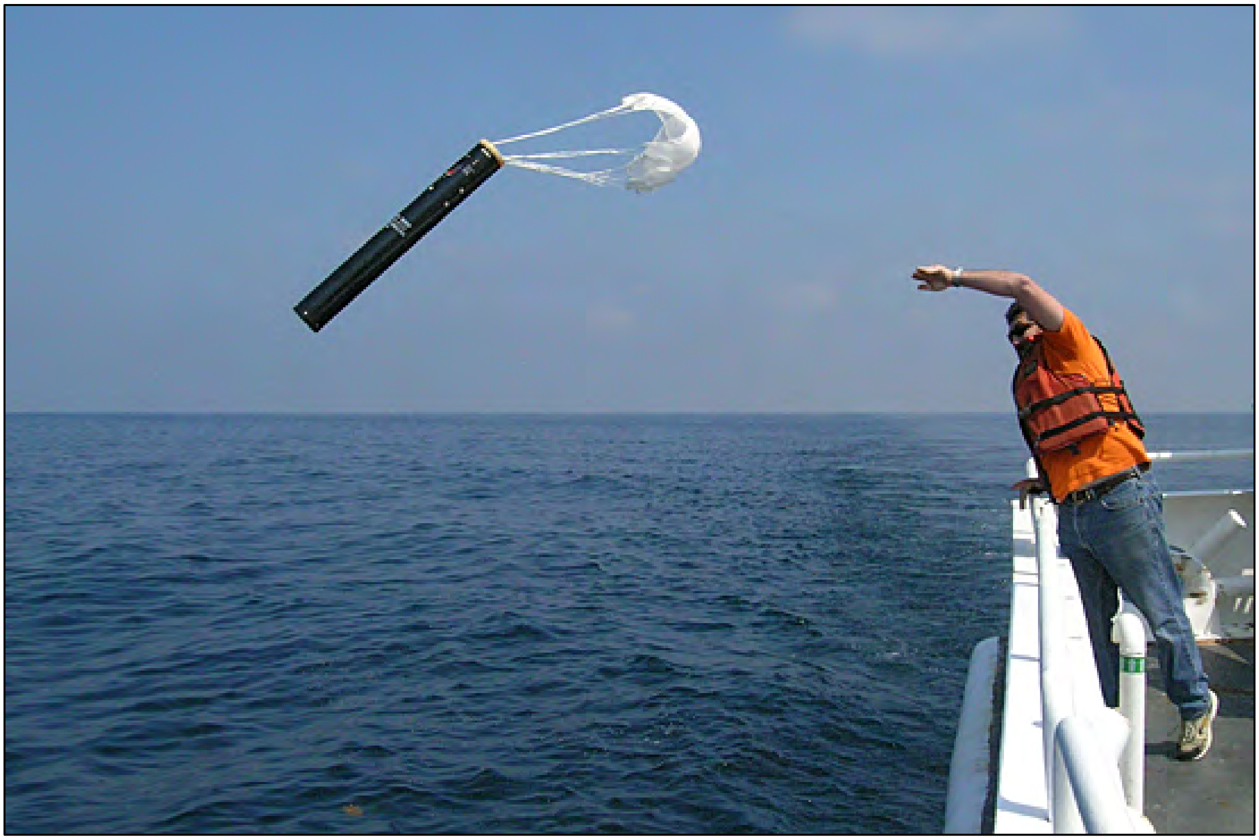
Figure A-29 Lubell LL916 piezoelectric underwater sound playback system

14. High-Frequency Acoustic Recording Package (HARP)

HARPs consist of three parts; hydrophones to convert sound pressure into a voltage signal that is amplified and filtered, a Data Acquisition System (DAS) that records and stores sound, and digital disk drives for recording onto disk (Figure A-30). The internal components of a HARP hydrophone include: two transducers, a signal conditioning electronics circuit board, and connector. These components are packaged in a thin-walled, pliable, polyurethane tube filled with oil to provide good acoustic coupling of the transducers with the seawater while protecting the circuit board from the environment. The seafloor instrument frames are compact arrangements of flotation, data recording electronics, batteries, ballast and release systems which free-fall to the seafloor, record sound for a specified period, and are recalled back to the sea surface for data retrieval and battery replenishment. Seafloor packages are easy to deploy and recover from typical oceanographic ships and mid-sized fishing vessels. In all configurations listed, the hydrophone sensor was designed to be tethered 10 m above the seafloor package which provides a quieter acoustic background for better sound recordings than near the sea surface.

