REQUEST FOR LETTERS OF AUTHORIZATION

FOR THE INCIDENTAL HARASSMENT OF MARINE MAMMALS RESULTING FROM U.S. NAVY TRAINING AND TESTING ACTIVITIES IN THE HAWAII-SOUTHERN CALIFORNIA TRAINING AND TESTING STUDY AREA

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 INTRODUCTION AND DESCRIPTION OF ACTIVITIES

1.1 INTRODUCTION

The United States (U.S.) Department of the Navy (Navy) has prepared this consolidated request for two Letters of Authorization (LOAs) for the incidental taking (as defined in Chapter 5) of marine mammals during the conduct of training and testing activities within the Hawaii-Southern California Training and Testing (HSTT) Study Area. The Navy is requesting a five-year LOA for training activities, and a 5-year LOA for testing activities, each proposed to be conducted from 2014 through 2019.

Under the Marine Mammal Protection Act (MMPA) of 1972 as amended (16 United States Code [U.S.C.] § 1371(a)(5)), the Secretary of Commerce shall allow, upon request, the incidental, but not intentional, taking of marine mammals by U.S. citizens who engage in a specified activity during periods of not more than five years, if certain findings are made and regulations are issued after notice and opportunity for public comment. The Secretary must find that the taking will have a negligible impact on the species or stock(s) and will not have an unmitigable adverse impact on the availability of the species or stock(s) for subsistence uses. The regulations must set forth the permissible methods of taking, other means of effecting the least practicable adverse impact on the species or stock(s), and requirements pertaining to the monitoring and reporting of such taking.

The Navy is preparing an Environmental Impact Statement (EIS)/Overseas Environmental Impact Statement (OEIS) for the HSTT Study Area to evaluate all components of the proposed training and testing activities. A description of the HSTT Study Area (Figure 1-1) and various components is provided in Chapter 2. A description of the training and testing activities for which the Navy is requesting incidental take authorizations is provided in the following sections. This request for LOAs is based on the proposed training and testing activities of the Navy's Preferred Alternative (Alternative 2 in the EIS/OEIS).

This document has been prepared in accordance with the applicable regulations of the MMPA, as amended by the National Defense Authorization Act for Fiscal Year 2004 (Public Law [PL] 108-136) and its implementing regulations. The request for LOAs is based on: (1) the analysis of spatial and temporal distributions of protected marine mammals in the HSTT Study Area (hereafter referred to as the Study Area), (2) the review of training and testing activities that have the potential to incidentally take marine mammals per the EIS/OEIS, and (3) a technical risk assessment to determine the likelihood of effects. This chapter describes those training and testing activities that are likely to result in Level B harassment, Level A harassment, or mortality under the MMPA. Of the Navy activities analyzed for the HSTT EIS/OEIS, the Navy has determined that only the use of active sonar, in-water detonations, and temporary pile driving and removal have the potential to affect marine mammals that may be present within the Study Area, and rise to the level of harassment under the MMPA. In addition to these potential impacts from specific activities, the Navy will also request takes from ship strikes that may occur during training or testing activities. These takes, however, are not specific to any particular training or testing activity.

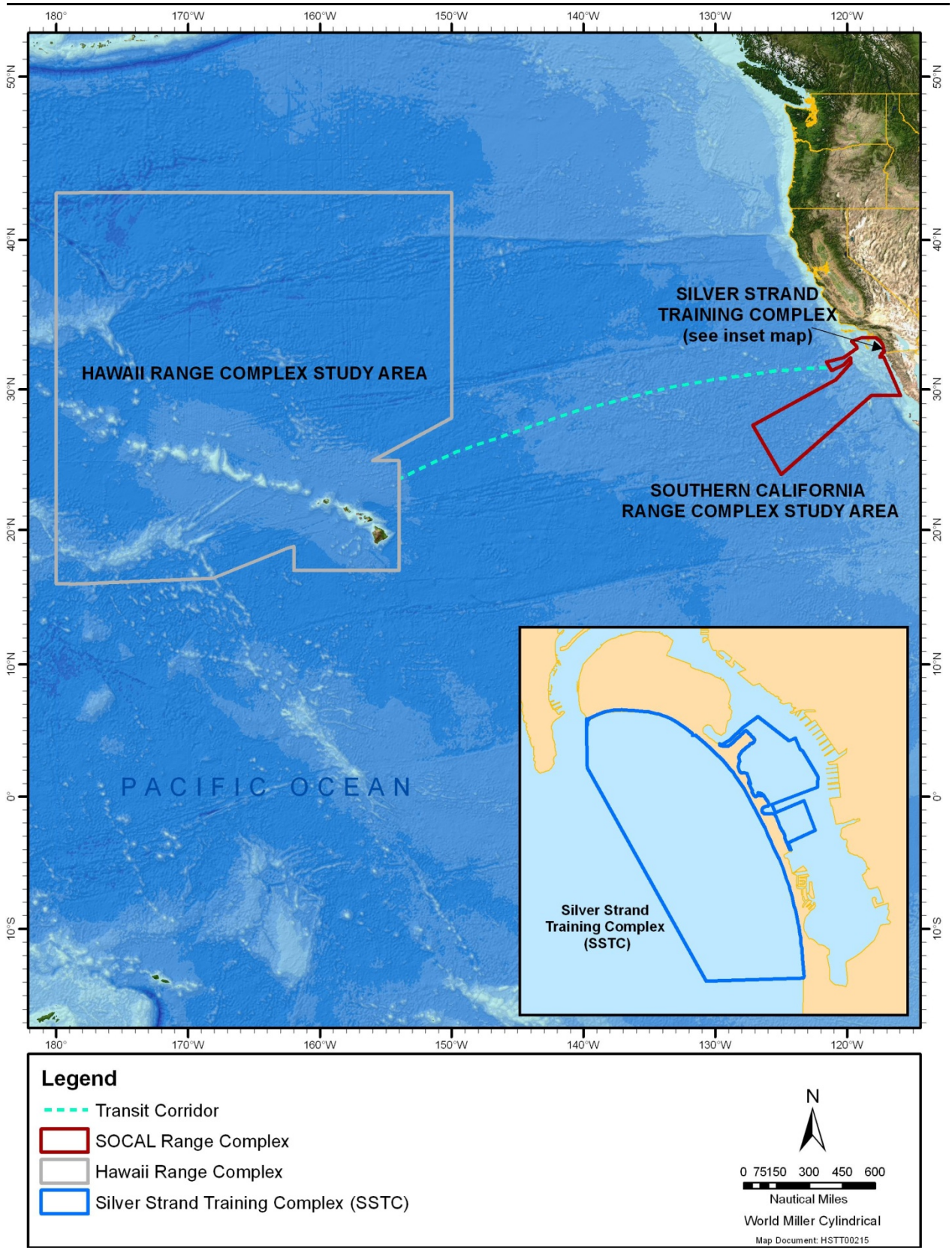

Figure 1-1: Hawaii-Southern California Training and Testing Study Area

1.2 BACKGROUND

The Navy's mission is to organize, train, equip, and maintain combat-ready naval forces capable of winning wars, deterring aggression, and maintaining freedom of the seas. This mission is mandated by federal law (Title 10 U.S.C. § 5062), which ensures the readiness of the naval forces of the United States.[1] The Navy executes this responsibility by establishing and executing training programs, including at-sea training and exercises, and ensuring naval forces have access to the ranges, operating areas, and airspace needed to develop and maintain skills for conducting naval activities. Further, the Navy's testing activities ensure naval forces are equipped with well-maintained systems that take advantage of the latest technological advances.

The Navy's research and acquisition community conducts military readiness activities that involve testing. The Navy tests ships, aircraft, weapons, combat systems, sensors and related equipment, and conducts scientific research activities to achieve and maintain military readiness.

To meet training, testing, and acquisition requirements, the Navy is preparing an EIS/OEIS to assess the potential environmental impacts associated with ongoing and proposed naval activities in the Study Area. The Navy is the lead agency for the HSTT EIS/OEIS, and National Marine Fisheries Service (NMFS) is a cooperating agency pursuant to 40 C.F.R. §§ 1501.6 and 1508.5.

In addition, in accordance with Section 7(c) of the Endangered Species Act (ESA) of 1973, as amended, the Navy is required to consult with NMFS for those actions it has determined may affect ESA-listed species or critical habitat.

1.3 OVERVIEW OF TRAINING ACTIVITIES

The Navy routinely trains in the HSTT Study Area in preparation for national defense missions. Training activities and exercises covered in this LOA request are briefly described below, and in more detail within the HSTT Draft EIS/OEIS (U.S. Department of the Navy 2012a). Each military training activity described meets a requirement that can be traced ultimately to requirements set forth by the National Command Authority.[2]

1.3.1 DESCRIPTION OF CURRENT TRAINING ACTIVITIES WITHIN THE STUDY AREA

The Navy categorizes training activities into functional warfare areas called primary mission areas. Training activities fall into eight primary mission areas (Anti-Air Warfare; Amphibious Warfare; Strike Warfare; Anti-Surface Warfare; Anti-Submarine Warfare; Electronic Warfare; Mine Warfare; Naval Special Warfare). Most training activities are categorized under one of these primary mission areas; those activities that do not fall within one of these areas are in a separate "other" category. Each warfare community (surface, subsurface, aviation, and special warfare) may train within some or all of these primary mission areas.

1 Title 10, Section 5062 of the United States Code provides: "The Navy shall be organized, trained, and equipped primarily for prompt and sustained combat incident to operations at sea. It is responsible for the preparation of Naval forces necessary for the effective prosecution of war except as otherwise assigned and, in accordance with Integrated Joint Mobilization Plans, for the expansion of the peacetime components of the Navy to meet the needs of war."
2 National Command Authority (NCA) is a term used by the United States military and government to refer to the ultimate lawful source of military orders. The term refers collectively to the President of the United States (as commander-in-chief) and the United States Secretary of Defense.

The Navy describes and analyzes the effects of its training activities within the HSTT Draft EIS/OEIS (U.S. Department of the Navy 2012a). In its assessment, the Navy concluded that for the HSTT Draft EIS/OEIS, sonar use, underwater detonations, and Elevated Causeway (ELCAS) pile driving and removal were the stressors most likely to result in impacts on marine mammals that could rise to the level of harassment as defined under the MMPA. Therefore, this LOA application provides the Navy's assessment of potential effects from these stressors in terms of the various warfare mission areas in which they would be conducted. In terms of Navy warfare areas, this includes:

- Amphibious Warfare (underwater detonations, ELCAS pile driving and removal)
- Anti-Surface Warfare (underwater detonations)
- Anti-Submarine Warfare (non-impulse sources, underwater detonations)
- Mine Warfare (non-impulse sources, underwater detonations)
- Naval Special Warfare (underwater detonations)

The Navy's activities in Anti-Air Warfare, Strike Warfare, and Electronic Warfare do not involve non-impulse sourcesuse, underwater detonations, pile driving, airguns, or any other stressors that could result in harassment of marine mammals. The activities in these warfare areas are therefore not considered further in this application. The analysis and rationale for excluding these warfare areas from this LOA application are contained in the Navy's HSTT EIS/OEIS.

1.3.1.1 Amphibious Warfare

The mission of amphibious warfare is to project military power from the sea to the shore through the use of naval firepower and Marine Corps landing forces. It is used to attack a threat located on land by a military force embarked on ships. Amphibious warfare operations include small unit reconnaissance or raid missions to large-scale amphibious operations involving multiple ships and aircraft combined into a strike group. Amphibious warfare training ranges from individual, crew, and small unit events to large task force exercises. Individual and crew training include amphibious vehicles and naval gunfire support training. Such training includes shore assaults, boat raids, airfield or port seizures, and reconnaissance. Large-scale amphibious exercises involve ship-to-shore maneuver, naval fire support, such as shore bombardment, and air strike and close air support training. However, only those portions of amphibious warfare training that occur at sea were analyzed, in particular, underwater detonations associated with naval gunfire support training. The Navy conducts other amphibious warfare support activities in the near shore region from the beach to approximately 1,000 yards (yds.) (914 m) from shore that could potentially impact marine mammals. This includes pile driving associated with temporary ELCAS installation and removal which is analyzed in this application.

1.3.1.2 Anti-Surface Warfare

The mission of anti-surface warfare is to defend against enemy ships or boats. In the conduct of anti-surface warfare, aircraft use cannons, air-launched cruise missiles or other precision-guided munitions; ships employ torpedoes, naval guns, and surface-to-surface missiles; and submarines attack surface ships using torpedoes or submarine-launched, anti-ship cruise missiles. Anti-surface warfare training includes surface-to-surface gunnery and missile exercises, air-to-surface gunnery and missile exercises, and submarine missile or exercise torpedo launch events.

1.3.1.3 Anti-Submarine Warfare

The mission of anti-submarine warfare is to locate, neutralize, and defeat hostile submarine threats to surface forces. Anti-submarine warfare is based on the principle of a layered defense of surveillance and

attack aircraft, ships, and submarines all searching for hostile submarines. These forces operate together or independently to gain early warning and detection, and to localize, track, target, and attack hostile submarine threats. Anti-submarine warfare training addresses basic skills such as detection and classification of submarines, distinguishing between sounds made by enemy submarines and those of friendly submarines, ships, and marine life. More advanced, integrated anti-submarine warfare training exercises are conducted in coordinated, at-sea training events involving submarines, ships, and aircraft. This training integrates the full spectrum of anti-submarine warfare from detecting and tracking a submarine to attacking a target using either exercise torpedoes or simulated weapons.

1.3.1.4 Mine Warfare

The mission of mine warfare is to detect, and avoid or neutralize mines to protect Navy ships and submarines and to maintain free access to ports and shipping lanes. Mine warfare also includes offensive mine laying to gain control or deny the enemy access to sea space. Naval mines can be laid by ships (including purpose-built minelayers), submarines or aircraft. Mine warfare training includes exercises in which ships, aircraft, submarines, underwater vehicles, or marine mammal detection systems search for mines. Explosive Ordnance Disposal personnel train to destroy or disable mines by attaching and detonating underwater explosives to simulated mines. Other neutralization techniques involve impacting the mine with a bullet-like projectile or intentionally triggering the mine to detonate.

1.3.1.5 Naval Special Warfare

The mission of naval special warfare is to conduct unconventional warfare, direct action, combat terrorism, special reconnaissance, information warfare, security assistance, counter-drug operations, and recovery of personnel from hostile situations. Naval special warfare operations are highly specialized and require continual and intense training. Naval special warfare units are required to utilize a combination of specialized training, equipment, and tactics, including insertion and extraction operations using parachutes, submerged vehicles, rubber boats, and helicopters; boat-to-shore and boat-to-boat gunnery; underwater demolition training; reconnaissance; and small arms training.

1.4 Overview of Testing Activities

Testing activities covered in this LOA request are briefly described below, and in more detail within the HSTT Draft EIS/OEIS (U.S. Department of the Navy 2012a). Each military testing activity described meets a requirement that can be traced ultimately to requirements set forth by the National Command Authority.

1.4.1 Description of Current Testing Activities within the Study Area

The Navy researches, develops, tests, and evaluates new platforms, systems and technologies. Many tests are conducted in realistic conditions at sea, and can range in scale from testing new software to operating portable devices to conducting tests of live weapons (such as the Service Weapon Test of a torpedo) to ensure they function as intended. Testing activities may occur independently of or in conjunction with training activities.

Many testing activities are conducted similarly to Navy training activities and are also categorized under one of the primary mission areas described above in Section 1.3.1. Other testing activities are unique and are described within their specific testing categories. Because each test is conducted by a specific component of the Navy's research and acquisition community, which includes the Navy's Systems Commands and the Navy's scientific research organizations, the testing activities described in this LOA

application are organized first by that particular organization as described below and in the order as presented.

The Navy describes and analyzes the effects of its testing activities within the HSTT Draft EIS/OEIS (U.S. Department of the Navy 2012a). In its assessment, the Navy concluded that for the HSTT Draft EIS/OEIS, acoustic stressors from the use of underwater acoustic sources and underwater detonations resulted in impacts on marine mammals that rose to the level of harassment as defined under the MMPA. Therefore, this LOA application provides the Navy's assessment of potential effects from these stressors in terms of the various activities in which they would be used.

In terms of these categories, Navy testing includes:

- Naval Air Systems Command (NAVAIR) Testing
    - Anti-Surface Warfare Testing (underwater detonations)
    - Anti-Submarine Warfare Testing (non-impulse sources, underwater detonations)
    - Mine Warfare Testing (non-impulse sources, underwater detonations)
- Naval Sea Systems Command (NAVSEA) Testing
    - New Ship Construction (non-impulse sources, underwater detonations)
    - Life Cycle Activities (non-impulse sources, underwater detonations)
    - Anti-Surface Warfare/ Anti-Submarine Warfare Testing (non-impulse sources, underwater detonations)
    - Mine Warfare Testing (non-impulse sources, underwater detonations)
    - Ship Protection Systems and Swimmer Defense Testing (acoustic, underwater detonations)
    - Unmanned Vehicle Testing (non-impulse sources)
    - Other Testing (non-impulse sources)
- Space and Naval Warfare Systems Command (SPAWAR) Testing
    - SPAWAR Research, Development, Test & Evaluation (non-impulse sources)
- Office of Naval Research (ONR) and Naval Research Laboratory (NRL) Testing
    - ONR/NRL Research, Development, Test & Evaluation (non-impulse sources)

Other Navy testing activities that do not involve underwater non-impulse sources or impulse sources that could result in harassment of marine mammals are not considered further in this application.

1.4.1.1 Naval Air Systems Command Testing

Naval Air Systems Command testing activities generally fall in the primary mission areas used by the fleets. Naval Air Systems Command events include, but are not limited to, the testing of new aircraft platforms, weapons, and systems before those platforms, weapons and systems are delivered to the fleet. In addition to the testing of new platforms, weapons, and systems, NAVAIR also conducts lot acceptance testing of weapons and systems, such as sonobuoys.

Many platforms (e.g., the P-8A Poseidon aircraft) and systems (e.g., the airborne laser mine detection system) currently being tested by NAVAIR will ultimately be integrated into fleet training activities. Training with systems and platforms transferred to the fleet within the 2014-2019 timeframe are analyzed in the training sections of this application. This section only addresses NAVAIR's testing activities.

For the most part, NAVAIR conducts its testing activities in the same way the fleet conducts its training activities. However, there are some distinctions. Naval Air Systems Command's testing activities may occur in different locations than equivalent fleet training activities, and the manner in which a test of a particular system is conducted may differ slightly from the way the fleet trains with the same system. Because of these distinctions, the analysis of NAVAIR's testing activities and the fleet's training activities may differ.

1.4.1.2 Anti-Surface Warfare Testing

The mission of anti-surface warfare is to defend against enemy ships or boats. In the conduct of anti-surface warfare, aircraft use cannons, air-launched rockets and missiles, or other precision-guided munitions. Anti-surface warfare testing includes air-to-surface gunnery and missile exercises.

Testing of anti-surface warfare systems is required to ensure the equipment used for defense from surface threats is fully functional under the conditions for which it will be used. Tests may be conducted on new guns or run rounds, missiles, and rockets. Testing of these systems may be conducted on new aircraft and on existing aircraft following maintenance, repair, or modification. For some systems, tests are conducted periodically to assess operability. Additionally, tests may be conducted in support of scientific research to assess new and emerging technologies. Testing events are often integrated into training activities and in most cases the systems are used in the same manner in which they are used for fleet training activities.

1.4.1.3 Anti-Submarine Warfare Testing

The mission of anti-submarine warfare is to locate, neutralize, and defeat hostile submarine threats to surface forces. Anti-submarine warfare is based on the principle of a layered defense of surveillance and attack aircraft, ships, and submarines all searching for hostile submarines. These forces operate together or independently to gain early warning and detection, and to localize, track, target, and attack hostile submarine threats. Anti-submarine warfare testing addresses basic skills such as detection and classification of submarines, distinguishing between sounds made by enemy submarines and those of friendly submarines, ships, and marine life. More advanced, integrated anti-submarine warfare testing is conducted in coordinated, at-sea training events involving submarines, ships, and aircraft. This testing integrates the full spectrum of anti-submarine warfare from detecting and tracking a submarine to attacking a target using various torpedoes and weapons.

1.4.1.4 Mine Warfare Testing

The mission of mine warfare is to detect, and avoid or neutralize mines to protect Navy ships and submarines and to maintain free access to ports and shipping lanes. Mine warfare also includes offensive mine laying by aircraft to gain control or deny the enemy access to sea space. Mine warfare testing includes activities in which aircraft detection systems are used to search for and record the location of mines for subsequent neutralization. Mine neutralization tests evaluate a system's effectiveness at intentionally detonating or otherwise disabling the mine. Different mine neutralization systems are designed to neutralize mines either at the sea surface or deployed deeper within the water column. One system uses a bullet-like projectile to disable or destroy the mine. Another system uses remotely operated vehicles to neutralized subsurface mines. All components of these systems are tested in the at-sea environment to ensure they meet mission requirements.