Figure A-30 HARP

<u>**Sonobuoy**</u>**:** A sonobuoy is a relatively small expendable HARP system that can be dropped from a ship in order to study underwater acoustics (Figure A-31). Once the sonobuoy is deployed, a radio transmitter attached to a float remains on the surface for communication with the ship while one or more hydrophones below the surface record underwater acoutics.



Source: http://www.whoi.edu/page.do?pid=80696&i=2724

Figure A-31 Sonobuoy being deployed

15. Ecological Acoustic Reader (EAR)

Passive acoustic data is collected using an Ecological Acoustic Recorder (EAR). The EAR is a microprocessor-based autonomous recorder that samples the ambient sound field on a programmable duty cycle. EARs are generally programmed to record for periods of 30 seconds every 15 minutes at a sampling rate of 25-40 kHz, although these settings are at times different depending on the site and target sounds. An event detector allows for loud sounds that fall within certain parameters to turn on the recorder during duty periods to capture a 15-second recording. Data obtained from each EAR are aurally and visually analyzed.

16. Active Acoustic Sources Used in PIFSC Fisheries and Ecosystem Research

A wide range of active acoustic sources are used in PIFSC fisheries and ecosystem research for remotely sensing bathymetric, oceanographic, and biological features of the environment. Most of these sources involve relatively high frequency, directional, and brief repeated signals tuned to provide sufficient focus on and resolution of specific objects. Table A-1 shows important characteristics of these sources used on

NOAA research vessels conducting NWFSC fisheries surveys, followed by descriptions of some of the primary general categories of sources, including all those for which acoustic takes of marine mammals are calculated in the LOA application.

Table A-1 Output characteristics for predominant PIFSC acoustic sources

Abbreviations: kHz = kilohertz; dB re 1 µPa at 1 m = decibels referenced at one micro Pascal at one meter; ms = millisecond; Hz = hertz

Acoustic system	Operating frequencies (kHz)	Maximum source level (dB re 1 µPa at 1 m)	Single ping duration (ms) and repetition rate (Hz)	Orientation/ Directionality	Nominal beam width (degrees)
Simrad EK60 narrow beam echosounder	38, 70, 120, 200	224	1 ms @ 1 Hz	Downward looking	7°
Simrad EM300 multibeam echosounder	30	237	0.7 to 15 ms @ 5 Hz	Downward looking	1°
ADCP Ocean Surveyor	75	223.6	1 ms @ 4 Hz	Downward looking (30° tilt)	4°
Netmind	30, 200	190	up to 0.3 ms @ 7 to 9 Hz	Trawl-mounted	50°

Single Frequency Sonars

Didson: The Didson sonars operate on a low frequency of 12 MHz that allows for high resolution for up to 30 m even in dark turbid waters. This type of sonar is used for fish imaging and identification.

Multi-frequency Sonars

Similar to multibeam echosounders, multi-frequency split-beam sensors are deployed from NOAA survey vessels to acoustically map the distributions and estimate the abundances and biomasses of many types of fish; characterize their biotic and abiotic environments; investigate ecological linkages; and gather information about their schooling behavior, migration patterns, and avoidance reactions to the survey vessel. The use of multiple frequencies allows coverage of a broad range of marine acoustic survey activity, ranging from studies of small plankton to large fish schools in a variety of environments from shallow coastal waters to deep ocean basins. Simultaneous use of several discrete echosounder frequencies facilitates accurate estimates of the size of individual fish, and can also be used for species identification based on differences in frequency-dependent acoustic backscattering between species. The PIFSC makes use of several multi frequency Echo-Sounders such as the

Simrad EK60: The Simrad EK60 is a split-beam echo sounder with built-in calibration. It is specifically suited for permanent installation onboard a research vessel. The Simrad EK60 can operate seven echo sounder frequencies simultaneously ranging from 18 to 710 kHz. the Simrad EK60 is comprised of one color display, one processor Unit (personal computer), an Ethernet switch, one or more transceiver units, and one or more transducers.

Simrad ES60: The Simrad ES60 is a split-beam echo sounder comprised of a color display, a processor unit, one or more transceiver units, one or more single beam transducers. The transceiver unit is normally mounted close to the transducer. This prevents noise from being picked up by a long transducer cable. It is connected to the processor unit with a standard Ethernet cable. The Simrad ES60 can operate on several echo sounder frequencies simultaneously ranging from 18 to 200 kHz.

Multi-beam Echosounder and Sonar

Multibeam echosounders (Figure A-32) and sonars work by transmitting acoustic pulses into the water then measuring the time required for the pulses to reflect and return to the receiver and the angle of the reflected signal The depth and position of the reflecting surface can be determined from this information, provided that the speed of sound in water can be accurately calculated for the entire signal path.

The use of multiple acoustic 'beams' allows coverage of a greater area compared to single beam sonar. The sensor arrays for multibeam echosounders and sonars are usually mounted on the keel of the vessel and have the ability to look horizontally in the water column as well as straight down. Multibeam echosounders and sonars are used for mapping seafloor bathymetry, estimating fish biomass, characterizing fish schools, and studying fish behavior. The multibeam echosounders used by PIFSC are mounted to the hull of the research vessels and emit frequencies in the 3.5-260 kHz range.