1.4.1.5 Naval Sea Systems Command Testing

Naval Sea Systems Command testing activities are aligned with its mission of new ship construction, life cycle support, and other weapon systems development and testing. Each major category of NAVSEA activities is described below.

1.4.1.6 New Ship Construction Activities

Ship construction activities include pierside testing of ship systems, tests to determine how the ship performs at sea (sea trials), and developmental and operational test and evaluation programs for new technologies and systems. Pierside and at-sea testing of systems aboard a ship may include sonar, acoustic countermeasures, radars, and radio equipment. During sea trials, each new ship propulsion engine is operated at full power and subjected to high-speed runs and steering tests. At-sea test firing of shipboard weapon systems, including guns, torpedoes, and missiles, are also conducted.

1.4.1.7 Life Cycle Activities

Testing activities are conducted throughout the life of a Navy ship to verify performance and mission capabilities. Sonar system testing occurs pierside during maintenance, repair, and overhaul availabilities, and at sea immediately following most major overhaul periods. A Combat System Ship Qualification Trial is conducted for new ships and for ships that have undergone modification or overhaul of their combat systems.

Radar cross signature testing of surface ships is conducted on new vessels and periodically throughout a ship's life to measure how detectable the ship is by radar. Additionally, electromagnetic measurements of off-board electromagnetic signature are conducted for submarines, ships, and surface craft periodically.

1.4.1.8 Other Weapon Systems Development and Testing

Numerous test activities and technical evaluations, in support of NAVSEA's systems development mission, often occur in conjunction with fleet activities within the Study Area. Tests within this category include, but are not limited to, anti-surface warfare, anti-submarine warfare, and mine warfare tests using torpedoes, sonobuoys, and mine detection and neutralization systems.

1.4.1.9 Space and Naval Warfare Systems Command Testing

Space and Naval Warfare Systems Command (SPAWAR) is the information dominance systems command for the United States Navy. The mission of SPAWAR is to acquire, develop, deliver and sustain decision superiority for the warfighter at the right time and for the right cost. SPAWAR Systems Center Pacific (SSC Pacific) is the research and development part of SPAWAR focused on developing and transitioning technologies in the area of command, control, communications, computers, intelligence, surveillance, and reconnaissance. SSC Pacific conducts research, development, test, and evaluation projects to support emerging technologies for intelligence, surveillance, and reconnaissance (ISR); anti-terrorism and force protection; mine countermeasures; anti-submarine warfare; oceanographic research; remote sensing; and communications. These activities include, but are not limited to, the testing of unmanned undersea and surface vehicles, a wide variety of ISR sensor systems, underwater surveillance technologies, and underwater communications.

While this LOA request describes the typical and anticipated SPAWAR test and evaluation activities to be conducted in the Study Area, unforeseen emergent Navy requirements may influence actual testing

activities. Activities that would occur under SPAWAR testing events have been identified to the extent practicable within this application.

1.4.1.10 Office of Naval Research and Naval Research Laboratory Testing

As the Navy's Science and Technology provider, ONR and NRL provide technology solutions for Navy and Marine Corps needs. The Office of Naval Research's mission, defined by law, is to plan, foster, and encourage scientific research in recognition of its paramount importance as related to the maintenance of future naval power, and the preservation of national security. Further, ONR manages the Navy's basic, applied, and advanced research to foster transition from science and technology to higher levels of research, development, test and evaluation. The Ocean Battlespace Sensing Department explores science and technology in the areas of oceanographic and meteorological observations, modeling, and prediction in the battlespace environment; submarine detection and classification (anti-submarine warfare); and mine warfare applications for detecting and neutralizing mines in both the ocean and littoral environment. The ONR events include: research, development, test, and evaluation activities; surface processes acoustic communications experiments; shallow water acoustic communications experiments; sediment acoustics experiments; shallow water acoustic propagation experiments; and long range acoustic propagation experiments. While this LOA request describes the typical and anticipated ONR test and experimentation activities to be conducted in the Study Area, unforeseen emergent Navy requirements and scientific advances may influence actual testing activities. Activities that would occur under ONR testing events have been identified and described to the extent possible within this application.

1.5 Description of Sonar, Ordnance, Targets, and Other Systems

The Navy uses a variety of sensors, platforms, weapons, and other devices, including ones used to ensure the safety of Sailors and Marines, to meet its mission. Training and testing with these systems may introduce acoustic (sound) energy into the environment. This section presents and organizes sonar systems, ordnance, munitions, targets, and other systems in a manner intended to facilitate understanding of the activities in which these systems are used. In this application underwater sound is described as one of two types; impulsive and non-impulsive. Underwater detonations of explosives and other percussive events are impulsive sounds. Sonar and similar sound producing systems are categorized as non-impulsive sound sources in this LOA application.

1.5.1 Sonar and Other Non-Impulsive Sources

Modern sonar technology includes a variety of sonar sensor and processing systems. In concept, the simplest active sonar emits sound waves, or "pings," sent out in multiple directions and the sound waves then reflect off of the target object in multiple directions. The sonar source calculates the time it takes for the reflected sound waves to return; this calculation determines the distance to the target object. More sophisticated active sonar systems emit a ping and then rapidly scan or listen to the sound waves in a specific area. This provides both distance to the target and directional information. Even more advanced sonar systems use multiple receivers to listen to echoes from several directions simultaneously and provide efficient detection of both direction and distance. It should be noted that active sonar is rarely used continuously throughout the listed activities. In addition, when sonar is in use, the sonar "pings" occur at intervals, referred to as a duty cycle, and the signals themselves are very short in duration. For example, sonar that emits a 1-second ping every 10 seconds has a 10 percent duty cycle. The Navy utilizes sonar systems and other acoustic sensors in support of a variety of mission requirements. Primary uses include the detection of and defense against submarines (anti-submarine

warfare) and mines (mine warfare); safe navigation and effective communications; use of unmanned undersea vehicles; and oceanographic surveys.

1.5.2 ORDNANCE/MUNITIONS

Most ordnance and munitions used during training and testing events fall into three basic categories: projectiles (such as gun rounds), missiles (including rockets), and bombs. Ordnance can be further defined by their net explosive weight, which considers the type and quantity of the explosive substance without the packaging, casings, bullets, etc. Net explosive weight (NEW) is the trinitrotoluene (TNT) equivalent of energetic material, which is the standard measure of strength of bombs and other explosives. For example, a 5-inch shell fired from a Navy gun is analyzed at approximately 9.5 lb. (4.3 kg) of NEW. The Navy also uses non-explosive ordnance in place of high explosive ordnance in many training and testing events. Non-explosive ordnance munitions look and perform similarly to high explosive ordnance, but lack the main explosive charge.

1.5.3 DEFENSIVE COUNTERMEASURES

Naval forces depend on effective defensive countermeasures to protect themselves against missile and torpedo attack. Defensive countermeasures are devices designed to confuse, distract, and confound precision guided munitions. Defensive countermeasures analyzed in this LOA application include acoustic countermeasures, which are used by surface ships and submarines to defend against torpedo attack. Acoustic countermeasures are either released from ships and submarines, or towed at a distance behind the ship.

1.5.4 MINE WARFARE SYSTEMS

Mine warfare systems fall into two broad categories, mine detection and mine neutralization.

1.5.4.1 Mine Detection Systems

Mine detection systems are used to locate, classify, and map suspected mines. Once located, the mines can either be neutralized or avoided. These systems are specialized to either locate mines on the surface, in the water column, or on the sea floor. The following mine detection systems were analyzed for this LOA application:

- **Towed or Hull-Mounted Mine Detection Systems.** These detection systems use acoustic and laser or video sensors to locate and classify suspect mines. Fixed and rotary wing platforms, ships, and unmanned vehicles are used for towed systems, which can rapidly assess large areas.
- **Unmanned/Remotely Operated Vehicles.** These vehicles use acoustic and video or lasers to locate and classify mines. Unmanned/remotely operated vehicles provide unique mine warfare capabilities in nearshore littoral areas, surf zones, ports, and channels.
- **Marine Mammal Systems.** The U.S. Navy deploys trained Atlantic bottlenose dolphins (*Tursiops truncatus*) and California sea lions (*Zalophus californianus*) for integrated training involving two primary mission areas: to find objects such as inert mine shapes, and to detect swimmers or other intruders around Navy facilities such as piers. These marine mammal systems also include one or more motorized small boats and several crew members for each trained marine mammal. When not engaged in the training activity, Navy marine mammals are either housed in temporary enclosures on land or aboard ships involved in training exercises. Sea lions are transported in boats and dolphins are transferred in boats or by swimming alongside the boat under the handler's control. Upon finding the 'target' of the search, the animal returns to the boat and alerts the animal handlers that an object or swimmer has been detected. In the case of

a detected object, the human handlers give the animal a marker that the animal can bite onto and carry down to place near the detected object. In the case of a detected swimmer, animals are given a localization marker or leg cuff that they are trained to deploy via a pressure trigger. After deploying the localization marker or leg cuff, the animal swims free of the area to return to the animal support boat. For detected objects, human divers or remote vehicles are deployed to recover the item. Swimmers that have been marked with a leg cuff are reeled in by security support boat personnel via a line attached to the cuff.

1.5.4.2 Mine Neutralization Systems

These systems disrupt, disable, or detonate mines to clear ports and shipping lanes, as well as littoral, surf, and beach areas in support of naval amphibious operations. Mine neutralization systems can clear individual mines or a large number of mines quickly. The following mine neutralization systems were analyzed for this LOA application:

- **Towed Influence Mine Sweep Systems.** These systems use towed equipment that mimic a particular ship's magnetic and acoustic signature triggering the mine and causing it to explode.
- **Unmanned/Remotely Operated Mine Neutralization Systems**. Surface ships and helicopters operate these systems, which place explosive charges near or directly against mines to destroy the mine.
- Airborne Projectile-based Mine Clearance System neutralizes mines by firing a small- or medium–caliber non-explosive, supercavitating projectile from a hovering helicopter.
- **Diver Emplaced Explosive Charges.** Operating from small craft, divers emplace explosive charges near or on mines to destroy the mine or disrupt its ability to function.

1.5.5 Classification of Non-Impulsive and Impulsive Sources Analyzed

In order to better organize and facilitate the analysis of approximately 300 individual sources of underwater non-impulsive sound or impulsive energy, a series of source classifications, or source bins, were developed. The use of source classification bins provides the following benefits:

- provides the ability for new sensors or munitions to be covered under existing authorizations, as long as those sources fall within the parameters of a "bin;"
- simplifies the source utilization data collection and reporting requirements anticipated under the MMPA;
- ensures a conservative approach to all impacts estimates, as all sources within a given class are modeled as the loudest source (lowest frequency, highest source level, longest duty cycle, or largest net explosive weight within that bin);
- allows analysis to be conducted in a more efficient manner, without any compromise of analytical results;
- provides a framework to support the reallocation of source usage (hours/explosives) between different source bins, as long as the total numbers of takes remain within the overall analyzed and authorized limits. This flexibility is required to support evolving Navy training and testing requirements, which are linked to real world events.

There are two primary types of source classes: non-impulsive and impulsive. A description of each source classification is provided in Tables 1-1 and 1-2. Non-impulsive sources are grouped into bins based on the frequency, source level when warranted, and the application in which the source would be used. Impulsive bins are based on the net explosive weight of the munitions or explosive devices.

The following factors further describe the considerations associated with the development of non-impulsive source bins:

- Frequency of the non-impulsive source:
  - Low-frequency sources operate below 1 kilohertz (kHz)
  - Mid-frequency sources operate at and above 1 kHz, up to and including 10 kHz
  - High-frequency sources operate above 10 kHz, up to and including 100 kHz
  - Very high-frequency sources operate above 100 kHz but below 200 kHz
- Source level of the non-impulsive source:
  - Greater than 160 decibels (dB), but less than 180 dB
  - Equal to 180 dB and up to 200 dB
  - Greater than 200 dB
- Application in which the source would be used:
  - How a sensor is employed supports how the sensor's acoustic emissions are analyzed.
  - Factors considered include pulse length (time source is on); beam pattern (whether sound is emitted as a narrow, focused beam, or, as with most explosives, in all directions); and duty cycle (how often or how many times a transmission occurs in a given time period during an event).

As described in the HSTT Draft EIS/OEIS (U.S. Department of the Navy 2012a), there are non-impulsive sources of low source level, narrow beam width, downward directed transmission, short pulse lengths, frequencies beyond known hearing ranges of marine mammals, or some combination of these factors that are not anticipated to result in takes of protected species and therefore were not modeled. These sources generally meet the following criteria and are qualitatively analyzed in this EIS/OEIS hereafter to determine the appropriate determinations under NEPA, MMPA, and ESA.

- Acoustic sources with frequencies greater than 200 kHz
- Sources with source levels less than 160 dB

1.5.6 Source Classes Analyzed for Training and Testing

For this LOA request, Table 1-1 shows the impulsive sources (e.g., underwater explosives) associated with Navy training and testing activities in the Study Area analyzed. Table 1-2 shows non-impulsive sources (e.g., sonar) associated with Navy training activities analyzed and Table 1-3 shows non-impulsive sources associated with Navy testing activities analyzed for this LOA request.

Table 1-1: Impulsive Training and Testing Source Classes Analyzed

Source Class	Representative Munitions	Net Explosive Weight (lbs)
E1	Medium-caliber projectiles	0.1-0.25
E2	Medium-caliber projectiles	0.26-0.5
E3	Large-caliber projectiles	>0.5-2.5
E4	Improved Extended Echo Ranging Sonobuoy	>2.5-5.0
E5	5 in. projectiles	>5-10
E6	15 lb. shaped charge	>10-20
E7	40 lb. demo block/shaped charge	>20-60
E8	250 lb. bomb	>60-100
E9	500 lb. bomb	>100-250
E10	1,000 lb. bomb	>250-500
E11	650 lb. mine	>500-650
E12	2,000 lb. bomb	>650-1,000
E13	1,200 lb. HBX charge	>1,000-1,740

Table 1-2: Non-Impulsive Training Source Classes Analyzed

Source Class Category	Source Class	Description
Mid-Frequency (MF): Tactical and non-tactical sources that produce mid-frequency (1 to 10 kHz) signals	**MF1**	Active hull-mounted surface ship sonar (e.g., AN/SQS-53C and AN/SQS-60)
	MF1K	Kingfisher object avoidance mode associated with MF1 sonar
	MF2	Active hull-mounted surface ship sonar (e.g., AN/SQS-56)
	MF2K	Kingfisher mode associated with MF2 sonar
	MF3	Active hull-mounted submarine sonar (e.g., AN/BQQ-10)
	MF4	Active helicopter-deployed dipping sonar (e.g., AN/AQS-22 and AN/AQS-13)
	MF5	Active acoustic sonobuoys (e.g., AN/SSQ-62 DICASS)
	MF6	Active underwater sound signal devices (e.g., MK-84)
	MF11	Hull-mounted surface ship sonar with an active duty cycle greater than 80%
	MF12	High duty cycle – variable depth sonar
High-Frequency (HF) and Very High-Frequency (VHF): Tactical and non-tactical sources that produce high-frequency (greater than 10 kHz but less than 200 kHz) signals	**HF1**	Active hull-mounted submarine sonar (e.g., AN/BQQ-15)
	HF4	Active mine detection, classification, and neutralization sonar (e.g., AN/SQS-20)

Table 1-2: Non-Impulsive Training Source Classes Analyzed (continued)

Source Class Category	Source Class	Description
Mid-Frequency (MF): Tactical and non-tactical sources that produce mid-frequency (1 to 10 kHz) signals	**MF1**	Active hull-mounted surface ship sonar (e.g., AN/SQS-53C and AN/SQS-60)
	MF1K	Kingfisher object avoidance mode associated with MF1 sonar
	MF2	Active hull-mounted surface ship sonar (e.g., AN/SQS-56)
	MF2K	Kingfisher mode associated with MF2 sonar
	MF3	Active hull-mounted submarine sonar (e.g., AN/BQQ-10)
	MF4	Active helicopter-deployed dipping sonar (e.g., AN/AQS-22 and AN/AQS-13)
	MF5	Active acoustic sonobuoys (e.g., AN/SSQ-62 DICASS)
	MF6	Active underwater sound signal devices (e.g., MK-84)
	MF11	Hull-mounted surface ship sonar with an active duty cycle greater than 80%
	MF12	High duty cycle – variable depth sonar
High-Frequency (HF) and Very High-Frequency (VHF): Tactical and non-tactical sources that produce high-frequency (greater than 10 kHz but less than 200 kHz) signals	**HF1**	Active hull-mounted submarine sonar (e.g., AN/BQQ-15)
	HF4	Active mine detection, classification, and neutralization sonar (e.g., AN/SQS-20)
Anti-Submarine Warfare (ASW): Tactical sources such as active sonobuoys and acoustic countermeasures systems used during ASW training activities	**ASW1**	MF active Deep Water Active Distributed System (DWADS)
	ASW2	MF active Multistatic Active Coherent (MAC) sonobuoy (e.g., AN/SSQ-125)
	ASW3	MF active towed active acoustic countermeasure systems (e.g., AN/SLQ-25 NIXIE)
	ASW4	MF active expendable active acoustic device countermeasures (e.g., MK-3)
Torpedoes (TORP): Source classes associated with active acoustic signals produced by torpedoes	**TORP1**	HF active lightweight torpedo sonar (e.g., MK-46, MK-54, or Anti-Torpedo Torpedo)
	TORP2	HF active heavyweight torpedo sonar (e.g., MK-48)

Table 1-3: Non-Impulsive Testing Source Classes Analyzed

Source Class Category	Source Class	Description
Low-Frequency (LF): Sources that produce low-frequency (less than 1 kilohertz [kHz]) signals	**LF4**	Low-frequency sources equal to 180 dB and up to 200 dB
	LF5	Low-frequency sources less than 180 dB
	LF6	Low-frequency sonar currently in development (e.g., anti-submarine warfare sonar associated with the Littoral Combat Ship)
Mid-Frequency (MF): Tactical and non-tactical sources that produce mid-frequency (1 to 10 kHz) signals	**MF1**	Hull-mounted surface ship sonar (e.g., AN/SQS-53C and AN/SQS-60)
	MF1K	Kingfisher mode associated with MF1 sonar (Sound Navigation and Ranging)
	MF2	Hull-mounted surface ship sonar (e.g., AN/SQS-56)
	MF3	Hull-mounted submarine sonar (e.g., AN/BQQ-10)
	MF4	Helicopter-deployed dipping sonar (e.g., AN/AQS-22 and AN/AQS-13)
	MF5	Active acoustic sonobuoys (e.g., DICASS)
	MF6	Active underwater sound signal devices (e.g., MK-84)
	MF8	Active sources (greater than 200 dB)
	MF9	Active sources (equal to 180 dB and up to 200 dB)
	MF10	Active sources (greater than 160 dB, but less than 180 dB) not otherwise binned
	MF12	High duty cycle – variable depth sonar
High-Frequency (HF) and Very High-Frequency (VHF): Tactical and non-tactical sources that produce high-frequency (greater than 10 kHz but less than 200 kHz) signals	**HF1**	Hull-mounted submarine sonar (e.g., AN/BQQ-10)
	HF3	Hull-mounted submarine sonar (classified)
	HF4	Mine detection, classification, and neutralization sonar (e.g., AN/SQS-20)
	HF5	Active sources (greater than 200 dB)
	HF6	Active sources (equal to 180 dB and up to 200 dB)
Anti-Submarine Warfare (ASW): Tactical sources such as active sonobuoys and acoustic countermeasures systems used during the conduct of anti-submarine warfare testing activities	**ASW1**	Mid-frequency Deep Water Active Distributed System (DWADS)
	ASW2	Mid-frequency Multistatic Active Coherent sonobuoy (e.g., AN/SSQ-125)
	ASW2H	Mid-frequency Multistatic Active Coherent sonobuoy (e.g., AN/SSQ-125) – Sources that are analyzed by hours
	ASW3	Mid-frequency towed active acoustic countermeasure systems (e.g., AN/SLQ-25)
	ASW4	Mid-frequency expendable active acoustic device countermeasures (e.g., MK-3)
Torpedoes (TORP): Source classes associated with the active acoustic signals produced by torpedoes	**TORP1**	Lightweight torpedo (e.g., MK-46, MK-54, or Anti-Torpedo Torpedo)
	TORP2	Heavyweight torpedo (e.g., MK-48)
Acoustic Modems (M): Systems used to transmit data acoustically through water	**M3**	Mid-frequency acoustic modems (greater than 190 dB)
Swimmer Detection Sonar (SD): Systems used to detect divers and submerged swimmers	**SD1 – SD2**	High-frequency sources with short pulse lengths, used for the detection of swimmers and other objects for the purpose of port security.