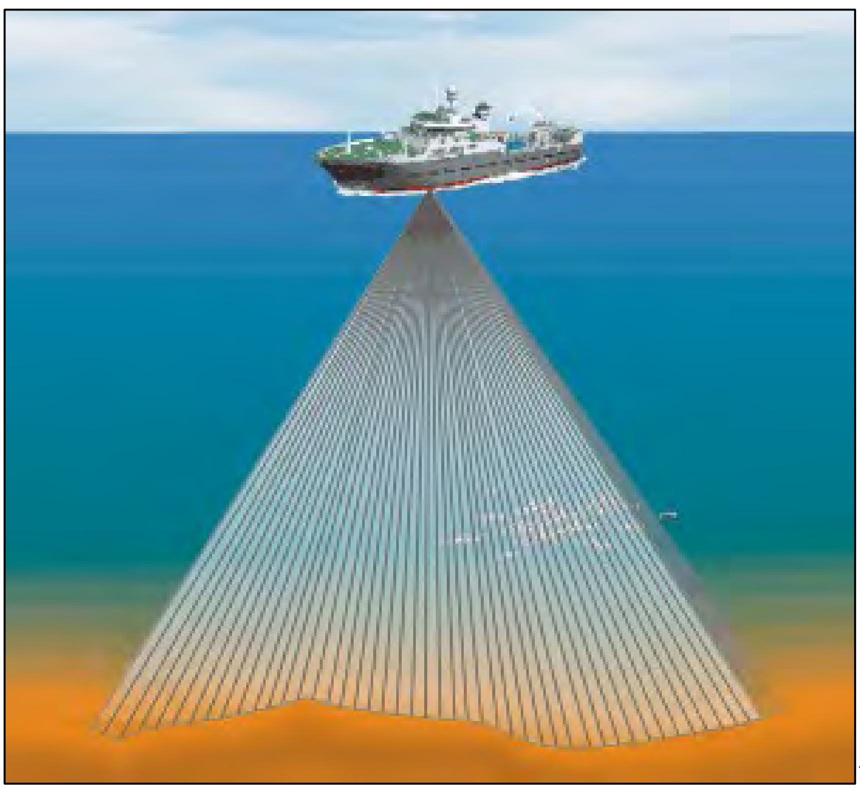

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Figure A-32 Multibeam sonar

Trawl Mounted OES Netmind

The NetMind™ Trawl Monitoring System allows continuous monitoring of net dimensions during towing to assess consistency, maintain quality control, and provide swept area for biomass calculations (Figure A-33). The NetMind system is utilized on every tow possible. Towing protocols are not altered based on the real time NetMind display.

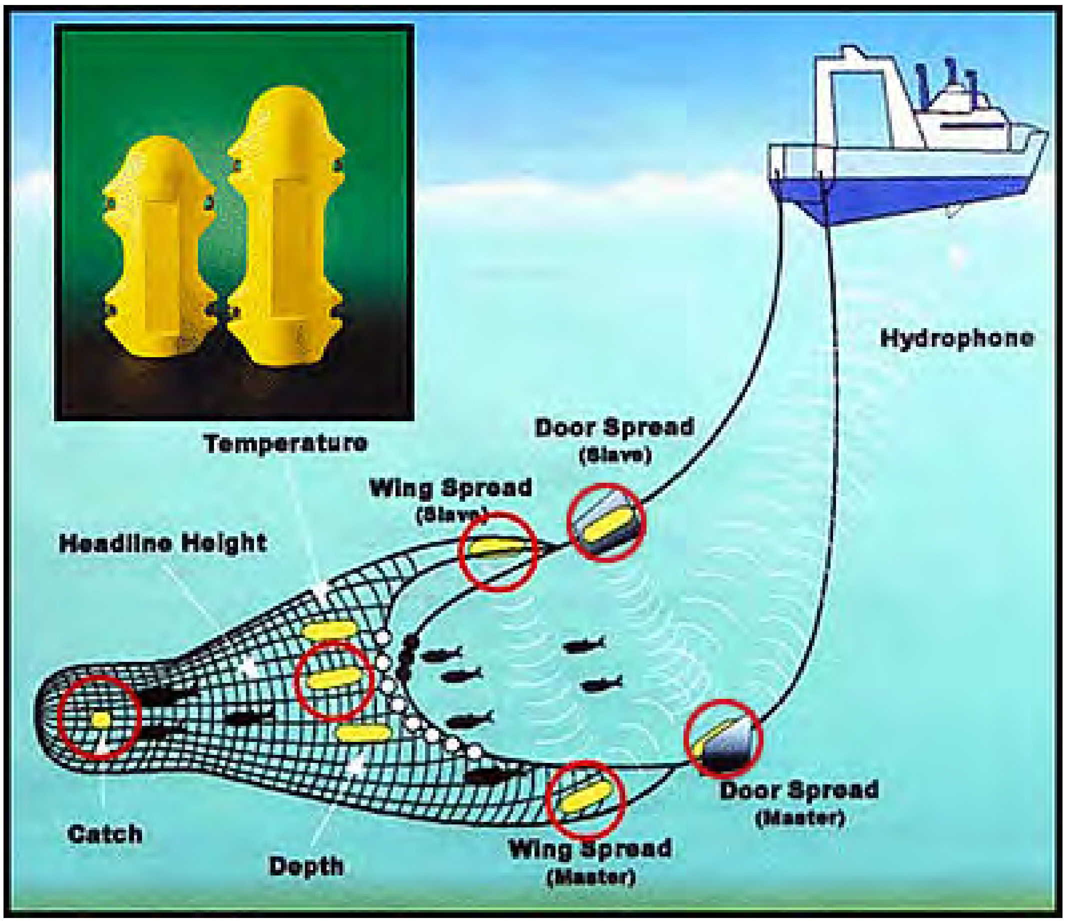


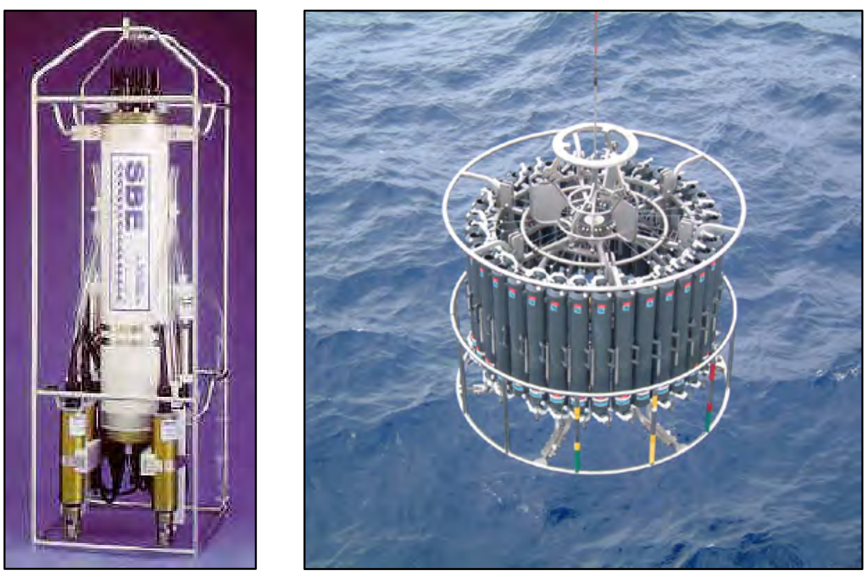
Figure A-33 NetMind

Acoustic Doppler Current Profiler (ADCP)

An Acoustic Doppler Current Profiler (ADCP) is a type of sonar used for measuring water current velocities simultaneously at a range of depths. An ADCP instrument can be mounted to a mooring or to the bottom of a boat. The ADCP works by transmitting "pings" of sound at a constant frequency into the water. As the sound waves travel, they ricochet off particles suspended in the moving water, and reflect back to the instrument (WHOI 2011). Sound waves bounced back from a particle moving away from the profiler have a slightly lowered frequency when they return and particles moving toward the instrument send back higher frequency waves. The difference in frequency between the waves the profiler sends out and the waves it receives is called the Doppler shift. The instrument uses this shift to calculate how fast the particle and the water around it are moving. Sound waves that hit particles far from the profiler take longer to come back than waves that strike close by. By measuring the time it takes for the waves to return to the sensor, and the Doppler shift, the profiler can measure current speed at many different depths with each series of pings (WHOI 2011).

17. Conductivity, Temperature, and Depth (CTD)

A CTD profiler is the primary research tool for determining chemical and physical properties of seawater. A shipboard CTD is made up of a set of small probes attached to a large (1 to 2 m in diameter) metal rosette wheel (Figure A-34). The rosette is lowered through the water column on a cable, and CTD data are observed in real time via a conducting cable connecting the CTD to a computer on the ship. The rosette also holds a series of sampling bottles that can be triggered to close at different depths in order to collect a suite of water samples that can be used to determine additional properties of the water over the depth of the CTD cast. A standard CTD cast, depending on water depth, requires two to five hours to complete (WHOI 2011). The data from a suite of samples collected at different depths are often called a depth profile, and are plotted with the value of the variable of interest on the x-axis and the water depth on the y-axis. Depth profiles for different variables can be compared in order to glean information about physical, chemical, and biological processes occurring in the water column.



Source: Sea-Bird Electronics, Bellevue WA

Figure A-34 Sea-Bird 911 plus CTD profiler and deployment on a sampling rosette.

Conductivity is measured as a proxy for salinity, or the concentration of salts dissolved in the seawater. Salinity is expressed in ‘practical salinity units’ (psu) which represent the sum of the concentrations of several different ions. Salinity is calculated from measurements of conductivity. Salinity influences the types of organisms that live in a body of water, as well as physical properties of the water. For instance, salinity influences the density and freezing point of seawater.