Table 1-3: Non-Impulsive Testing Source Classes Analyzed (continued)

Source Class Category	Source Class	Description
Airguns (AG): Underwater airguns are used during swimmer defense and diver deterrent training and testing activities	**AG**	Up to 60 cubic inch airguns (e.g., Sercel Mini-G)
Synthetic Aperture Sonar (SAS): Sonar in which active acoustic signals are post-processed to form high-resolution images of the seafloor	**SAS1**	MF SAS systems
	SAS2	HF SAS systems
	SAS3	VHF SAS systems

1.5.7 Source Classes Excluded From Quantitative Analysis for Training and Testing

An entire source class, or some sources from a class, are excluded from quantitative analysis within the scope of this LOA request if any of the following criteria are met:

- The source is expected to result in responses that are short term and inconsequential.
- The sources operate at frequencies greater than 200 kHz.
- The sources operate at source levels less than 160 dB.
- Bins contain sources needed for safe operation and navigation.

Table 1-4 presents a description of the sources and source bins that the Navy excluded from quantitative analysis and the reasons for those exclusions.

Table 1-4: Source Classes Excluded from Quantitative Analysis

Source Class Category	Source Class	Justification
Doppler Sonar (DS)/ Speed Logs Navigation equipment, downward focused, narrow beamwidth, HF/VHF spectrum utilizing very short pulse length pulses.	**DS2, DS3, DS4**	Marine mammals are expected to exhibit no more than short-term and inconsequential responses to the sonar, profiler or pinger given the source's characteristics (e.g., narrow downward-directed beam), which is focused directly beneath the platform. Such reactions are not considered to constitute "taking" and, therefore, no additional allowance is included for animals that might be affected by these sound sources.
Fathometers (FA) High-frequency sources used to determine water depth	**FA1, FA2, FA3, FA4**	Marine mammals are expected to exhibit no more than short-term and inconsequential responses to the fathometer, given its characteristics (e.g., narrow downward-directed beam). Such reactions are not considered to constitute "taking" and, therefore, no additional allowance is included for animals that might be affected by these sound sources. Fathometers generate a downward looking narrowly focused beam directly below the vessel (typically much less than 30 degrees), using a short pulse length (less than 10 msec). Use of fathometers is required for safe operation of Navy vessels.
Hand-held Sonar (HHS) High-frequency sonar devices used by Navy divers for object location	**HHS1**	Hand-held sonar generate very high frequency sound at low power levels (150 – 178 dB re 1 [mu] Pascal), short pulse lengths, and narrow beam widths. Because output from these sound sources would attenuate to below any current threshold for protected species within approximately 10-15 m, and they are under positive control of the diver on which direction the sonar is pointed, noise impacts are not anticipated and are not addressed further in this analysis.
Imaging Sonar (IMS) HF or VHF, very short pulse lengths, narrow bandwidths. IMS1 is a side scan sonar (HF/VHF, narrow beams, downward directed). IMS2 is a downward looking source, narrow beam, and operates above 200 kHz (basically a fathometer)	**IMS1, IMS2**	These side scan sonar operate in a very high frequency range (over 120 kHz) relative to marine mammal hearing (Richardson et al. 1995; Southall et al. 2007). The frequency range from these side scan sonar is beyond the hearing range of mysticetes (baleen whales) and pinnipeds, and, therefore, not expected to affect these species in the HSTT Study Area. The frequency range from these side scan sonar falls within the upper end of odontocete (toothed whale) hearing spectrum (Richardson et al. 1995), which means that they are not perceived as loud acoustic signals with frequencies below 120 kHz by these animals. Therefore, these animals would not react to the sound in a biologically significant way. Further, in addition to spreading loss for acoustic propagation in the water column, high frequency acoustic energies are more quickly absorbed through the water column than sounds with lower frequencies (Urick 1983). Additionally, these systems are generally operated in the vicinity of the sea floor, thus reducing the sound potential of exposure even more. Marine mammals are expected to exhibit no more than short-term and inconsequential responses to the IMS given their characteristics (e.g., narrow downward-directed beam and short pulse length (generally 20 msec). Such reactions are not considered to constitute "taking" and, therefore, no additional allowance is included for animals that might be affected by these sound sources.
High Frequency Acoustic Modems and Tracking Pingers	**M2, P1, P2, P3, P4,**	As determined for the Ocean Observatories Initiative for multi-beam echo sounder, SBP, altimeters, acoustic modems, and tracking pingers operating at frequencies between 2 and 170 kHz, fish and marine mammals would not be disturbed by any of these proposed acoustic sources given their low duty cycles (single pings in some cases), short pulse lengths (typically 20 msec), the brief period when an individual animal would potentially be within the very narrow beam of the source, and the relatively low source levels of the pingers and acoustic modems. Marine mammals are expected to exhibit no more than short-term and inconsequential responses to these systems given their characteristics. Such reactions are not considered to constitute "taking" and, therefore, no additional allowance is included for animals that might be affected by these sound sources.
Acoustic Releases (R) Systems that transmit active acoustic signals to release a bottom-mounted object from its housing in order to retrieve the device at the surface	**R1, R2, R3**	Mid-frequency acoustic release (up to 190 dB) and high-frequency acoustic release (up to 225 dB). Since these are only used to retrieve bottom mounted devices they are typically only a single ping. Marine mammals are expected to exhibit no more than short-term and inconsequential responses to these sound sources given that any sound emitted is extremely minimal. Such reactions are not considered to constitute "taking" and, therefore, no additional allowance is included for animals that might be affected by these sound sources.
Side Scan Sonar (SSS) Sonar that use active acoustic signals to produce high-resolution images of the seafloor	**SSS1, SSS2, SSS3**	Marine mammals are expected to exhibit no more than short-term and inconsequential responses to these systems given their characteristics such as a downward-directed beam and using short pulse lengths (less than 20 msec). Such reactions are not considered to constitute "taking" and, therefore, no additional allowance is included for animals that might be affected by these sound sources.

1.6 PROPOSED ACTION

The Navy proposes to continue conducting training and testing activities within the HSTT study area. The Navy has been conducting military readiness training and testing activities in the HSTT Study Area since the 1940s. Recently, these activities were analyzed in three separate EISs completed between 2008 and 2011; the Hawaii Range Complex (HRC) EIS/OEIS (U.S. Department of the Navy 2008a), the Southern California (SOCAL) Range Complex EIS/OEIS (U.S. Department of the Navy 2008b), and the Silver Strand Training Complex (SSTC) EIS (U.S. Department of the Navy 2011a). These documents, among others, and their associated MMPA authorizations, describe the baseline of training and testing activities currently conducted in the Study Area.

The tempo and types of training and testing activities have fluctuated due to changing requirements; the introduction of new technologies; the dynamic nature of international events; advances in warfighting doctrine and procedures; and changes in basing locations for ships, aircraft, and personnel (force structure changes). Such developments have influenced the frequency, duration, intensity, and location of required training and testing.

1.6.1 STUDY AREA ADDITIONS

The Hawaii-Southern California Training and Testing (HSTT) Study Area (Study Area) (Figure 1-2) is comprised of established operating and warning areas across the north-central Pacific Ocean, from Southern California west to Hawaii and the International Date Line. The Study Area includes three existing range complexes: the SOCAL Range Complex, HRC, and SSTC. In addition to these range complexes, the Study Area also includes Navy pierside locations where sonar maintenance and testing activities occur, and transit corridors on the high seas that are not part of the range complexes, where training and sonar testing may occur during vessel transit.

The Study Area has slightly expanded beyond the areas included in previous Navy authorizations. This expansion of the Study Area from previous analyses is not an increase in areas where the Navy will train and test, but is merely an expansion of the area to be included in the incidental take authorization in support of the HSTT EIS/OEIS.

- Transit Corridor**:** Another area not previously analyzed is the open ocean between Southern California and Hawaii. Within this area, Navy ships frequently transit, and during those transits conduct limited training and testing. The Navy will include these activities along this transit corridor in this request. The portion of the Transit Corridor to the east of 140° west longitude will be included in the SOCAL activities and the area to the west of that meridian will be included in the HRC activities since these portions of the corridor correspond with the stocks in those range complexes.
- Navy Piers and Shipyards**:** The Navy conducts some sonar system testing at Navy ports (San Diego, Pearl Harbor), Navy shipyards (Pearl Harbor), and contractor shipyards (San Diego). These sonar maintenance and testing activities would be included in this request.
- San Diego Bay**:** Ships berthed at Naval Base San Diego transit the San Diego Bay to and from the naval base. During these transits, some sonar maintenance testing could occur.

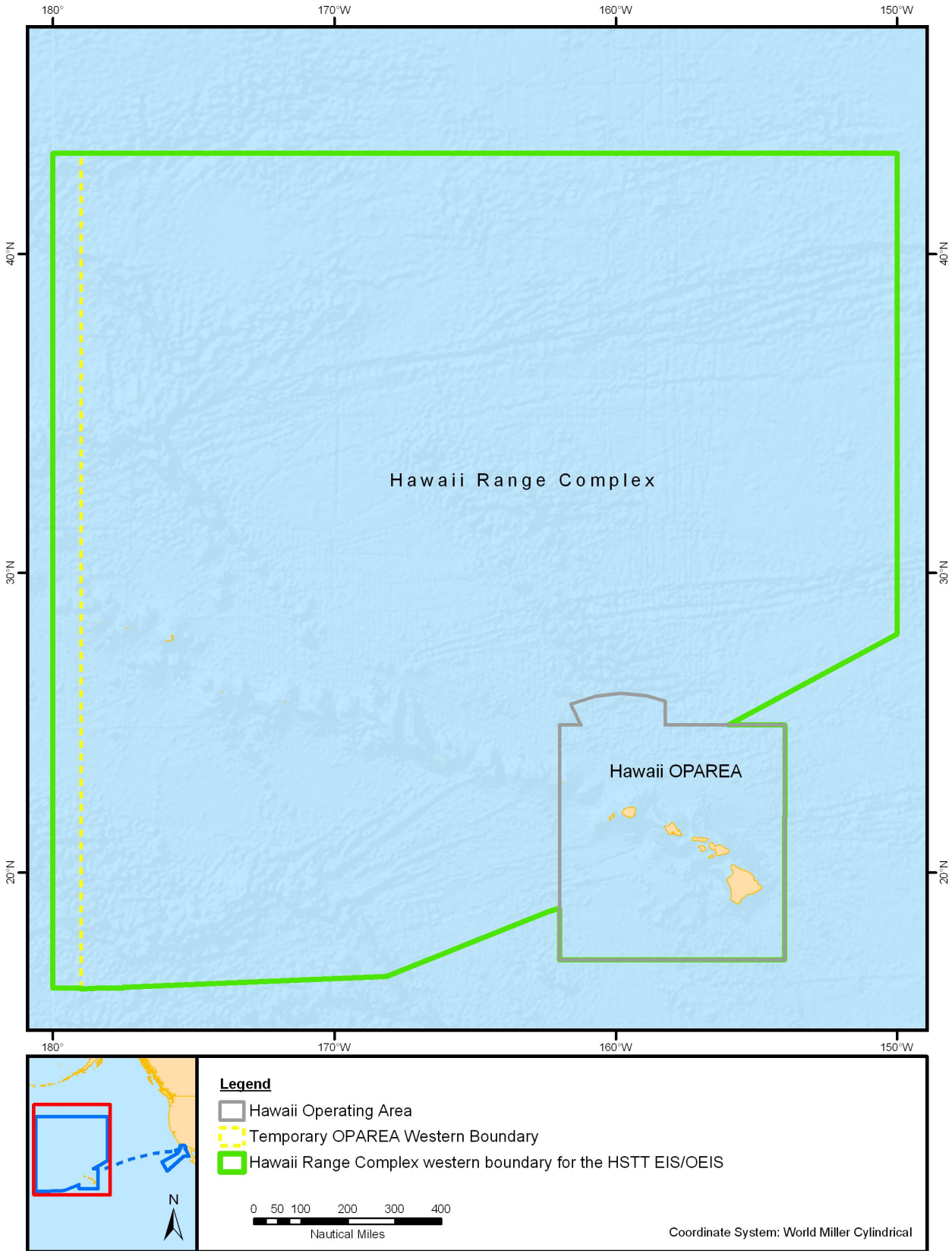

Figure 1-2: The Hawaii-Southern California Training and Testing Study Area

1.6.2 TRAINING

The training activities that the Navy proposes to conduct in the Study Area are described in Table 1-5. The table is organized according to primary mission areas and includes the activity name, associated stressor(s), description of the activity, the primary platform used (e.g. ship or aircraft type), duration of activity, amount of non-impulsive sound or explosives used in the activity, the areas where the activity is conducted, and the number of activities per year. More detailed activity descriptions can be found in the HSTT EIS/OEIS. The Navy's Proposed Action is an adjustment to existing baseline training activities, as defined in the HRC EIS/OEIS (U.S. Department of the Navy 2008a), the SOCAL Range Complex EIS/OEIS (U.S. Department of the Navy 2008b), and the SSTC EIS (U.S. Department of the Navy 2011a), combines with change in training needed due to force changes and slight modifications to previous study areas.

The Navy's Proposed Action includes changes to training requirements necessary to accommodate:

- Force structure changes including the relocation of ships, aircraft, and personnel. As forces are moved within the existing Navy structure, training needs will necessarily change as the location of forces change.
- Planned new aircraft platforms, new vessel classes, and new weapons systems.
- Ongoing training activities that were not addressed in previous documentation.

Finally, the Proposed Action includes the establishment of new range capabilities, such as hydrophone modifications, upgrades and replacement at instrumented Navy underwater tracking ranges.

Table 1-5: Training Activities Within the Study Area

Category	Training Event	Description	Weapons/Rounds/ Sound Source	Annual HSTT Events
Amphibious Warfare				
Impulsive	Fire Support Exercise-at Sea (FIREX at Sea)	Surface ship uses large-caliber gun to support forces ashore; however, land target simulated at sea. Rounds impact water and are scored by passive acoustic hydrophones located at or near target area.	Large-caliber HE rounds	12 (HRC only)
Impulsive	Elevated Causeway System (ELCAS)	A pier is constructed off of the beach. Piles are driven into the bottom with an impact hammer. Piles are removed from seabed via vibratory extractor. Only in-water impacts are analyzed.	Impact hammer or vibratory extractor	4 (SOCAL only)
Anti-Surface Warfare				
Impulsive	Gunnery Exercise (Surface-to-Surface) Ship – Medium-caliber (GUNEX [S-S] – Ship) Medium caliber	Surface ship crews engage surface targets with medium-caliber guns	Medium- and large-caliber HE and non-HE rounds	240
Impulsive	Gunnery Exercise (Surface-to-Surface) Ship – Large caliber (GUNEX [S-S] – Ship) Large-caliber	Surface ships engage surface targets with ship's large-caliber guns	Large-caliber HE rounds	266

Table 1-5: Training Activities Within the Study Area (continued)

Category	Training Event	Description	Weapons/Rounds/ Sound Source	Annual HSTT Events
Anti-Surface Warfare (continued)				
Impulsive	Gunnery Exercise Surface-to-Surface (Boat) – Medium-caliber (GUNEX-S-S [Boat])- Medium caliber	Small boat crews engage surface targets with medium-caliber weapons	Medium-caliber projectiles and crew's using grenades	24
Impulsive	Missile Exercise (Surface-to-Surface) (MISSILEX [S-S])	Surface ship crews defend against and other surface ships with missiles	Anti-surface missile, such as Harpoon	16
Impulsive	Gunnery Exercise (Air-to-Surface) (GUNEX [A-S])	Fixed-wing or helicopter fires small- and medium-caliber guns to engage surface targets	Small- and medium-caliber weapons	230
Impulsive	Missile Exercise (Air-to-Surface) – Rocket (MISSILEX [A-S] – Rocket)	Fixed-wing or helicopter fires guided and unguided rockets against surface targets	Guided and unguided rockets	150
Impulsive	Missile Exercise (Air-to-Surface) (MISSILEX [A-S])	Fixed-wing or helicopter fires precision-guided missiles against surface targets	Anti-surface missile, such as HELLFIRE, Maverick, or TOW missiles	271
Impulsive	Bombing Exercise (Air-to-Surface) (BOMBEX [A-S])	Fixed-wing aircraft drop bombs against surface targets	Guided and unguided bombs	153
Non-impulsive, Impulsive	Sinking Exercise (SINKEX)	Aircraft, ship, and submarines use ordnance on surface target, usually deactivated ship, which is deliberately sunk using multiple weapons	A variety of weapons, which may include: Maverick missile, MK-80 series bombs, large-caliber weapons, MK-48 torpedo	8
Anti-Submarine Warfare				
Non-impulsive	Tracking Exercise/ Torpedo Exercise-Submarine	Submarine searches, detects, and tracks submarine(s) and surface ship(s). Exercise torpedo may be used.	BQQ-10 sonar, Submarine HF, MK-48 torpedo or exercise torpedo	80 TORPEX 117 TRACKEX
Non-impulsive	Tracking Exercise/ Torpedo Exercise-Surface (DDG/CG)	Surface ship searches, tracks, and detects submarine(s). Exercise torpedo may be used.	SQS-53 sonar, NIXIE, MK-46/MK-54 torpedo or exercise torpedo	52 TORPEX 568 TRACKEX
Non-impulsive	Tracking Exercise/ Torpedo Exercise-Surface (FFG)	Surface ship searches, tracks, and detects submarine(s). Exercise torpedo may be used during this event.	SQS-56 sonar, NIXIE, MK-46/MK-54 torpedo or exercise torpedo	16 TORPEX 102 TRACKEX
Non-impulsive	Tracking Exercise/ Torpedo Exercise-Surface (LCS)	Surface ship searches, tracks, and detects submarine(s). Exercise torpedo may be used during this event.	HDC-VDS, DWADS MK-46/MK-54 exercise torpedo	20 HDC-VDS events 56 DWADS events

Table 1-5: Training Activities Within the Study Area (continued)

Stressor	Training Event	Description	Weapons/Rounds/ Sound Source	Annual HSTT Events
Anti-Submarine Warfare (continued)				
Non-impulsive	Tracking Exercise/Torpedo Exercise-Helicopter	Helicopter searches, tracks, and detects submarine(s). Exercise torpedo may be used.	AQS-22 Dipping sonar, DICASS sonobuoys, MK-46/MK-54 exercise torpedo	12 TORPEX 787 TRACKEX
Non-impulsive	Tracking Exercise/Torpedo Exercise-Maritime Patrol Aircraft	Maritime patrol aircraft use sonobuoys to search, detect, and track submarine(s). Exercise torpedo may be used.	DICASS sonobuoys, MK-46/MK-54 Exercise torpedo	44 TORPEX 368 TRACKEX
Non-impulsive, Impulsive	Tracking Exercise-Maritime Patrol Aircraft Extended Echo Ranging Sonobuoys	Maritime patrol aircraft search, detect, and track submarine(s) using explosive source sonobuoys or multistatic active coherent system	IEER sonobuoys AEER sonobuoys	144
Non-impulsive	Kilo Dip-Helicopter	Helicopter briefly deploy dipping Acoustic Sources to ensure system's operational status	AQS-22 Dipping Sonar	1,060 (SOCAL only)
Major Training Events				
Non-impulsive	Submarine Command Course (SCC) Operations	Train prospective submarine Commanding Officers to operate against surface, air, and subsurface threats.	BQQ-10 sonar, Submarine HF sonar, ADC, NAE, MK-48 exercise torpedoes	2 (HRC only)
Non-impulsive, Impulsive	Composite Training Unit Exercise	Intermediate level exercise designed to train cohesive Strike Group prior to deployment or Joint Task Force Exercise. Typically multiple surface ships, helicopters, maritime patrol aircraft, submarines, and various unmanned vehicles.	Various sonar, acoustic deterrents, NIXIE, sonobuoys	4 (SOCAL only)
Non-impulsive, Impulsive	Joint Task Force Exercise/ Sustainment Exercise	Final fleet exercise prior Strike Group deployment. Serves as ready-to-deploy certification for all units. Typically multiple surface ships, helicopters, maritime patrol aircraft, submarines, and various unmanned vehicle.	Various sonar, acoustic deterrents, NIXIE, sonobuoys	6 (SOCAL only)
Non-impulsive, Impulsive	Rim of the Pacific Exercise	Biennial multinational training exercise in which navies from Pacific Rim nations and United Kingdom assemble in Pearl Harbor, Hawaii to conduct training throughout the Hawaiian Islands in a number of warfare areas. RIMPAC events are non-annual.	Various sonar, acoustic deterrents, NIXIE, sonobuoys	1 (non-annual)
Non-impulsive	Integrated Anti-Submarine Warfare Course Phase II	Multiple ships, aircraft, and submarines train to integrate use of multiple sensors to search, detect, and track submarine(s). IAC is an intermediate level at-sea training event and can occur in conjunction with other major exercises.	Various sonar, acoustic deterrents, NIXIE, sonobuoys	4

Table 1-5: Training Activities Within the Study Area (continued)

Stressor	Training Event	Description	Weapons/Rounds/ Sound Source	Annual HSTT Events
Mine Warfare				
Non-impulsive	Group Sail	Multiple ships and helicopters train to integrate use of sensors to search, detect, and track submarine(s). Group Sails not dedicated ASW only events and involve multiple warfare areas.	Various sonar, acoustic deterrents, NIXIE, sonobuoys	10
Non-impulsive, Impulsive	Undersea Warfare Exercise	Multiple ships, aircraft and submarines train to integrate use of multiple sensors to search, detect, and track submarine(s). ASW specific tracking events occur over multiple days.	Various sonar, acoustic deterrents, NIXIE, sonobuoys	5 (HRC only)
Non-impulsive, Impulsive	Multi-Strike Group Exercise	Multiday exercise in which up to three strike groups conduct training exercises simultaneously. Training occurs in multiple warfare areas.	Various sonar, acoustic deterrents, NIXIE, sonobuoys	1 (HRC only)
Non-impulsive	Ship ASW Readiness and Evaluation Measuring (SHAREM)	Multiday exercise involving multiple ships, submarines, and aircraft in several coordinated events. Used to “assess” surface ship ASW readiness and effectiveness.	Various sonar, acoustic deterrents, NIXIE, sonobuoys	2 (SOCAL only)
Mine Warfare				
Non-impulsive	Mine Countermeasure Exercise-MCM Sonar-Ship Sonar	Surface ship detect and avoid mines shapes while navigating restricted areas or channels using active sonar	SQS-53 or SQS-56 sonar	122
Non-impulsive	Mine Countermeasure Exercise-Surface (SMCMEX)	Surface ship (MCM, LCS) detect, locate, identify, and avoid mines while navigating restricted areas or channels using active sonar	SQQ-32 sonar (MCM) or AQS-20A (LCS)	266 (SOCAL only)
Impulsive	Mine Neutralization-Explosive Ordnance Disposal (EOD)	Personnel train to disable mines using mine shaped targets as training aid. Explosive charges may be used.	1.25 lb to 60 lb charge	376
Impulsive	Mine Neutralization – Remotely Operated Vehicle	Helicopter aircrews disable mines using remotely operated underwater vehicles	Underwater detonations	248
Impulsive	Shock Wave Generator	Navy divers place very small charge on a simulated underwater mine	0.033 lb charge	90
Non-impulsive	Submarine Mine Exercise	Submarine practices detecting mines in designated area	Submarine HF sonar	66
Non-impulsive, Impulsive	Maritime Homeland Defense/Security Mine Countermeasures	Maritime homeland defense/security mine countermeasures naval mine warfare training conducted at various ports and harbors, in support of maritime homeland defense/security. Civilian Port Defense events are non-annual.	Various minehunting sonar, underwater detonations	2

Table 1-5: Training Activities Within the Study Area (continued)

Stressor	Training Event	Description	Weapons/Rounds/ Sound Source	Annual HSTT Events
Naval Special Warfare				
Impulsive	Underwater Demolition Multiple Charge – Mat Weave and Obstacle Loading (NSW)	Navy personnel train to construct, place, and safely detonate multiple charges laid in a pattern for underwater obstacle clearance	Mat Weave: 500 lb charge Obstacle Loading: 320 lb charge	18 (SOCAL only)
Impulsive	Underwater Demolition Qualification/ Certification	Navy divers conduct training and certification in placing underwater demolition charges	25.5 lb. NEW charge	24 (SOCAL only)
Other Training Activities				
Non-impulsive	Submarine Navigation	Submarine locates underwater objects and ships while transiting from port	BQQ-10 sonar, Submarine HF sonar	300
Non-impulsive	Submarine Under Ice Certification	Submarine trains to operate under ice. Ice conditions are simulated during training and certification events.	Submarine HF Sonar	18
Non-impulsive	Surface Ship Sonar Maintenance	Pier side and at-sea maintenance of surface ship sonar systems. Half of all maintenance use is pierside, half at sea.	SQS-53 and SQS-56 sonar	640
Non-impulsive	Submarine Sonar Maintenance	Pier side and at-sea maintenance of submarine sonar systems	BQQ-10 sonar	204

1.6.3 TESTING

The testing activities that the Navy proposes to conduct in the Study Area are described in Tables 1-6 through 1-9.

1.6.3.1 Naval Air Systems Command

Table 1-6: Naval Air Systems Command Testing Activities within the Study Area

Category	Testing Event	Description	Weapons/Rounds/ Sound Source	Annual HSTT Events
Anti-Surface Warfare (ASUW)				
Impulsive	Air-to-Surface Missile Test	This event is similar to the training event missile exercise (air-to-surface). Test may involve both fixed wing and rotary wing aircraft launching missiles at surface maritime targets to evaluate the weapons system or as part of another systems integration test.	HE missiles	110
Impulsive	Air-to-Surface Gunnery Test	Strike fighter and helicopter aircrews evaluate new or enhanced aircraft guns against surface maritime targets to test that the gun, gun ammunition, or associated systems meet required specifications or to train aircrew in the operation of a new or enhanced weapons system.	Medium-caliber weapons	55 (SOCAL only)

Table 1-6: Naval Air Systems Command Testing Activities within the Study Area (continued)

Stressor	Testing Event	Description	Weapons/Rounds/ Sound Source	Annual HSTT Events
Anti-Surface Warfare (ASUW) (continued)				
Impulsive	Rocket Test	Rocket tests evaluate the integration, accuracy, performance, and safe separation of laser-guided and unguided 2.75-inch rockets fired from a hovering or forward flying helicopter or from a fixed wing strike aircraft.	Guided and unguided rockets	66 (SOCAL only)
Anti-Submarine Warfare (ASW)				
Non-impulsive	Anti-submarine Warfare Torpedo Test	This event is similar to the training event torpedo exercise. The Test evaluates anti-submarine warfare systems onboard rotary wing and fixed wing aircraft and the ability to search for, detect, classify, localize, and track a submarine or similar target. Some tests from fixed-wing aircraft will involve releasing torpedoes and sonobuoys from high altitudes (approximately 25,000 ft.).	Exercise (Non-explosive) torpedoes	48
Non-impulsive	Kilo Dip	A kilo dip is the operational term used to describe a functional check of a helicopter deployed dipping sonar system. The sonar system is briefly activated to ensure all systems are functional. A kilo dip is simply a precursor to more comprehensive testing.	AQS-22 Dipping Sonar	10
Non-impulsive, Impulsive	Sonobuoy Lot Acceptance Test	Sonobuoys are deployed from surface vessels and aircraft to verify the integrity and performance of a lot, or group, of sonobuoys in advance of delivery to the fleet for operational use.	IEER sonobuoys, DICASS active sonobuoys, High Duty Cycle sonobuoys, various SUS devices, Multi-static Active Coherent sonobuoys	36 (SOCAL only)
Non-impulsive, Impulsive	Anti-submarine Warfare Tracking Test - Helicopter	This event is similar to the training event ASW tracking exercise (helicopter). The test evaluates the sensors and systems used to detect and track submarines and to ensure that helicopter systems used to deploy the tracking systems perform to specifications.	AQS-22 Dipping Sonar DICASS active sonobuoys, High Duty Cycle sonobuoys, MK84 SUS, Multi-static Active Coherent sonobuoys	310
Non-impulsive, Impulsive	Anti-submarine Warfare Tracking Test – Maritime Patrol Aircraft	This event is similar to the training event ASW TRACKEX-MPA. The test evaluates the sensors and systems used by maritime patrol aircraft to detect and track submarines and to ensure that aircraft systems used to deploy the tracking systems perform to specifications and meet operational requirements.	DICASS active sonobuoys, IEER sonobuoys (2 detonations per IEER buoy), High Duty Cycle sonobuoys, various SUS devices, Multi-static Active Coherent sonobuoys	47

Table 1-6: Naval Air Systems Command Testing Activities within the Study Area (continued)

Stressor	Testing Event	Description	Weapons/Rounds/ Sound Source	Annual HSTT Events
Mine Warfare (MIW)				
Impulsive	Airborne Mine Neutralization System Test (AMNS)	Airborne mine neutralization tests of the AN/ASQ-235 evaluate the system's ability to detect and destroy mines from a hovering MH-60S helicopter. The AN/ASQ-235 uses up to four unmanned underwater vehicles equipped with high-frequency sonar, video cameras, and explosive neutralizers.	Medium-caliber HE rounds HE neutralizers	17 (SOCAL only)
Non-impulsive	Airborne Towed Minehunting Sonar System Test	Tests of the AN/AQS-20A to evaluate the search capabilities of this towed, mine hunting, detection, and classification system. The sonar on the AN/AQS-20A identifies mine-like objects in the deeper parts of the water column.	Mine hunting sonar	17 (SOCAL only)
Impulsive	Airborne Projectile-based Mine Clearance System Test	A MH-60S helicopter uses a laser-based detection system to search for mines and to fix mine locations for neutralization with an airborne projectile-based mine clearance system. The system neutralizes mines by firing a small- or medium-caliber non-explosive, supercavitating projectile from a hovering helicopter.	HE mines	17 (SOCAL only)

1.6.3.2 Naval Sea Systems Command

Table 1-7: Naval Sea Systems Command Testing Activities within the Study Area

Stressor	Testing Event	Description	Weapons/Rounds/ Sound Source	Annual HSTT Events
New Ship Construction				
Non-impulsive	Surface Combatant Sea Trials – Pierside Sonar Testing	Tests ship's sonar systems pierside to ensure proper operation.	Surface ship sonar Underwater communication	4
Non-impulsive	Surface Combatant Sea Trials – Anti-Submarine Warfare (ASW) Testing	Ships demonstrate capability of countermeasure systems and underwater surveillance and communications systems.	Surface ship sonar Underwater communication	4
Non-impulsive	Mission Package Testing – ASW	Ships and their supporting platforms (e.g., helicopters, unmanned aerial vehicles) detect, localize, and prosecute submarines.	Ship sonar Sonobuoy sonar Torpedo sonar	56

Table 1-7: Naval Sea Systems Command Testing Activities within the Study Area (continued)

Stressor	Testing Event	Description	Weapons/Rounds/ Sound Source	Annual HSTT Events
New Ship Construction (continued)				
Impulsive	Mission Package Testing – ASUW	Ships defense against surface targets with medium range missiles.	HE missiles, medium and large caliber rounds	16
Impulsive, Non-impulsive	Mission Package Testing – Mine Countermeasures	Ships conduct mine countermeasure operations.	HE charges Towed sonar systems Mine countermeasure systems	20
Life Cycle Activities				
Non-impulsive	Surface Ship Sonar Testing/Maintenance (in OPAREAs and Ports)	Pierside and at-sea testing of surface ship systems occurs periodically following major maintenance periods and for routine maintenance.	Surface ship sonar Underwater communications	27
Non-impulsive	Submarine Sonar Testing/Maintenance (in OPAREAs and Ports)	Pierside and at-sea testing of submarine systems occurs periodically following major maintenance periods and for routine maintenance.	Submarine sonar	27
Non-impulsive	Combat System Ship Qualification Trial (CSSQT)-In-port Maintenance Period	Each combat system is tested to ensure they are functioning in a technically acceptable manner and are operationally ready to support at-sea CSSQT events.	Surface ship sonar Underwater communication	4
Non-impulsive	Combat System Ship Qualification Trial (CSSQT)-Undersea Warfare (USW)	Tests ships ability to track and engage undersea targets.	Surface ship sonar Active sonobuoys Underwater communications Torpedo sonar	21
Anti-Surface Warfare (ASUW)/Anti-Submarine Warfare (ASW) Testing				
Non-impulsive	Torpedo (Non-explosive) Testing	Air, surface, or submarine crews employ torpedoes against submarines or surface vessels. All torpedoes are recovered.	Surface ship sonar Submarine sonar Torpedo sonar	38
Impulsive, Non-impulsive	Torpedo (Explosive) Testing	Air, surface, or submarine crews employ high-explosive torpedoes against artificial targets or deactivated ships.	HE Torpedoes Torpedo sonar	4
Non-impulsive, impulsive	Countermeasure Testing	Various acoustic systems (e.g., towed arrays) are employed to detect, localize, and track incoming weapons. Torpedoes are launched from surface ships to localize and attack incoming weapons; can be inert or HE torpedo.	Surface ship sonar Torpedo sonar HE Torpedoes	8
Non-impulsive	Pierside Sonar Testing	Pierside testing to ensure systems are fully functional in a controlled pierside environment prior to at-sea test activities.	Ship and submarine sonar	10
Non-impulsive	At-sea Sonar Testing	At-sea testing to ensure systems are fully functional in an open ocean environment.	Submarine and ship sonar, sonobuoys, helicopter-deployed sonar, towed sonar systems	20

Table 1-7: Naval Sea Systems Command Testing Activities within the Study Area (continued)

Stressor	Testing Event	Description	Weapons/Rounds/ Sound Source	Annual HSTT Events
Mine Warfare (MIW) Testing				
Non-impulsive	Mine Detection and Classification Testing	Air, surface, and subsurface vessels detect and classify mines and mine-like objects.	Mine hunting sonar	13
Impulsive , Non-impulsive	Mine Countermeasure/ Neutralization Testing	Air, surface, and subsurface vessels neutralize threat mines that would otherwise restrict passage through an area.	Mine hunting sonar Detonations	14 (SOCAL only)
Non-impulsive	Pierside Systems Health Checks	Mine warfare systems are tested in pierside locations to ensure acoustic and electromagnetic sensors are fully functional prior to at-sea test activities.	Mine hunting sonar	4 (San Diego only)
Shipboard Protection Systems and Swimmer Defense Testing				
Non-impulsive, impulsive	Pierside Integrated Swimmer Defense	Swimmer defense testing ensures that systems can effectively detect, characterize, verify, and engage swimmer/diver threats in harbor environments.	Swimmer defense sonar and airgun	5 (San Diego only)
Unmanned Vehicle Testing				
Non-impulsive	Unmanned Vehicle Development and Payload Testing	Vehicle development involves the production and upgrade of new unmanned platforms on which to attach various payloads used for different purposes.	Synthetic aperture sonar	43
Other Testing				
Non-impulsive	Acoustic Communications Testing	Acoustic modems, submarines, and surface vessels transmit signals to communicate.	Acoustic modems	2

1.6.3.3 Space and Naval Warfare Systems Command

Table 1-8: Space and Naval Warfare Systems Command Testing Activities within the Study Area

Stressor	Testing Event	Description	Weapons/Rounds/ Sound Source	Annual HSTT Events
SPAWAR RDT&E				
Non-impulsive	Autonomous Undersea Vehicle (AUV) Anti-Terrorism/Force Protection (AT/FP) Mine Countermeasures	Autonomous undersea vehicle shallow water mine countermeasure testing is focused on testing of unmanned undersea vehicles with mine hunting sensors (side-scan sub-bottom profilers, synthetic aperture sonar) in marine environments in and around rocky outcroppings. Anti-terrorism/force protection mine countermeasures testing is focused on mine countermeasure missions in confined areas between piers and pilings.	Autonomous Undersea Vehicle, sonar	112
Non-impulsive	AUV Underwater Communications	This testing is focused on providing two-way networked communications below the ocean surface while maintaining mission profile.	Autonomous Undersea Vehicle, acoustic modems	112
Non-impulsive	Fixed System Underwater Communications	Fixed underwater communications systems testing is focused on testing stationary or free floating equipment that provides two-way networked communications below the ocean surface while maintaining mission profile.	Fixed systems, acoustic modems	37
Non-impulsive	AUV Autonomous Oceanographic Research and Meteorology and Oceanography (METOC)	Research comprised of ocean gliders and autonomous undersea vehicles. Gliders are portable, long-endurance buoyancy driven vehicles that provide means to sample and characterize ocean water properties. Autonomous undersea vehicles are larger, shorter endurance vehicles.	Ocean glider, Autonomous Undersea Vehicle	112
Non-impulsive	Fixed Autonomous Oceanographic Research and METOC	Develop, integrate, and demonstrate deployable autonomous undersea technologies that improve Navy's capability to conduct effective anti-submarine warfare and intelligence, surveillance, and reconnaissance operations in littoral waters.	Fixed systems, acoustic Doppler current profiler, acoustic releases	26
Non-impulsive	Passive Mobile Intelligence, Surveillance, and Reconnaissance Sensor Systems	These systems use passive arrays hosted by surface and subsurface vehicles and vessels for conducting submarine detection and tracking experiments and demonstrations.	Surface or subsurface vehicle, towed sound projector	27
Non-impulsive	Fixed Intelligence, Surveillance, and Reconnaissance Sensor Systems	These systems use stationary fixed arrays for conducting submarine detection and tracking experiments and demonstrations.	Fixed and free floating arrays, towed sound source, free floating buoys	43
Non-impulsive	Anti-Terrorism/ Force Protection (AT/FP) Fixed Sensor Systems	These systems are for AT/FP operation (e.g., swimmer detection) in Navy ports and bays, and this category covers pre-operational testing	Fixed system, mid-frequency source	11

1.6.3.4 Office of Navy Research

Table 1-9: Office of Naval Research Testing Activities within the Study Area

Stressor	Testing Event	Description	Weapons/Rounds/ Sound Source	Annual HSTT Events
Office of Naval Research RDT&E				
Non-impulsive	Kauai Acoustic Communications Experiment (Coastal)	The primary purpose of the Kauai Acoustic Communications Experiment is to collect acoustic and environmental data appropriate for studying the coupling of oceanography, acoustics, and underwater communications.	Mid- and high-frequency sources	2 (HRC only)

1.6.4 SUMMARY OF NON-IMPULSIVE AND IMPULSIVE SOURCES

1.6.4.1 Training Non-Impulsive Source Classes

Table 1-10 provides a quantitative annual summary of training activities by non-impulsive source class analyzed in this LOA request.

Table 1-10: Annual Hours of Non-Impulsive Sources Used During Training within the Study Area

Source Class Category	Source Class	Annual Use	Metric
Mid-Frequency (MF) Active sources from 1 to 10 kHz	**MF1**	11,588	# of hours
	MF1K	88	# of hours
	MF2	3,060	# of hours
	MF2K	34	# of hours
	MF3	2,336	# of hours
	MF4	888	# of hours
	MF5	13,718	# of items
	MF11	1,120	# of hours
	MF12	1,094	# of hours
High-Frequency (HF) and Very High-Frequency (VHF) Tactical and non-tactical sources that produce signals greater than 10kHz but less than 200kHz	**HF1**	1,754	# of hours
	HF4	4,848	# of hours
Anti-Submarine Warfare (ASW) Active ASW sources	**ASW1**	224	# of hours
	ASW2	1,800	# of items
	ASW3	16,561	# of hours
	ASW4	1,540	# of items
Torpedoes (TORP) Active torpedo sonar	**TORP1**	170	# of items
	TORP2	400	# of items

1.6.4.2 Testing Non-Impulsive Source Classes

Tables 1-11 provides a quantitative annual summary of testing activities by non-impulsive source class analyzed in this LOA request.

Table 1-11: Annual Hours of Non-Impulsive Sources Used During Testing within the Study Area

Source Class Category	Source Class	Annual Use	Metric
Low-Frequency (LF) Sources that produce signals less than 1 kHz	**LF4**	52	# of hours
	LF5	2,160	# of hours
	LF6	192	# of hours
Mid-Frequency (MF) Tactical and non-tactical sources that produce signals from 1 to 10 kHz	**MF1**	180	# of hours
	MF1K	18	# of hours
	MF2	84	# of hours
	MF3	392	# of hours
	MF4	693	# of hours
	MF5	5,024	# of items
	MF6	540	# of items
	MF8	2	# of hours
	MF9	3,039	# of hours
	MF10	35	# of hours
	MF12	336	# of hours
High-Frequency (HF) and Very High-Frequency (VHF): Tactical and non-tactical sources that produce signals greater than 10kHz but less than 200kHz	**HF1**	1,025	# of hours
	HF3	273	# of hours
	HF4	1,336	# of hours
	HF5	1,094	# of hours
	HF6	3,460	# of hours
Anti-Submarine Warfare (ASW) Tactical sources used during anti-submarine warfare training and testing activities	**ASW1**	224	# of hours
	ASW2	2,260	# of items
	ASW2H	162	# of hours
	ASW3	1,278	# of hours
	ASW4	477	# of items
Torpedoes (TORP) Source classes associated with active acoustic signals produced by torpedoes	**TORP1**	701	# of items
	TORP2	732	# of items
Acoustic Modems (M) Transmit data acoustically through the water	**M3**	4,995	# of hours
Swimmer Detection Sonar (SD) Used to detect divers and submerged swimmers	**SD1**	38	# of hours
Airguns (AG) Used during swimmer defense and diver deterrent training and testing activities	**AG**	5	# of hours
Synthetic Aperture Sonar (SAS): Sonar in which active acoustic signals are post-processed to form high-resolution images of the seafloor	**SAS1**	2,700	# of hours
	SAS2	4,956	# of hours
	SAS3	3,360	# of hours

1.6.4.3 Training and Testing Impulsive Source Classes

Table 1-12 provides a quantitative annual summary of training impulsive source classes analyzed in this LOA request. Table 1-13 is the annual quantitative summary of testing impulsive source classes.