Temperature is generally measured using a high-sensitivity thermistor protected inside a thin walled stainless steel tube. The resistance across the thermistor is measured as the CTD profiler is lowered through the water column to give a continuous profile of the water temperature at all water depths.

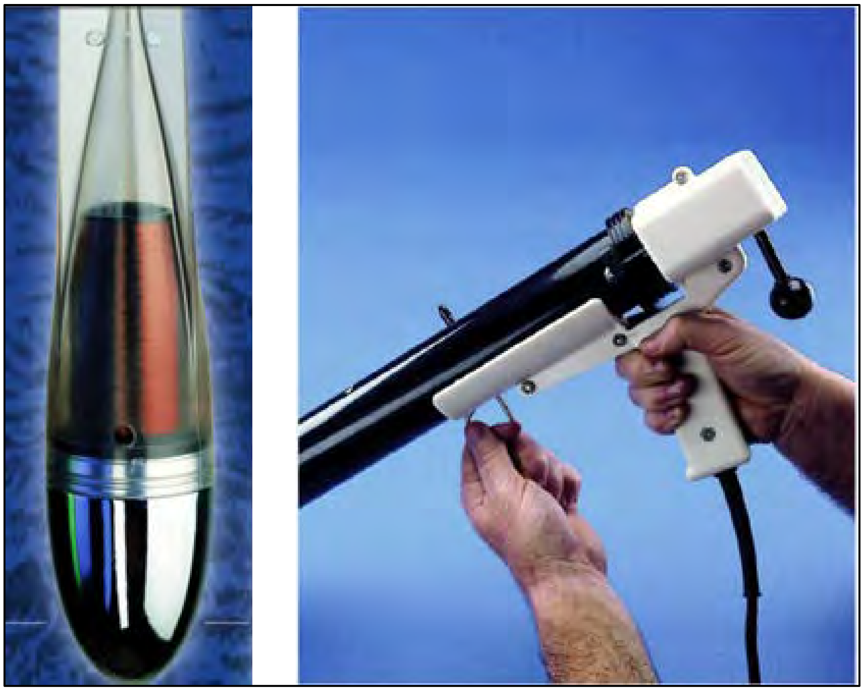
The depth of the CTD sensor array is continuously monitored using a very sensitive electronic pressure sensor. Salinity, temperature, and depth data measured by the CTD instrument are essential for characterization of seawater properties.

18. XBT (Expendable Bathythermograph)

A standard XBT/XSV system consists of an expendable probe, a data processing/recording system, and a launcher (Figure A-35). An electrical connection between the probe and the processor/recorder is made when the canister containing the probe is placed within the launcher and the launcher breech door is closed. Following launch, wire dereels from the probe as it descends vertically through the water. Simultaneously, wire dereels from a spool within the probe canister, compensating for any movement of the ship and allowing the probe to freefall from the sea surface unaffected by ship motion or sea state.

The XBT probes consist of a metal weight surrounding a temperature probe, attached to a copper wire that conducts the signal to the vessel. The copper wire is protected within a plastic housing. Probes are generally launched from the leeward side of the vessel and as far aft as possible. Launching from these locations helps obtain high reliability and minimizes the chances that the fine copper probe wire will come in contact with the ship's hull which may cause spikes in the data or a catastrophic wire break. A portable shipboard data acquisition system records, processes, and interprets the data the probes collect.

XBT drops occur at predetermined times along with surface chlorophyll sampling. Opportunistic drops may also occur. Typically, three XBT drops are made per survey day. XBT drops may be repeated if the displayed profile does not show a well-defined mixed layer and thermocline. Deep Blue probes are preferred, as they survey to a depth of 760 m and take approximately 2 minutes per drop. As the XBT probes are expendable, they are not retrieved and are left on the seafloor after data collection.



Source: Lockheed Martin Sippican Inc.