Table 1-12: Annual Number of Impulsive Source Detonations During Training within the Study Area

Explosive Class	Net Explosive Weight (NEW)	Annual In-Water Detonations
		Training
E1	(0.1 lb. – 0.25 lb.)	19,840
E2	(0.26 lb. – 0.5 lb.)	1,044
E3	(0.6 lb. – 2.5 lb.)	3,020
E4	(>2.5 lb.-5 lb.)	668
E5	(>5 lb.-10 lb.)	8,154
E6	(>10 lb.-20 lb.)	538
E7	(>20 lb.-60 lb.)	407
E8	(>60 lb.-100 lb.)	64
E9	(>100 lb. – 250 lb.)	16
E10	(>250 lb. – 500 lb.)	19
E11	(>500 lb. – 650 lb.)	8
E12	(>650 lb. – 1000 lb.)	224
E13	(>1000 lb. – 1,740 lb.)	9

Table 1-13: Annual Number of Impulsive Source Detonations During Testing within the Study Area

Explosive Class	Net Explosive Weight (NEW)	Annual In-Water Detonations
		Testing
E1	(0.1 lb. – 0.25 lb.)	14,501
E2	(0.26 lb. – 0.5 lb.)	0
E3	(0.6 lb. – 2.5 lb.)	2,990
E4	(>2.5 lb.-5 lb.)	753
E5	(>5 lb.-10 lb.)	202
E6	(>10 lb.-20 lb.)	37
E7	(>20 lb.-60 lb.)	21
E8	(>60 lb.-100 lb.)	12
E9	(>100 lb. – 250 lb.)	0
E10	(>250 lb. – 500 lb.)	31
E11	(>500 lb. – 650 lb.)	14
E12	(>650 lb. – 1000 lb.)	0
E13	(>1000 lb. – 1,740 lb.)	0

1.6.5 OTHER STRESSORS – VESSEL STRIKES

Vessels strikes may occur from surface operations and sub-surface operations (excluding bottom crawling, unmanned underwater vehicles). Vessels used as part of the proposed action include ships, submarines and boats ranging in size from small, 16 ft. (5 m) Rigid Hull Inflatable Boat (RHIB) to aircraft carriers (CVN) with lengths up to 1,092 ft. (333 m). Representative Navy vessel types, lengths, and speeds used in both training and testing activities are shown in Table 1-14.

Large Navy ships greater than 60 ft. (18 meters) generally operate at speeds in the range of 10 to 15 knots for fuel conservation when cruising. Submarines generally operate at speeds in the range of 8 to 13 knots during transit and slower for certain tactical maneuvers. Small craft (for purposes of this discussion – less than 60 ft. [18 m] in length) have much more variable speeds, dependent on the mission. While these speeds are representative, some vessels operate outside of these speeds due to unique training or safety requirements for a given event. Examples include increased speeds needed for flight operations, full speed runs to test engineering equipment, time critical positioning needs, etc. Examples of decreased speeds include speeds less than 5 knots or completely stopped for launching small boats, certain tactical maneuvers, target launch or retrievals, etc.

The number of Navy vessels in the Study Area varies based on training and testing schedules. Most activities include either one or two vessels, with an average of one vessel per activity, and last from a few hours up to two weeks. Multiple ships, however, can be involved with major training events, although ships can often operate for extended periods beyond the horizon and out of visual sight from each other. Vessel movement and the use of in-water devices as part of the proposed action would be concentrated in portions of the Study Area within SOCAL, naval installations at San Diego and Pearl Harbor, and on instrumented underwater ranges (see Chapter 2).

Navy policy (Chief of Naval Operations Instruction [OPNAVINST] 3100.6H) requires Navy vessels to report all whale strikes. That information is collected by the Office of the Chief of Naval Operations Energy and Environmental Readiness Division and cumulatively provided to NMFS on an annual basis. In addition, as part of previous NMFS MMPA permits for HRC and SOCAL, the Navy and NMFS also have standardized regional reporting protocols for communicating to regional NMFS stranding coordinators information on any Navy ship strikes as soon as possible. These communication procedures will remain in place for the HSTT as part of this LOA application.

In context of Navy ship traffic as compared to other sources of large vessel traffic (commercial shipping), the Center for Naval Analysis (Mintz and Parker 2006) conducted a review of historic data for commercial vessels, coastal shipping patterns, and Navy vessels. In 2011, the Center for Naval Analysis repeated this analysis for the HSTT Study Area (Mintz and Filadelfo 2011). In the 2011 review of regional shipping expressed in terms of the amount of annual hours of shipping from Navy ships as compared to commercial ship hours from transits conducted for a representative year (2009), Navy surface ships accounted for 97,000 hours of accumulated at-sea time within subareas of the HSTT. Commercial shipping accounted for 875,000 hours of accumulated at-sea time during transits through the HSTT with heavy traffic to and from the Panama Canal and to and from overseas Pacific ports. Navy shipping therefore represented only 11% of all at-sea shipping traffic within HSTT Study Area. Metrics reported in Mintz and Filadelfo (2011) are expressed in terms of at-sea hours specifically within the HSTT. Navy ships move within portions of the HSTT where individual ships could have a higher risk of ship strike, but the volume of commercial ship traffic traveling in straight lines (i.e., passing through) is still greater.

Table 1-14: Typical Navy Boat and Vessel Types with Length Greater than 18 Meters Used within the Study Area

Vessel Type (>18 m)	**Example(s)** (specifications in meters (m) for length, metric tons (mt) for mass, and knots for speed)	**Typical Operating Speed** (knots)
Aircraft Carrier	**Aircraft Carrier (CVN)** length: 333 m beam: 41 m draft: 12 m displacement: 81,284 mt max. speed: 30+ knots	10 to 15
Surface Combatants	**Cruiser (CG)** length: 173 m beam: 17 m draft: 10 m displacement: 9,754 mt max. speed: 30+ knots **Destroyer (DDG)** length: 155 m beam: 18 m draft: 9 m displacement: 9,648 mt max. speed: 30+ knots **Frigate (FFG)** length: 136 m beam: 14 m draft: 7 m displacement: 4,166 mt max. speed: 30+ knots **Littoral Combat Ship (LCS)** length: 115 m beam: 18 m draft: 4 m displacement: 3,000 mt max. speed: 40+ knots	10 to 15
Amphibious Warfare Ships	**Amphibious Assault Ship (LHA, LHD)** length: 253 m beam: 32 m draft: 8 m displacement: 42,442 mt max. speed: 20+knots **Amphibious Transport Dock (LPD)** length: 208 m beam: 32 m draft: 7 m displacement: 25,997 mt max. speed: 20+knots **Dock Landing Ship (LSD)** length: 186 m beam: 26 m draft: 6 m displacement: 16,976 mt max. speed: 20+knots	10 to 15
Mine Warship Ship	**Mine Countermeasures Ship (MCM)** length: 68 m beam: 12 m draft: 4 m displacement: 1,333 max. speed: 14 knots	5 to 8
Submarines	**Attack Submarine (SSN)** length: 115 m beam: 12 m draft: 9 m displacement: 12,353 mt max. speed: 20+knots **Guided Missile Submarine (SSGN)** length: 171 m beam: 13 m draft: 12 m displacement: 19,000 mt max. speed: 20+knots	8 to 13
Combat Logistics Force Ships*	**Fast Combat Support Ship (T-AOE)** length: 230 m beam: 33 m draft: 12 m displacement: 49,583 max. speed: 25 knots **Dry Cargo/Ammunition Ship (T-AKE)** length: 210 m beam: 32 m draft: 9 m displacement: 41,658 mt max speed: 20 knots **Fleet Replenishment Oilers (T-AO)** length: 206 m beam: 30 m draft: 11 displacement: 42,674 mt max. speed: 20 knots **Fleet Ocean Tugs (T-ATF)** length: 69 m beam: 13 m draft: 5 m displacement: 2,297 max. speed: 14 knots	8 to 12
Support Craft/Other	**Landing Craft, Utility (LCU)** length: 41m beam: 9 m draft: 2 m displacement: 381 mt max. speed: 11 knots **Landing Craft, Mechanized (LCM)** length: 23 m beam: 6 m draft: 1 m displacement: 107 mt max. speed: 11 knots	3 to 5
Support Craft/Other Specialized High Speed	**MK V Special Operations Craft** length: 25 m beam: 5 m displacement: 52 mt max. speed: 50 knots	Variable

* CLF vessels are not normally permanently homeported in Pearl Harbor or San Diego, but are frequently used for various fleet support and training support events in the HSTT.

2 DURATION AND LOCATION OF ACTIVITIES

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

Training and testing activities would be conducted in the Hawaii-Southern California Training and Testing (HSTT) Study Area (Study Area) throughout the year from January 2014 through January 2019.

The Study Area is comprised of established operating and warning areas across the north-central Pacific Ocean, from Southern California west to Hawaii and the International Date Line. The Study Area includes three existing range complexes: the Southern California (SOCAL) Range Complex, Hawaii Range Complex (HRC), and Silver Strand Training Complex (SSTC). In addition to these range complexes, the Study Area also includes United States (U.S.) Department of the Navy (Navy) pierside locations where sonar maintenance and testing occurs within the Study Area, and additional areas on the high seas that are not part of the range complexes, where training and sonar testing may occur during vessel transit. The Study Area and typical transit corridor are depicted in Figure 1-1.

The Study Area includes several Navy range complexes. A range complex is an organized and designated set of specifically bounded geographic areas and encompasses a water component (above and below the surface), airspace, and may encompass a land component where training and testing of military platforms, tactics, munitions, explosives, and electronic warfare systems occurs. Range complexes include established operating areas (OPAREAs) and special use airspace, which may be further divided to provide better control of the area and events for safety reasons.

- OPAREA: An ocean area defined by geographic coordinates with defined surface and subsurface areas and associated special use airspace OPAREAs may include the following:
    - **Surface Danger Zones:** A danger zone is a defined water area used for target practice, bombing, rocket firing or other especially hazardous military activities. Danger zones are established pursuant to statutory authority of the Secretary of the Army and are administered by the Army Corps of Engineers. Danger zones may be closed to the public on a full time or intermittent basis (33 Code of Federal Regulations 334).
    - **Restricted Areas:** A restricted area is a defined water area for the purpose of prohibiting or limiting public access to the area. Restricted areas generally provide security for Government property and/or protection to the public from the risks of damage or injury arising from the Government's use of that area (33 Code of Federal Regulations 334).

- Special Use Airspace: Airspace of defined dimensions where activities must be confined because of their nature or where limitations may be imposed upon aircraft operations that are not part of those activities (Federal Aviation Administration Order 7400.8). Types of special use airspace most commonly found in range complexes include the following:
    - **Restricted Areas:** Airspace where aircraft are subject to restriction due to the existence of unusual, often invisible hazards (e.g., release of ordnance) to aircraft. Some areas are under strict control of the Department of Defense (DoD) and some are shared with non-military agencies.
    - **Military Operations Areas:** Airspace with defined vertical and lateral limits established for the purpose of separating or segregating certain military training and testing activities from instrument flight rules traffic and to identify visual flight rules traffic where these activities are conducted.

- **Warning Area:** Areas of defined dimensions, extending from 3 nautical miles (nm) outward from the coast of the United States, which serve to warn nonparticipating aircraft of potential danger.
- **Air Traffic Controlled Assigned Airspace:** Airspace that is Federal Aviation Administration defined and is not over an existing OPAREA. It is used to contain specified activities, such as military flight training, that are segregated from other instrument flight rules air traffic.

The Study Area includes the transit corridor and only the at-sea components of SOCAL, HRC, SSTC, and select pierside locations in San Diego Bay and Pearl Harbor. The remaining inland waters and land-based portions of the range complexes are not a part of the Study Area.

2.1 HAWAII RANGE COMPLEX

The HRC geographically encompasses ocean areas located around the Hawaiian Island chain. The ocean areas extend from 16 degrees north latitude to 43 degrees north latitude and from 150 degrees west longitude to the International Date Line, forming an area approximately 1,700 nm by 1,600 nm. The largest component of the HRC is the Temporary OPAREA, extending north and west from the island of Kauai, and comprising over 2 million square nautical miles (nm^2) of air and sea space. This area is used for Navy ship transits throughout the year, and is used only a few times each year for missile defense testing activities. In spite of the Temporary OPAREA's size, nearly all of the training and testing activities in the HRC take place within the smaller Hawaii OPAREA, that portion of the range complex immediately surrounding the island chain from Hawaii. The Hawaii OPAREA consists of 235,000 nm^2 (806,000 km^2) of special use airspace, and sea and undersea areas.

Special Use Airspace

The HRC includes over 115,000 nm^2 of special use airspace. As depicted in Figure 2-1, this airspace is almost entirely over the ocean and includes warning areas, air traffic controlled assigned airspace, and restricted areas.

- Warning Areas of the HRC make up more than 58,000 nm^2 of special use airspace and include the following: Warning Area (W)-186, W-187, W-188, W-189, W-190, W-191, W-192, W-193, W-194, and W-196.
- The air traffic controlled assigned airspace areas of the HRC account for more than 57,000 nm^2 of special use airspace and include the following areas: Lono East, Lono Central, Lono West, Mako, Mela South, Mela Central, Mela North, Nene, Pali, Pele, Quint, and Taro.
- The restricted area airspace over or near land areas within the HRC make up another 81 nm^2 of special use airspace and include R-3101 and R-3107. Kaula Island is located completely within R-3107, west-southwest of Kauai. This Letter of Authorization (LOA) request includes analysis of only the marine environment surrounding Kaula Island, and not potential impacts to the island itself.

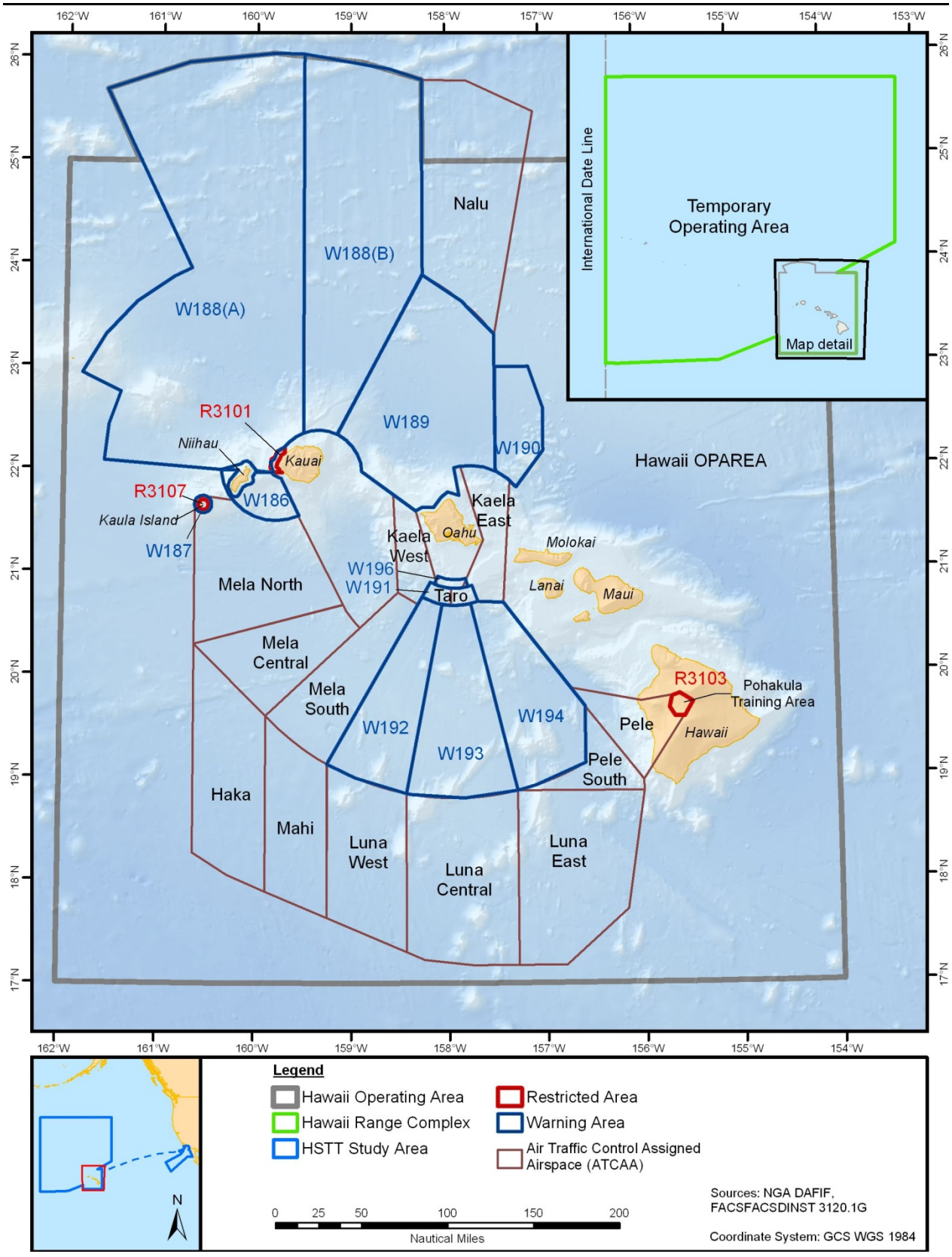

Figure 2-1: Hawaii Range Complex

Sea and Undersea Space

The HRC includes the ocean areas as described above, as well as specific training areas around the islands of Kauai, Oahu, and Maui (Figures 2-2, 2-3, and 2-4 respectively). The HRC also includes the ocean portion of the Pacific Missile Range Facility (PMRF) on Kauai, which is both a fleet training range and a fleet and Department of Defense (DoD) testing range. The facility includes 1,020 nm^2 of instrumented ocean area at depths between 1,800 ft. (549 m) and 15,000 ft. (4,572 m).

The HRC also includes the ocean areas of Papahanaumokuakea Marine National Monument, referred hereafter as the Monument, (The President 2006). Establishment of the Monument in June 2006 triggered a number of prohibitions on activities conducted in the Monument area. However, all military activities and exercises were specifically excluded from the listed prohibitions as long as the military exercises and activities are "carried out in a manner that avoids, to the extent practicable and consistent with operational requirements, adverse impacts on monument resources and qualities."

2.2 SOUTHERN CALIFORNIA RANGE COMPLEX

The SOCAL Range Complex is situated between Dana Point and San Diego, and extends more than 600 nm southwest into the Pacific Ocean (Figures 2-5, 2-6, and 2-7). The two primary components of the SOCAL Range Complex are the ocean OPAREAs and the special use airspace. These components encompass 120,000 nm^2 of sea space and 113,000 nm^2 of special use airspace. In addition, for this application the SSTC will be included as part of the SOCAL Range Complex.

Special Use Airspace

Most of the special use airspace in the SOCAL Range Complex is defined by W-291 (Figure 2-5). This warning area extends vertically from the ocean surface to 80,000 ft. (24,400 m) above mean sea level and encompasses 113,000 nm^2 of airspace. In addition to W-291, the SOCAL Range Complex includes the following two areas:

- Western San Clemente OPAREA is a special use airspace that extends from the surface to 5,000 ft. (1,500 m) above mean sea level.
- Helicopter Offshore Training Area is located off the coast of San Diego, and extends from the surface to 1,000 ft. (300 m) above mean sea level.

Sea and Undersea Space

The SOCAL Range Complex includes approximately 120,000 nm^2 (411,600 km^2) of sea and undersea space, largely defined as that ocean area underlying the Southern California special use airspace described above. The SOCAL Range Complex also extends beyond this airspace to include the surface and subsurface area from the northeastern border of W-291 to the coast of San Diego County, and includes San Diego Bay. In addition, a small portion of the Point Mugu Sea Range is included as the far northwestern corner of the SOCAL portion of the HSTT Study Area. This approximately 1,000 nm^2 (3,430 km^2) area that overlaps the Point Mugu Sea Range, and only that part of the Point Mugu Sea Range, is used by the Navy for anti-submarine warfare training conducted in the course of major range events and is analyzed under this document.

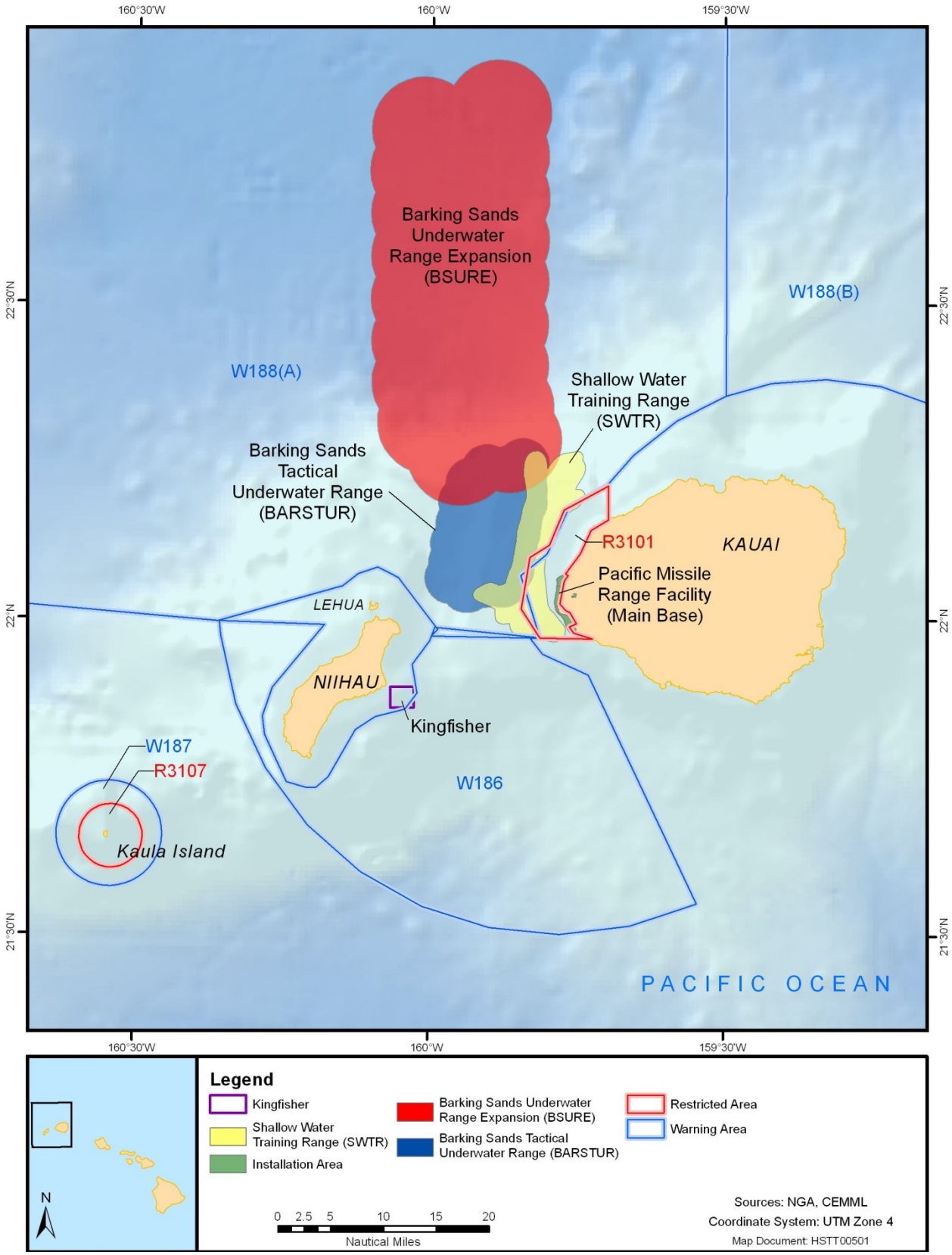

Figure 2-2: Navy Training and Testing Areas Around Kauai

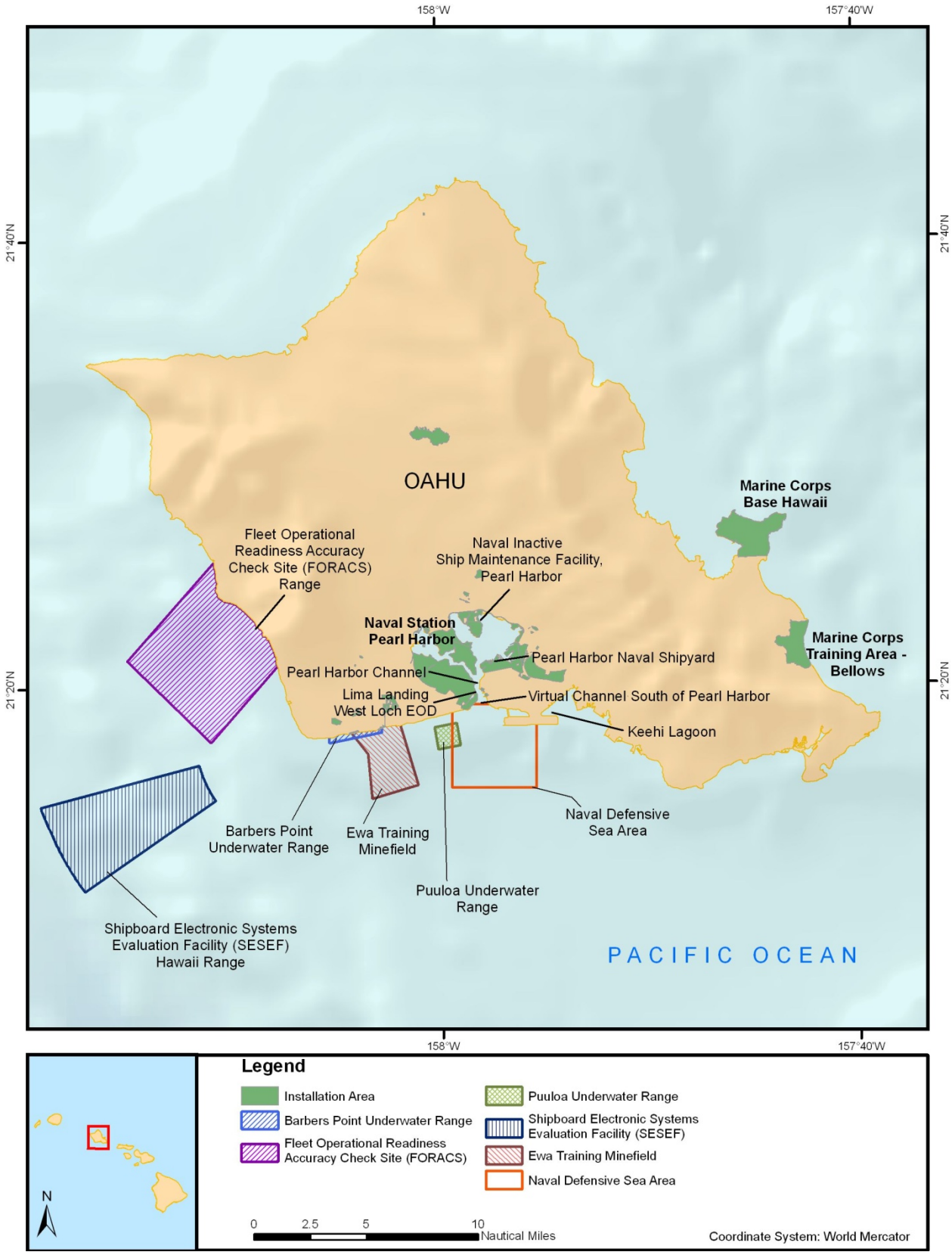

Figure 2-3: Navy Training and Testing Areas Around Oahu

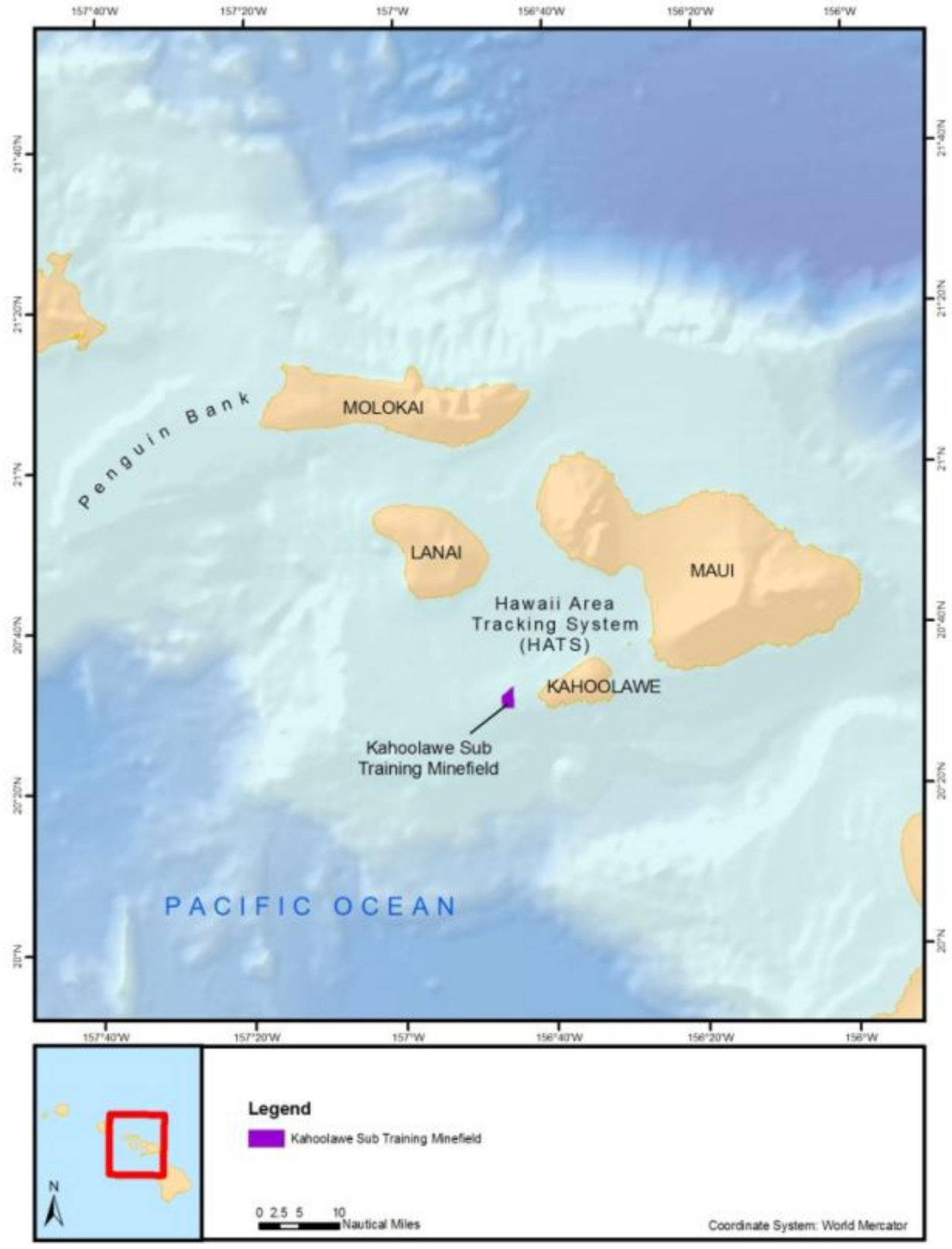

Figure 2-4: Navy Training and Testing Areas Around Maui

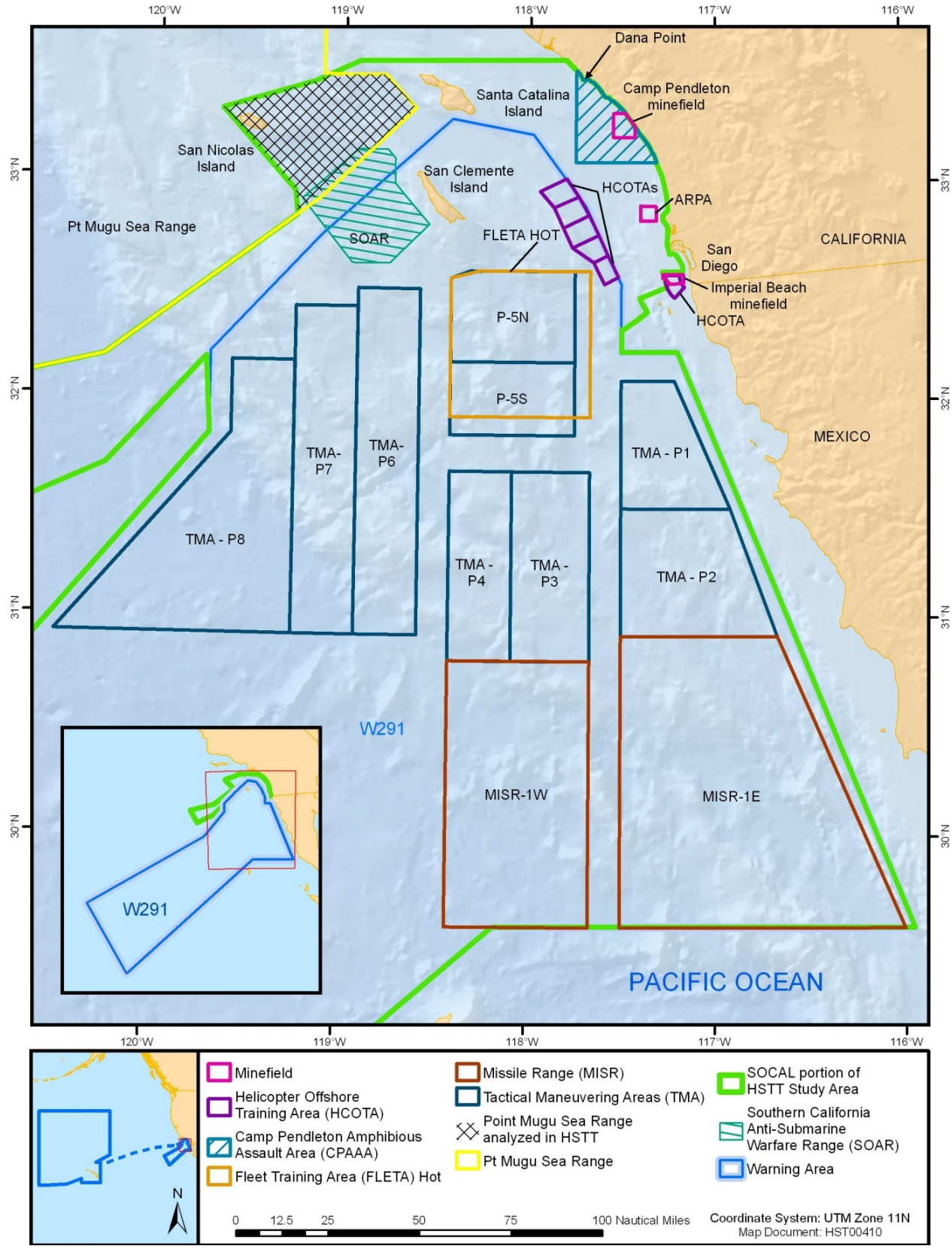

Figure 2-5: Southern California Training and Testing Areas

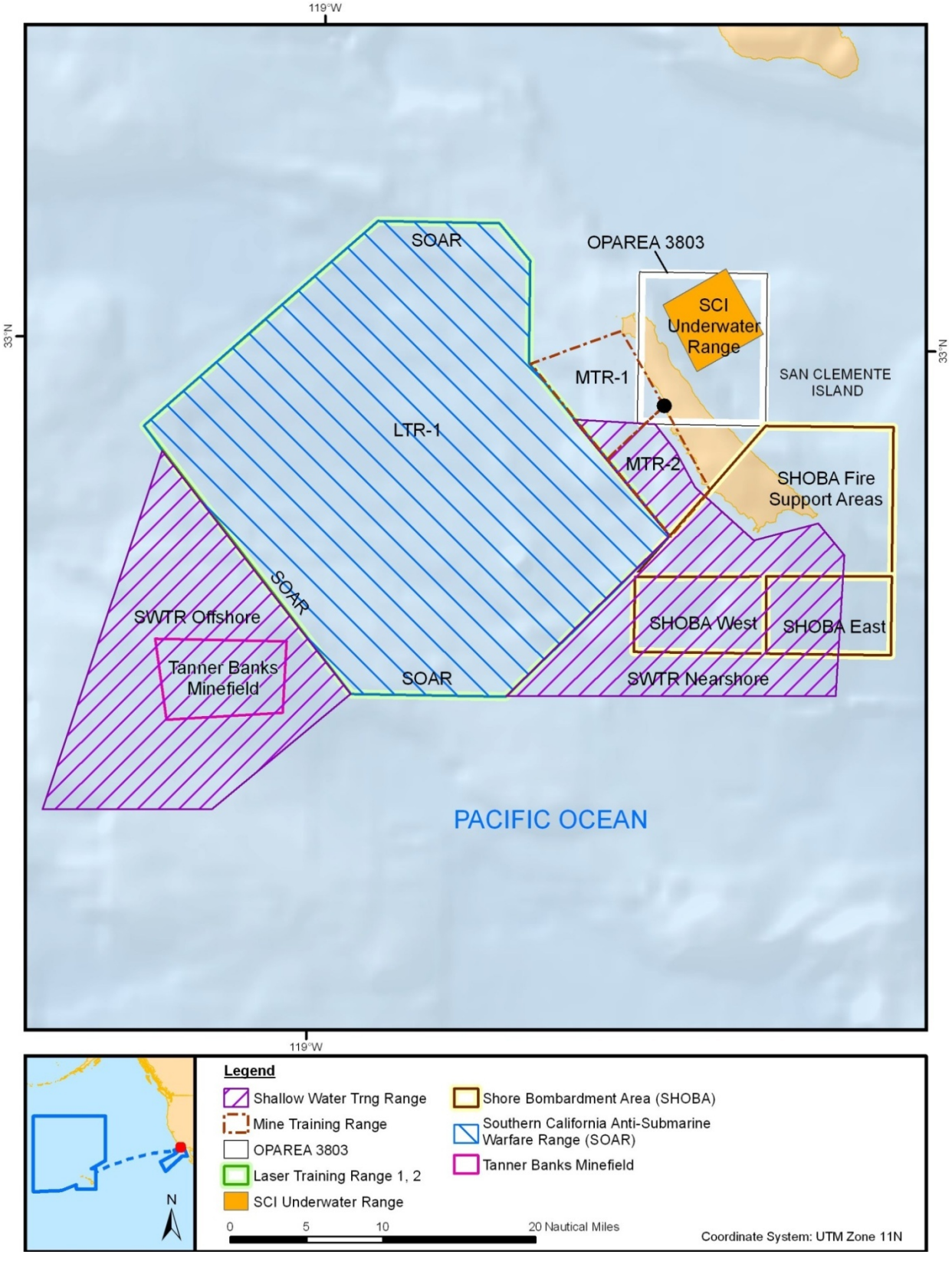

Figure 2-6: San Clemente Island Offshore Training and Testing Areas

Figure 2-7: San Clemente Island Nearshore Training and Testing Areas

2.3 SILVER STRAND TRAINING COMPLEX

The SSTC (Figure 2-8) is composed of 14 oceanside beach and boat training lanes (numbered as Boat Lanes 1-14; Yellow 1 and 2, Red 1 and 2, Green 1 and 2, Blue 1 and 2, Orange 1 and 2, White 1 and 2, and Purple 1 and 2), ocean anchorage areas (numbered 101 through 178), bayside water training areas (Alpha through Hotel), and one drop zone. The anchorages lie offshore of Coronado in the Pacific Ocean and overlap a portion of Boat Lanes 1-10.

2.4 OCEAN OPERATING AREAS OUTSIDE THE BOUNDS OF EXISTING RANGE COMPLEXES (TRANSIT CORRIDOR)

In addition to the three range complexes that are part of the Study Area, a transit corridor outside the boundaries of the range complexes is included in this request. Although not part of any defined range complex, this transit corridor is important to the Navy in that it provides adequate air, sea, and undersea space in which ships and aircraft can conduct training and some sonar maintenance and testing while en route between Southern California and Hawaii.

The transit corridor, defined as the great circle route (shortest distance) from San Diego to the center of the HRC, is depicted in Figure 1-1, and is generally used by ships transiting between the SOCAL Range Complex and HRC. While in transit, ships and aircraft would, at times, conduct basic and routine unit level training as long as the training does not interfere with the primary objective of reaching their intended destination. Ships also conduct sonar maintenance, which includes active sonar transmissions. Corresponding to the species and stocks specific to the general Hawaii area and those present in Southern California, the transit corridor west of 140° west longitude is considered as part of the HRC location and the transit corridor east of 140° west longitude is considered part of the SOCAL location.