Figure A-35 Expendable XBT probe on the left; LM-3A hand-held launcher on the right

19. TDR (Time depth Recorders)

Memory based logging tools record their data against time. To provide a log in a standard format, it is necessary to also record the measured depth against time, then match and merge together the two time based data sets to produce a data record that includes the depth associated with each measured data point.

20. Vessels Used for PIFSC Survey Activities

NOAA Ship *Oscar Elton Sette*

Source: http://www.moc.noaa.gov/oes/

Figure A-36 ***Oscar Elton Sette***

The NOAA Ship *Oscar Elton Sette* (Figure A-36) operates throughout the central and western Pacific, and conducts fisheries assessment surveys, physical and chemical oceanography, marine mammal projects and coral reef research. It collects fish and crustacean specimens using midwater trawls, longlines, and fish traps. Plankton, fish larvae and eggs are also collected with plankton nets and surface and midwater larval nets. The ship routinely conducts scuba diving missions for PIFSC. Ample deck space enables *Oscar Elton Sette* to carry a recompression chamber as an added safety margin for dive-intensive missions in remote regions. The ship is also actively involved in NMFS PIFSC marine debris cruises, which concentrate scientific efforts on the removal, classification and density of derelict fishing gear across the Pacific Islands Region.

Ka'imikai-o-Kanaloa

Source: http://www.soest.hawaii.edu/UMC/cms/kaimikai-o-kanaloa/

Figure A-37 ***Ka'imikai-o-Kanaloa***

The University of Hawaiʻi research vessel *Ka'imikai-o-Kanoloa* or KoK (Figure A-37) is designed to operate in coastal blue and blue-water areas. Owned and operated by the University of Hawaii, at 223 feet, the KoK displaces 1,961 tons and can accommodate up to 13 crew and 19 scientists. The KoK can remain at sea for 50 days with a full crew and science party, cruising at a maximum speed of 11 knots. The KoK is well equipped for a range of general oceanographic research operations. A SeaBeam bathymetric mapping system is capable of charting the seafloor to depths of 11 kilometers. The vessel also has an Acoustic Doppler Current Profiler to measure profiles of water velocity relative to the ship, a Conductivity-Temperature-Depth system to measuring seawater parameters such as salinity and temperature, and an uncontaminated seawater system. Four laboratories are available for use on the ship: a rock lab for the storage and analysis of solid samples recovered from the ocean, a wet lab for chemical sample analyses, a clean lab, and a dry lab. The KoK's large, moveable A-Frame; trawl winch; and CTD winch allow for the launching of scientific equipment, such as the Pisces submersibles and other ROVs, permitting a variety of oceanographic operations to be conducted at sea. The KoK is equipped with a Trimble NAVTRAC in the bridge and Ashtech in the main lab. Both of these systems can receive Differential Global Positioning System (DGPS) signals. Vessel communications include HF (SSB) and VHF radios, INMARSAT-C satellite communications and Internet, and cellular phone.

NOAA Ship *Hi'ialakai*

Source: http://www.moc.noaa.gov/hi/

Figure A-38 ***Hi'ialakai***

The NOAA Ship *Hi'ialakai* (Figure A-38) was acquired from the U.S. Coast Guard in October 2001, and was converted by NOAA from a T-AGOS surveillance vessel to a versatile platform that supports the research of NOAA's National Ocean Service (NOS), National Marine Sanctuaries (NMS), National Marine Fisheries Service (NMFS) and the Office of Oceanic and Atmospheric Research (OAR) as well as the U.S. Fish and Wildlife Service (USFWS) and the University of Hawaii. The ship operates across the PIR, including the Hawaiian Islands, American Samoa, the Commonwealth of the Northern Mariana Islands (CNMI), and Guam. *Hi'ialakai*, Hawaiian for "embracing pathways to the sea," is the primary platform for coral reef ecosystem mapping, bio-analysis assessments, coral reef health and fish stock studies. Scuba diving operations play a major role in scientific operations, and *Hi'ialakai* is well suited to support both shallow and deep-water dive projects. The ship is equipped to carry five small work boats for transporting divers to and from working areas, dive lockers to store scientific gear and equipment, and an air compressor to fill tanks. The ship also carries a three-person, double-lock recompression chamber; in the event of a diving accident, the diver can be treated on site. The *Hi'ialakai* carries out most of its dive intensive operations in the Northwest Hawaiian Islands.