2.5 PIERSIDE LOCATIONS

The Study Area includes select pierside locations where Navy surface ship and submarine sonar maintenance testing occur (Figure 2-9). For purposes of this request, pierside locations include channels and transit routes in ports, and facilities associated with ports and shipyards. These locations in the Study Area are located at Navy piers in San Diego, California (within the SOCAL location) and Navy piers, shipyard, and Intermediate Maintenance Facility in Pearl Harbor, Hawaii (as part of the HRC).

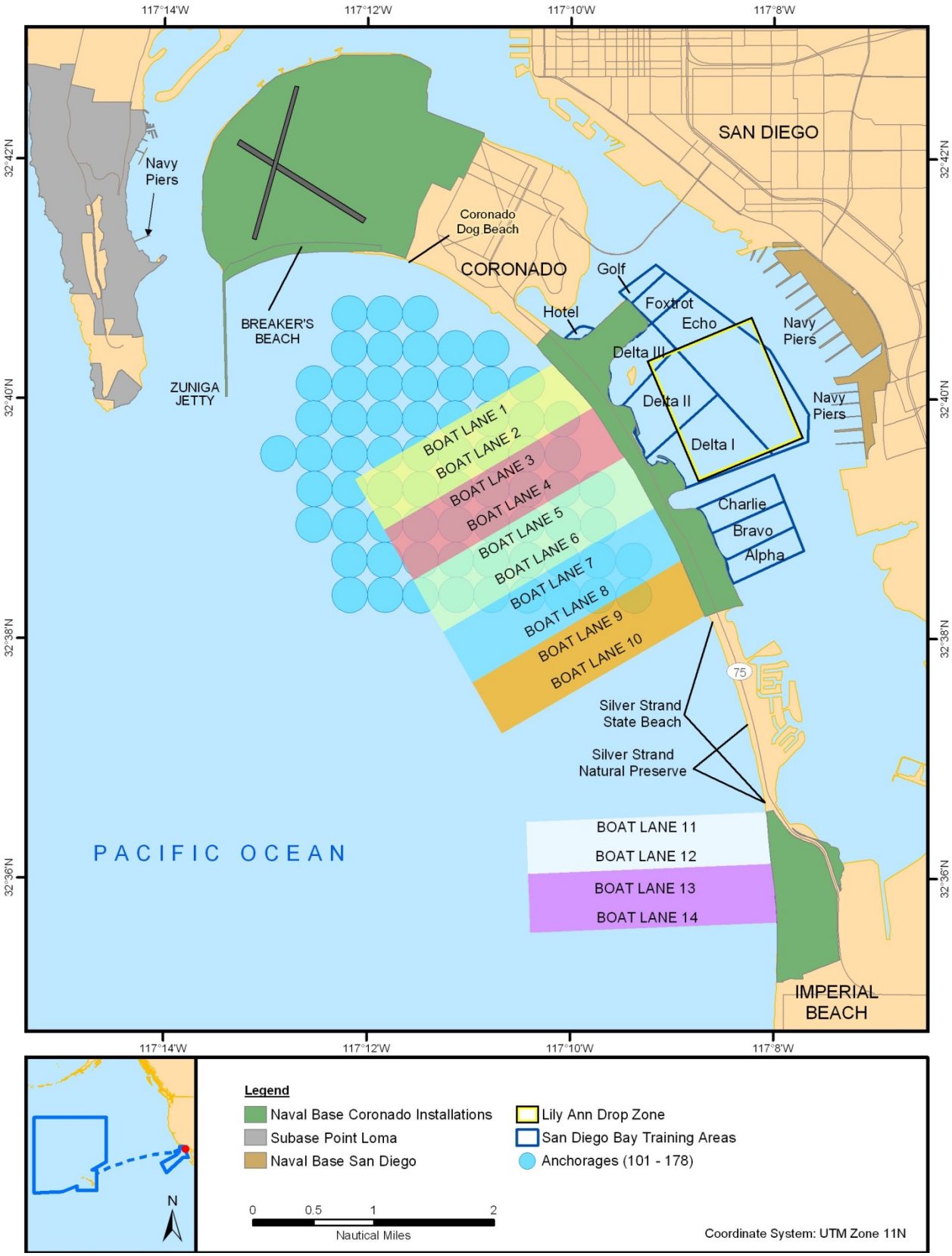

Figure 2-8: Silver Strand Training Complex

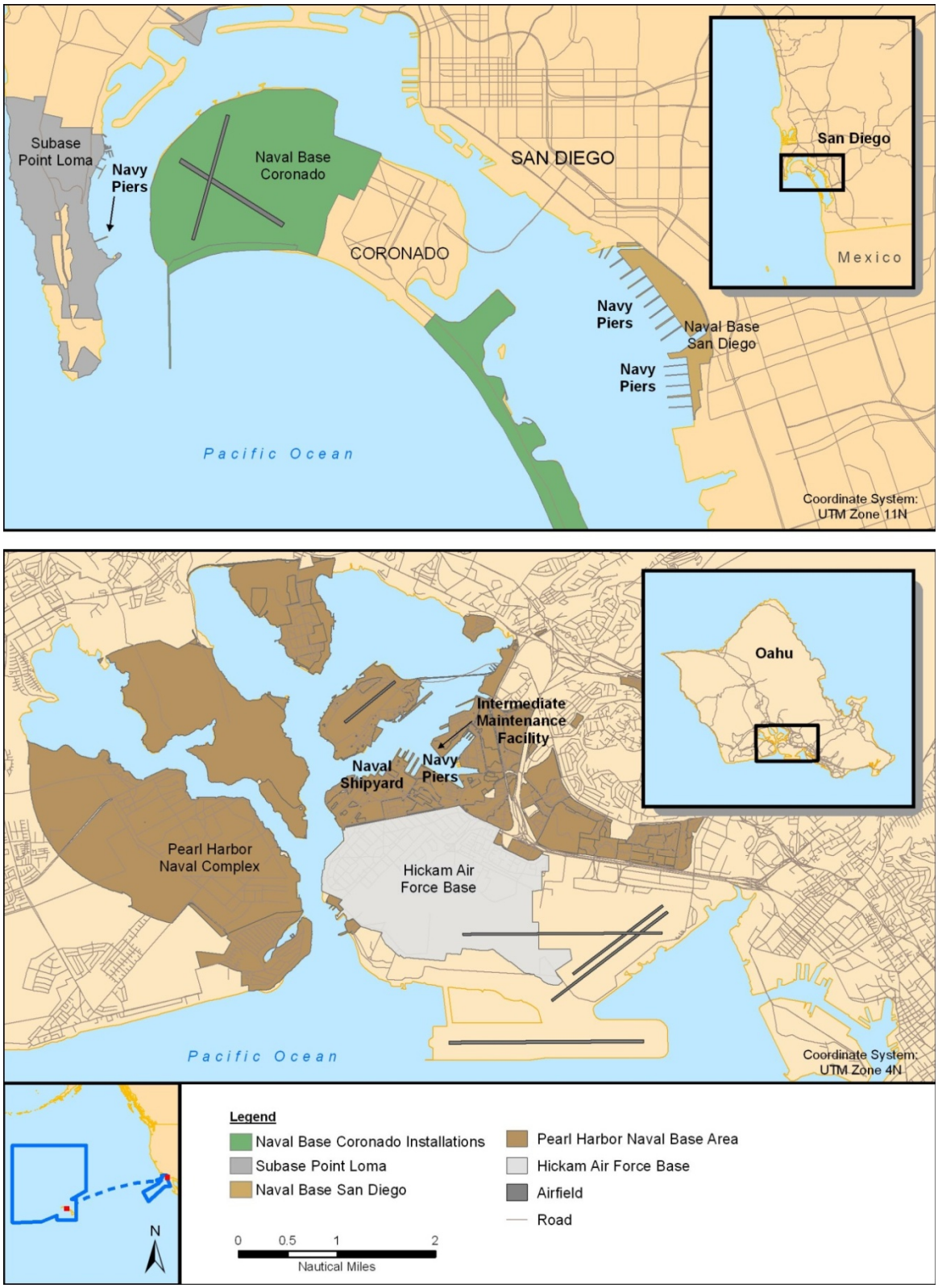

Figure 2-9: Navy Piers and Shipyards in the Study Area

3 MARINE MAMMAL SPECIES AND NUMBERS

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

Forty-three marine mammal species are known to occur in the Hawaii-Southern Training and Testing (HSTT) Study Area, including 7 mysticetes (baleen whales), 29 odontocetes (dolphins and toothed whales), 6 pinnipeds (seals and sea lions), and the Southern sea otter. Among these species there are 72 stocks managed by National Marine Fisheries Service (NMFS) or the United States Fish and Wildlife Service (USFWS) in the U.S. Exclusive Economic Zone (EEZ). These species and their numbers are presented in Table 3-1 and relevant information on their status, distribution, and seasonal distribution (when applicable) is presented in Chapter 4. Consistent with NMFS most recent Pacific Stock Assessment Report, a single species may include multiple stocks recognized for management purposes (e.g., spinner dolphin), while other species are grouped into a single stock due to limited species-specific information (e.g., beaked whales belonging to the genus *Mesoplodon*).

Species that may have once inhabited or transited the HSTT Study Area but have not been sighted in recent years (e.g., species which were extirpated from factors such as 19th and 20th century commercial exploitation) include the North Pacific right whale (*Eubalaena japonica*), harbor porpoise (*Phocoena phocoena*), and Steller sea lion (*Eumetopias jubatus*). These species are not expected to be exposed to or affected by any project activities and, therefore, are not discussed further. To reduce redundancy, additional information about the species and numbers of marine mammals likely to be found within the activity areas is included in Chapter 4.

Table 3-1: Marine Mammals with Possible or Confirmed Presence within the Study Area

Common Name	Scientific Name[1]	Study Area[2]	Stock[3]	Stock Abundance[4] (CV)	Study Area Abundance[5] (CV)	Occurrence in Study Area	ESA/MMPA Status[6]
Order Cetacea Suborder Mysticeti (Baleen Whales)							
Family Balaenopteridae (Rorquals)							
Humpback whale	*Megaptera novaeangliae*	SOCAL	California, Oregon, & Washington	2,043 (0.10)	36 (0.51)	Seasonal; More sightings around the northern Channel Islands	Endangered/Depleted
		HRC	Central North Pacific	10,103 (N/A)	4,491 (N/A)	Seasonal; Throughout known breeding grounds during winter and spring (most common November through April)	Endangered/Depleted
Blue whale	*Balaenoptera musculus*	SOCAL	Eastern North Pacific	2,497 (0.24)	842 (0.20)	Seasonal; arrive April–May; more common late summer to fall	Endangered/Depleted
		HRC	Central North Pacific	No Data	No data	Seasonal; infrequent winter migrant; few sightings	Endangered/Depleted
Fin whale	*Balaenoptera physalus*	SOCAL	California, Oregon, & Washington	3,044 (0.18)	359 (0.40)	Year-round presence	Endangered/Depleted
		HRC	Hawaiian	174 (0.72)	174 (0.72)	Seasonal; mainly fall and winter although considered rare in HRC	Endangered/Depleted
Sei whale	*Balaenoptera borealis*	SOCAL	Eastern North Pacific	126 (0.53)	7 (1.07)	Rare; infrequently sighted in California. Only nine confirmed sightings on WA/OR/CA surveys from 1991–2008	Endangered/Depleted
		HRC	Hawaiian	77 (1.06)	77 (1.06)	Rare; limited sightings of seasonal migrants that feed at higher latitudes	Endangered/Depleted
Bryde's whale	*Balaenoptera edeni*	SOCAL	Eastern Tropical Pacific	13,000 (0.20)	7 (1.07)	Limited summer occurrence	-
		HRC	Hawaiian	469 (0.45)	469 (0.45)	Uncommon; distributed throughout the Hawaii Exclusive Economic Zone	-

[1] Taxonomy follows Perrin 2009.
[2] SOCAL includes the eastern portion of the transit corridor and HRC includes the western portion of the transit corridor.
[3] Stock abundance estimates from Allen and Angliss 2010 and Carretta et al. 2011except where noted.
[4] The stated coefficient of variation (CV) is an indicator of uncertainty in the abundance estimate. It can range upward from zero, indicating no uncertainty, to high values. When the CV exceeds 1.0, the estimate is very uncertain. The uncertainty associated with movements of animals into or out of an area (due to factors such as availability of prey or changing oceanographic conditions) is much larger than is indicated by the CVs that are given.
[5] SOCAL Study Area abundance includes waters south of Point Conception (at 34.5°N) and reflects estimates from ship surveys conducted in the summer and fall between 1991 and 2005 (Barlow and Forney 2007). HRC Study Area abundance estimates include waters within the Hawaii Exclusive Economic Zone as estimated from a ship survey conducted in 2002 (Barlow 2006). Note that, in many cases, the Hawaiian stock estimates are the same as the Hawaii Exclusive Economic Zone estimates.
Extralimital means the species may rarely occur but is not expected in the area since it is outside of the species normal range.
[6] Blank entries refer to stocks that are not listed as threatened or endangered under the ESA or as depleted under the MMPA.

Common Name	Scientific Name[1]	Study Area[2]	Stock[3]	Stock Abundance[4] (CV)	Study Area Abundance[5] (CV)	Occurrence in Study Area	ESA/MMPA Status[6]
Minke whale	*Balaenoptera acutorostrata*	SOCAL	California, Oregon, & Washington	478 (1.36)	226 (1.02)	Less common in summer; small numbers around northern Channel Islands	-
		HRC	Hawaiian	No Data	No data	Regular but seasonal occurrence (November–March)	-
Family Eschrichtildae (Gray Whale)							
Gray whale	*Eschrichtius robustus*	SOCAL	Eastern North Pacific	18,813 (0.07)	Population migrates through SOCAL	Transient during seasonal migrations	-
		HRC	No known occurrence				
Suborder Odontoceti (Toothed Whales)							
Family Physeteridae (Sperm Whale)							
Sperm whale	*Physeter macrocephalus*	SOCAL	California, Oregon, & Washington	971 (0.31)	607 (0.57)	Common year round; more likely in waters > 1,000 m, most often > 2,000 m	Endangered/Depleted
		HRC	Hawaiian	6,919 (0.81)	6,919 (0.81)	Widely distributed year round; more likely in waters > 1,000 m, most often > 2,000 m	Endangered/Depleted
Family Kogiidae (Pygmy and Dwarf Sperm Whale)							
Pygmy sperm whale	*Kogia breviceps*	SOCAL	California, Oregon, & Washington	579 (1.02)	-	Seaward of 500–1000 m; limited sightings over entire Southern Cal. Bight	-
		HRC	Hawaiian	7,138 (1.12)	7,138 (1.12)	Stranding numbers suggest this species is more common than infrequent sightings during survey (Barlow 2006) indicated	-
Dwarf sperm whale	*Kogia sima*	SOCAL	California, Oregon, & Washington	Unknown	-	Seaward of 500–1000 m; no confirmed sightings over entire Southern Cal. Bight (all *Kogia spp*. or *Kogia breviceps*)	-
		HRC	Hawaiian	17,519 (0.74)	17,519 (0.74)	Stranding numbers suggest this species is more common than infrequent sightings during survey (Barlow 2006) indicated	-
Family Delphinidae (Dolphins)							
Killer whale	*Orcinus orca*	SOCAL	Eastern North Pacific Offshore	240 (0.49)	30 (0.73)	Uncommon; occurs infrequently; more likely in winter	-
		SOCAL	Eastern North Pacific Transient	451 (0.49)		Uncommon; occurs infrequently; more likely in winter	
		HRC	Hawaiian	349 (0.98)	349 (0.98)	Uncommon; infrequent sightings	-
False killer whale	*Pseudorca crassidens*	SOCAL	Eastern Tropical Pacific	Unknown	-	Uncommon; warm water species; although stranding records from the Channel Islands	-

Common Name	Scientific Name[1]	Study Area[2]	Stock[3]	Stock Abundance[4] (CV)	Study Area Abundance[5] (CV)	Occurrence in Study Area	ESA/MMPA Status[6]
False killer whale	*Pseudorca crassidens*	HRC	Hawaii Insular[7,8]	151 (0.20)	151 (0.20)	Regular	Proposed for endangered listing
		HRC	Hawaii Pelagic[7]	1,503 (0.66)	1,503 (0.66)	Regular	-
		HRC	Northwest Hawaiian Islands[7]	522 (1.09)	522 (1.09)	Regular	
Pygmy killer whale	*Feresa attenuata*	SOCAL	Tropical	Unknown	Extralimital	Extralimital within the south-west boundary of the SOCAL Range Complex	-
		HRC	Hawaiian	956 (0.83)	956 (0.83)	Year-round resident; abundance based on 3 sightings (Barlow 2006)	-
Short-finned pilot whale	*Globicephala macrorhynchus*	SOCAL	California, Oregon, & Washington	760 (0.64)	118 (1.04)	Uncommon; more common before 1982	-
		HRC	Hawaiian	8,870 (0.38)	8,870 (0.38)	Commonly observed around main Hawaiian Islands and Northwestern Hawaiian Islands	-
Melon-headed whale	*Peponocephala electra*	SOCAL	No known occurrence				
		HRC	Hawaiian	2,950 (1.17)	2,950 (1.17)	Regular	-
Long-beaked common dolphin	*Delphinus capensis*	SOCAL	California	27,046 (0.59)	17,530 (0.57)	Common; more inshore distribution (within 50 nm of coast)	-
		HRC	No known occurrence				
Short-beaked common dolphin	*Delphinus delphis*	SOCAL	California, Oregon, & Washington	411,211 (0.21)	165,400 (0.19)	Common; one of the most abundant SOCAL dolphins; higher summer densities	-
		HRC	No known occurrence				
Bottlenose dolphin coastal	*Tursiops truncatus*	SOCAL	California Coastal	323 (0.13)	323 (0.13)	Limited, small population within 1 km of shore	-
Bottlenose dolphin offshore	*Tursiops truncatus*	SOCAL	California, Oregon, & Washington Offshore	1,006 (0.48)	1,831 (0.47)	Common	-
Bottlenose dolphin Hawaiian Islands Stock Complex	*Tursiops truncatus*	HRC	Hawaii Pelagic	3,178 (0.59)	3,178 (0.59)	Common in deep offshore waters	-
		HRC	Kauai and Niihau	147 (0.11)	147 (0.11)	Common in shallow nearshore waters (1000 m or less)	-
		HRC	Oahu	594 (0.54)	594 (0.54)	Common in shallow nearshore waters (1000 m or less)	-
		HRC	4-Islands Region	153 (0.24)	153 (0.24)	Common in shallow nearshore waters (1000 m or less)	-
		HRC	Hawaii Island	102 (0.13)	102 (0.13)	Common in shallow nearshore waters (1000 m or less)	-

7 Bradford et al. (2012)
8. Carretta et al. (2012)

Common Name	Scientific Name[1]	Study Area[2]	Stock[3]	Stock Abundance[4] (CV)	Study Area Abundance[5] (CV)	Occurrence in Study Area	ESA/MMPA Status[6]
Pantropical spotted dolphin	*Stenella attenuata*	SOCAL	Eastern Tropical Pacific	Unknown	-	Rare; associated with warm tropical surface waters	-
		HRC	Hawaiian	8,978 (0.48)	8,978 (0.48)	Common; primary occurrence between 330 and 13,122 ft. depth	-
Striped dolphin	*Stenella coerulealba*	SOCAL	California, Oregon, & Washington	10,908 (0.34)	8,697 (0.34)	Occasional visitor; warm water oceanic species	-
		HRC	Hawaiian	13,143 (0.46)	13,143 (0.46)	Occurs regularly year round but infrequent sighting data	-
Spinner dolphin	*Stenella longirostris*	SOCAL	No known occurrence				
Spinner dolphin Hawaiian Island Stock Complex	*Stenella longirostris*	HRC	Hawaii Pelagic	Unknown	3,351 (0.74) for entire Hawaiian Islands Stock Complex	Common year round in offshore waters	-
		HRC	Hawaii Island	Unknown	3,351 (0.74) for entire Hawaiian Islands Stock Complex	Common year round; rest in nearshore waters during the day and move offshore to feed at night	-
		HRC	Oahu/4-Islands	Unknown	3,351 (0.74) for entire Hawaiian Islands Stock Complex	Common year round; rest in nearshore waters during the day and move offshore to feed at night	-
		HRC	Kauai/Niihau	Unknown	3,351 (0.74) for entire Hawaiian Islands Stock Complex	Common year round; rest in nearshore waters during the day and move offshore to feed at night	-
		HRC	Pearl and Hermes Reef	Unknown	3,351 (0.74) for entire Hawaiian Islands Stock Complex	Common year round; rest in nearshore waters during the day and move offshore to feed at night	-
		HRC	Kure/Midway	Unknown	3,351 (0.74) for entire Hawaiian Islands Stock Complex	Common year round; rest in nearshore waters during the day and move offshore to feed at night	-