NOAA Ship *Okeanos Explorer*

Source: http://www.moc.noaa.gov/oe/

Figure A-39 ***Okeanos Explorer***

The NOAA Ship *Okeanos Explorer* (Figure A-39) is the only federally funded U.S. ship assigned to systematically explore our largely unknown ocean for the purpose of discovery and the advancement of knowledge. Telepresence, using real-time broadband satellite communications, connects the ship and its discoveries live with audiences ashore. Since the ship was commissioned on August 13, 2008, the *Okeanos Explorer* has traveled the globe, exploring the Indonesian 'Coral Triangle Region;' benthic environments in the Galápagos; the geology, marine life, and hydrothermal systems of the Mid-Cayman Rise within the Caribbean Sea; and deep-sea habitats and marine life in the northern Gulf of Mexico. Mapping activities along the West and Mid-Atlantic Coasts have furthered our knowledge of these previously unexplored areas, setting the stage for future in-depth exploration activities. The *Okeanos Explorer* is 224 feet in length and displaces 2,298.3 metric tons. The equipment aboard the *Okeanos Explorer* includes remotely operated vehicles, multibeam sonar for as deep as 6,000 meters, and telepresence capabilities.

References

Aquatic Research Instruments (2011). <http://www.aquaticresearch.com > [accessed 16 March 2011].

Churnside, J. H., D. Griffith, D. A. Demer, R. L. Emmett, and R. D. Brodeur. (2009). Comparisons of Lidar, acoustic and trawl data on two scales in the Northeast Pacific Ocean. Calif. Coop. Oceanic Fish. Invest. Rep. 50:118–122. http://calcofi.org/publications/calcofireports/v50/118-122_Churnside.pdf

Dotson, R.C., Griffith, D.A., King, D.L., and Emmett, R.L. (2010). EVALUATION OF A MARINE MAMMAL EXCLUDER DEVICE (MMED) FOR A NORDIC 264 MIDWATER ROPE TRAWL. U.S. Dep. Commerce, NOAA Tech. Memo.NOAA-TM-NMFS-SWFSC-455. http://swfsc.noaa.gov/publications/TM/SWFSC/NOAA-TM-NMFS-SWFSC-455.pdf

Net Systems Inc. < http://www.net-sys.com> [accessed 16 March 2011].

Oozeki, Y., F.X. Hu, H. Kubota, H. Sugisaki, and R. Kimura. (2004). Newly designed quantitative frame trawl for sampling larval and juvenile pelagic fish. Fisheries Science 70: 223-232

Stauffer, Gary (compiler). (2004). NOAA Protocols for Groundfish Bottom Trawl Surveys of the Nation's Fishery Resources. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-F/SPO-65.

U.S. Fish and Wildlife Service (USFWS). 2012. Biological Opinion of the U.S. Fish and Wildlife Service for the Operation of Hawaii-based Pelagic Longline Fisheries, Shallow Set and Deep Set, Hawaii. Pacific Islands Fish and Wildlife Office, Honolulu, HI. 53 pp. January 6, 2012.

Yasook, N., Taradol, A., Timkrub, T.,Reungsivakul, N., and Siriraksophon, S. (2007). Standard Operating Procedures of Isaacs-Kidd Mid Water Trawl. Southeast Asian Fisheries Development Center. TD/RES 112.

WHOI (2011). Woods Hole Oceanographic Institution, Ships and Technology. <http://www.whoi.edu/ships_technology/> [accessed 16 March 2011].