Common Name	Scientific Name[1]	Study Area[2]	Stock[3]	Stock Abundance[4] (CV)	Study Area Abundance[5] (CV)	Occurrence in Study Area	ESA/MMPA Status[6]
Rough-toothed dolphin	*Steno bredanensis*	SOCAL	Tropical and warm temperate	Unknown	-	Rare; more tropical offshore species	-
		HRC	Hawaiian	8,709 (0.45)	8,709 (0.45)	Common throughout the main Hawaiian Islands and Hawaii Exclusive Economic Zone	-
Pacific white-sided dolphin	*Lagenorhynchus obliquidens*	SOCAL	California, Oregon, & Washington	26,930 (0.28)	2,196 (0.71)	Common; year-round cool water species; more abundant Novembers–April	-
		HRC	No known occurrence				
Northern right whale dolphin	*Lissodelphis borealis*	SOCAL	California, Oregon, & Washington	8,334 (0.40)	1,172 (0.52)	Common; cool water species; more abundant November–April	-
		HRC	No known occurrence				
Fraser's dolphin	*Lagenodelphis hosei*	SOCAL	No known occurrence				
		HRC	Hawaiian	10,226 (1.16)	10,226 (1.16)	Tropical species only recently documented within Hawaii Exclusive Economic Zone (2002 survey)	-
Risso's dolphins	*Grampus griseus*	SOCAL	California, Oregon, & Washington	6,272 (0.30)	3,418 (0.31)	Common; present in summer, but higher densities November–April	-
		HRC	Hawaiian	2,372 (0.97)	2,372 (0.97)	Have been considered rare but six sightings in Hawaii Exclusive Economic Zone during 2002 survey	-
Family Phocoenidae (Porpoises)							
Dall's porpoise	*Phocoenoidea dalli*	SOCAL	California, Oregon, & Washington	42,000 (0.33)	727 (0.99)	Common in cold water periods; more abundant November–April	-
		HRC	No known occurrence				
Family Ziphiidae (Beaked Whales)							
Cuvier's beaked whale	*Ziphius cavirostris*	SOCAL	California, Oregon, & Washington	2,143 (0.65)	911 (0.68)	Possible year-round occurrence but difficult to detect due to diving behavior	-
		HRC	Hawaiian	15,242 (1.43)	15,242 (1.43)	Year-round occurrence but difficult to detect due to diving behavior	-
Baird's beaked whale	*Berardius bairdii*	SOCAL	California, Oregon, & Washington	907 (0.49)	127 (1.14)	Primarily along continental slope from late spring to early fall	-
		HRC	No known occurrence				
Longman's beaked whale	*Indopacetus pacificus*	SOCAL	No known occurrence				
		HRC	Hawaiian	1,007 (1.26)	1,007 (1.26)	One of the rarest and least known cetacean species; abundance based on Barlow 2006 with 3 sightings, however, multiple sightings during 2010 HICEAS	-

Common Name	Scientific Name[1]	Study Area[2]	Stock[3]	Stock Abundance[4] (CV)	Study Area Abundance[5] (CV)	Occurrence in Study Area	ESA/MMPA Status[6]
Blainville's beaked whale	*Mesoplodon densirostris*	SOCAL	California, Oregon, & Washington	603 (1.16)	132 (0.96; for Mesoplodon spp.)	Distributed throughout deep waters and continental slope regions; difficult to detect given diving behavior	-
		HRC	Hawaiian	2,872 (1.25)	2,872 (1.25)	Year-round occurrence but difficult to detect due to diving behavior	-
Mesoplodont beaked whales (SOCAL estimates also include Blainville's beaked whale listed separately above)	*Mesoplodon spp.*	SOCAL	California, Oregon, & Washington	1,024 (0.77)	132 (0.96)	Distributed throughout deep waters and continental slope regions; difficult to detect given diving behavior. Limited sightings; generally seaward of 500–1000 m	-
		HRC	No known occurrence of five Mesoplodon species (*M. carlhubbsi, M. ginkgodens, M. perrini, M. peruvianus, M. stejnegeri*)				
Suborder Pinnipedia[8] Family Otariidae (Fur Seals and Sea Lions)							
California sea lion	*Zalophus californianus*	SOCAL	U.S. Stock	238,000	-	Most common pinniped, Channel Islands breeding sites in summer	-
		HRC	No known occurrence				
Northern fur seal	*Callorhinus ursinus*	SOCAL	San Miguel Island	9,968	Stock is outside of SOCAL	Common; small population breeds on San Miguel Island. May–October	-
		HRC	No known occurrence				
Guadalupe fur seal	*Arctocephalus townsendi*	SOCAL	Mexico	7,408	-	Rare; Occasional visitor to northern Channel Islands; mainly breeds on Guadalupe Island, Mexico, May–July	Threatened/Depleted
		HRC	No known occurrence				
Family Phocidae (True Seals)							
Hawaiian monk seal	*Monachus schauinslandi*	SOCAL	No known occurrence				
		HRC	Hawaiian	1,161	1,161	Predominantly occur at Northwestern Hawaiian Islands; approximately 150 in Main Hawaiian Islands[9]	Endangered/Depleted
Northern elephant seal	*Mirounga angustirostris*	SOCAL	California Breeding	124,000	SNI 9,794 pups in 2000. SCI up to 16 through 2000	Common; Channel Island haul-outs of different age classes; including SCI December–March and April–August; spend 8–10 months at sea	-
		HRC		-	-	Extralimital	
Harbor seal	*Phoca vitulina*	SOCAL	California	34,233	5,271 (All age classes from aerial counts)	Common; Channel Islands haul-outs including SCI and La Jolla; bulk of stock found north of Pt. Conception	-
		HRC	No known occurrence				

8 There are no data regarding the coefficient of variation (CV) for any pinniped given the abundance is determined differently than that of cetacean.
9 Littnan (2010)

4 AFFECTED SPECIES STATUS AND DISTRIBUTION

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

The marine mammal species discussed in this section are those for which general regulations governing potential incidental takes of small numbers of marine mammals are sought. Relevant information on their status, distribution, and seasonal distribution (when applicable) is presented below, as well as additional information about the numbers of marine mammals likely to be found within the activity areas. Information on the general biology and ecology of marine mammals is beyond the scope of this application and is included in the Hawaii-Southern California Training and Testing (HSTT) Environmental Impact Statement (EIS)/Overseas Environmental Impact Statement (OEIS) (U.S. Department of the Navy 2012a), the Southern California Marine Resource Assessment (U.S. Department of the Navy 2008c), and the Hawaii MRA (U.S. Department of the Navy 2005). In addition, National Marine Fisheries Service (NMFS) annually publishes stock assessment reports for all marine mammals in United States (U.S.) Exclusive Economic Zone (EEZ) waters, including stocks that occur within the HSST Study Area (Allen and Angliss 2010; Carretta et al. 2011; Carretta et al. 2012).

The Southern sea otter is managed by the U.S. Fish and Wildlife Service (USFWS). Potential incidental takes of this species will be dealt with under a separate informal consultation with the USFWS.

Blue Whale (*Balaenoptera musculus*)

Status- The Eastern North Pacific stock of blue whales includes animals found in the eastern North Pacific from the northern Gulf of Alaska to the eastern tropical Pacific (Carretta et al. 2011). The Central North Pacific stock of blue whales may occasionally occur in waters off Hawaii; however, sightings are few and they are considered an infrequent winter migrant (Carretta et al. 2011). The blue whale is listed as endangered under the ESA and MMPA.

HSTT Distribution and Seasonal Distribution- The blue whale inhabits all oceans and typically occurs near the coast, over the continental shelf, although it is also found in oceanic waters. In the North Pacific, their range includes waters off the U.S. west coast and the open ocean. Blue whales have been sighted, acoustically recorded and satellite tagged in the eastern tropical Pacific (Block et al. 2011; Ferguson 2005; Stafford et al. 2004). Most baleen whales spend their summers feeding in productive waters near the higher latitudes and winters in the warmer waters at lower latitudes (Sirovic et al. 2004). Blue whales in the North Pacific are known to migrate between higher latitude feeding grounds of the Gulf of Alaska and the Aleutian Islands to lower latitude breeding grounds of California and Baja California, Mexico (Calambokidis et al. 2009). Blue whales observed in the spring, summer, and fall off California, Washington, and British Columbia are known to be part of a group that returns to feeding areas off British Columbia and Alaska (Calambokidis and Barlow 2004; Calambokidis et al. 2009; Gregr et al. 2000; Mate et al. 1999; Moore et al. 2002; Stafford et al. 1999). These animals have shown site fidelity, returning to their mother's feeding grounds on their first migration (Calambokidis and Barlow 2004). They are known to migrate to waters off Mexico and as far as the Costa Rican Dome (Calambokidis and Barlow 2004; Calambokidis et al. 2009). Winter migration movements south along the Baja California, Mexico, coast to the Costa Rica Dome indicate that the Costa Rica Dome may be a calving and breeding area (Mate et al. 1999). The U.S. west coast is known to be a feeding area for this species during summer and fall (Bailey et al. 2009; Carretta et al. 2010a). This species has frequently been observed in

the Southern California portion of the Study Area (Carretta et al. 2000b; Smultea et al. 2009). Photographs of blue whales in California have been matched to individuals photographed off the Queen Charlotte Islands in northern British Columbia and the northern Gulf of Alaska (Calambokidis et al. 2009). Blue whales belonging to the Central North Pacific stock may feed in summer, south of the Aleutians and in the Gulf of Alaska, and migrate to wintering grounds in lower latitudes in the western and central Pacific, including Hawaii (Stafford et al. 2004; Watkins et al. 2000). Blue whales are thus known to occur in waters off Hawaii, but only seasonally (winter) and sighting frequency is low.

HSTT Population and Abundance- Widespread whaling over the last century is believed to have decreased the population of blue whales to approximately one percent of its pre-whaling population size (Branch et al. 2007; Sirovic et al. 2004). The current best available abundance estimate for blue whales in California, Oregon, and Washington is 2,497 (coefficient of variation = 0.24) (Carretta et al. 2011). The best available estimate of blue whales in the Southern California portion of the study area during the summer and fall (when they are most common) is 842 (coefficient of variation = 0.20) (Barlow and Forney 2007). In the North Pacific, up to five distinct populations of blue whales are believed to occur. In 2008, Cascadia Research conducted photographic identification surveys to make abundance estimates of blue whales along the U.S. West Coast. The results reflected an increase in blue whale abundance along the U.S. West Coast (Calambokidis et al. 2009). However, data are not sufficient to discern if this is due to a population increase or the result of an increased use of the area as a feeding ground. Due to the lack of sighting data, there is currently no abundance estimate for blue whales in Hawaiian waters.

Hearing and Vocalization- Blue whale vocalizations tend to be long (>20 s), low-frequency (<100 Hz) signals (see Thomson and Richardson 1995), with a range of 12 to 400 Hz and dominant energy in the infrasonic range of 12 to 25 Hz (Ketten 1998; McDonald et al. 2001; Mellinger and Clark 2003). Vocalizations are predominantly of two types - songs and calls. Blue whale calls have high acoustic energy, with reports of 186 to 188 dB re 1 µPa-m (Cummings and Thompson 1971; McDonald et al. 2001) and 195 dB re 1 µPa-m (Aburto et al. 1997) source levels. Calls are short-duration sounds (2 to 5 s) that are transient and frequency-modulated, having a higher frequency range and shorter duration than song units and often sweeping down in frequency (80 to 30Hz), with seasonally variable occurrence (McDonald et al. 2001; Thompson et al. 1996). Short-duration pulses of a high-intensity, broadband (858 ± 148 Hz) nature have been reported (Di Iorio et al. 2005).

Blue whale songs consist of repetitively patterned sounds produced over time spans of minutes to hours, or even days (Cummings and Thompson 1971; McDonald et al. 2001). The songs are divided into two components - pulsed/tonal units, which are continuous segments of sound, and phrases, which are repeated combinations of 1 to 5 units (Mellinger and Clark 2003; Payne and McVay 1971). A song is composed of many repeated phrases. Songs can be detected for hundreds, and even thousands of kilometers (Stafford et al. 1998), and have only been attributed to males (see McDonald et al. 2001; Oleson et al. 2007a). Worldwide, songs are showing a downward shift in frequency (see McDonald et al. 2009). For example, a comparison of recordings between November 2003 and November 1964-65 reveals a long-term shift in the frequency of blue whale calling near San Nicolas Island. In 2003, the spectral energy peak was 16 Hz compared to ~22.5 Hz in 1964-65, illustrating a more than 30 percent shift in call frequency over 4 decades (McDonald et al. 2006). McDonald et al. (2009) observed a 31 percent downward frequency shift in blue whale calls off the coast of California, and also noted lower frequencies in 7 of the world's 10 known blue whale songs originating in the Atlantic, Pacific, Southern, and Indian Oceans. Many possible explanations for the shifts exist, but none have emerged as the probable cause.

Although general characteristics of blue whale calls are shared in distinct regions (McDonald et al. 2001; Mellinger and Clark 2003; Rankin et al. 2005; Thompson et al. 1996), some variability appears to exist among different geographic areas (Rivers 1997). Sounds in the north Atlantic have been confirmed to have different characteristics (i.e., frequency, duration, and repetition) than those recorded in other parts of the world (Berchok et al. 2006; Mellinger and Clark 2003). Clear differences in call structure suggestive of separate populations for the western and eastern regions of the north Pacific have also been reported (Stafford et al. 2001); however, some overlap in calls from these geographically distinct regions have been observed, indicating that the whales may have the ability to mimic calls (Stafford and Moore 2005).

Calling rates of blue whales tend to vary based on feeding behavior. Stafford et al. (2005) recorded the highest calling rates when blue whale prey was closest to the surface during its vertical migration. Wiggins et al. (2005) reported the same trend of reduced vocalization during daytime foraging followed by an increase at dusk as prey moved up into the water column and dispersed. Blue whales make seasonal migrations to areas of high productivity to feed, and vocalize less at the feeding grounds than during migration (Burtenshaw et al. 2004). Oleson et al. (2007b) reported higher calling rates in shallow diving (<100 ft.) whales, while deeper diving whales (>165 ft.) were likely feeding and calling less.

A recent Navy-funded study involving use of hydrophones for passive acoustic monitoring in the Southern California Range Complex has provided preliminary information regarding a form of blue whale response to mid-frequency active sonar (Melcon et al. 2012). Melcon et al. used a probabilistic calculation series to conclude that blue whales decreased the proportion of time spent producing D calls when mid-frequency sonar was also present on the hydrophone recordings. Given the nature of passive acoustic monitoring using bottom mounted hydrophone recording devices, there are no data from this research regarding other potential behavioral changes such as actual foraging (Oleson et al. 2007a, 2007b) associated with a decreased rate of D calls. For instance, Melcon et al. 2012 does not provide information that actual blue whale foraging stopped or was displaced, only that blue whales may have temporarily ceased producing some D calls. The Navy's acoustic effect modeling accounts for this type of potential behavioral reaction by considering all exposures under the behavioral risk function as Level B harassment.

While no data on hearing ability for this species are available, Ketten (1997) hypothesized that mysticetes have acute infrasonic hearing. Based on vocalizations and anatomy, blue whales are assumed to predominantly hear low-frequency sounds below 400 Hz (Croll et al. 2001; Oleson et al. 2007b; Stafford and Moore 2005). In terms of functional hearing capability blue whales belong to the low-frequency group, which have the best hearing ranging from 7 Hz to 22 kHz (Southall et al. 2007).

Fin Whale (*Balaenoptera physalus*)

Status- The fin whale is listed as endangered under the ESA and as depleted under the MMPA. Pacific fin whale population structure is not well known. There is a California, Oregon, and Washington stock recognized, as well as a separate stock in the Gulf of California (Carretta et al. 2010a).

HSTT Distribution and Seasonal Distribution- Fin whales prefer temperate and polar waters and are scarcely seen in warm, tropical waters (Reeves et al. 2002). Fin whales typically congregate in areas of high productivity. They spend most of their time in coastal and shelf waters, but can often be found in waters of approximately 6,560 ft. (2,000 m) (Aissi et al. 2008; Reeves et al. 2002). Attracted for feeding, fin whales are often seen closer to shore after periodic patterns of upwelling and the resultant increased

krill density (Azzellino et al. 2008). The distribution of fin whales in the Pacific during the summer includes the northern area of the Hawaii portion of the Study Area to 32° N off the coast of California (Barlow 1995; Forney et al. 1995). Fin whales are relatively abundant in north Pacific offshore waters, including the Hawaii portion of the Study Area (Berzin and Vladimirov 1981; Mizroch et al. 2009). Acoustic signals that may be attributed to the fin whale have also been detected in the Transit Corridor portion of the Study Area (Northrop et al. 1968; Watkins et al. 2000).

Fin whales are found in Hawaiian waters, but this species is considered to be rare in this portion of the Study Area (Carretta et al. 2010a; Shallenberger 1981). There are known sightings from Kauai, Oahu, Hawaii and a single stranding record from Maui, Hawaii (Mobley et al. 1996; Shallenberger 1981; U.S. Department of the Navy 2011). Five sightings were made in offshore waters during a 2002 survey of waters within the Hawaiian Exclusive Economic Zone, and a single sighting was made during aerial surveys from 1993 to 1998 (Barlow et al. 2006; Carretta et al. 2010b; Mobley et al. 1996; Mobley et al. 2000). The most recent sighting was a single juvenile fin whale reported off Kauai in 2011 (U.S. Department of the Navy 2011). Based on sighting data and acoustic recordings, fin whales are likely to occur in Hawaiian waters mainly in fall and winter (Barlow et al. 2004; Barlow et al. 2006; Barlow et al. 2008).

This species has been documented from 60° N to 23° N, and they have frequently been recorded in offshore waters within the southern California portion of the Study Area (Carretta et al. 2010b; Mizroch et al. 2009). Aggregations of fin whales are present year-round in southern and central California (Forney et al. 1995). Aerial surveys conducted in October and November 2008 by the Marine Mammal Research Consultants within the southern California portion of the Study Area resulted in the sighting of 22 fin whales (Acevedo-Gutierrez 2002; Oleson and Hill 2009). Navy sponsored monitoring in the SOCAL Range Complex for the 2009-2010 period also recorded the presence of fin whales (U.S. Department of the Navy 2010).

HSTT Population and Abundance- The current best available abundance estimate for the Hawaiian stock of fin whales is 174 (coefficient of variation = 0.72) (Barlow 2003). The current best available abundance estimate of fin whales in California, Oregon, and Washington waters is 3,044 (coefficient of variation = 0.18) (Allen and Angliss 2010). Both surveys likely underestimate the numbers for both stocks, because large whales that could not be identified in the field (due to distance, bad sighting conditions, etc.) were recorded in these and other surveys as “unidentified rorqual” or “unidentified large whale” (Carretta et al. 2010a). Moore and Barlow (2011) indicate that since 1991, there is strong evidence of increasing fin whale abundance in the California Current area, they predict continued increases in fin whale numbers over the next decade, and that perhaps fin whale densities are reaching “current ecosystem limits”.

Hearing and Vocalization- Fin whales produce a variety of low-frequency (< 1 kHz) sounds, but the most typically recorded is a 20 Hz pulse lasting about 1 s, and reaching source levels of 189 ± 4 dB re 1 µPam (Charif et al. 2002; Clark and Ellison 2002; Edds 1988; Richardson et al. 1995; Širović et al. 2007; Watkins 1981; Watkins et al. 1987). These pulses frequently occur in long sequenced patterns, are downswept (e.g., 23-18 Hz), and can be repeated over the course of many hours (see Watkins et al. 1987). In temperate waters, intense bouts of these patterned sounds are very common from fall through spring, but also occur to a lesser extent during the summer in high latitude feeding areas (Clark and Charif 1998). The seasonality and stereotypic nature of these vocal sequences suggest that they are male reproductive displays (Watkins 1981; Watkins et al. 1987); a notion further supported by recent data linking these vocalizations to male fin whales only (Croll et al. 2002). Although acoustic recordings of fin whales from many diverse regions show close adherence to the typical 20 Hz bandwidth and

sequencing when performing these vocalizations, there have been slight differences in the pulse patterns, indicative of some geographic variation (see Thompson et al. 1992 and Watkins et al. 1987 for review). The source depth, or depth of calling fin whales, has been reported to be about 50 m (164 ft.) (Watkins et al. 1987), with detection possible up to 56 km (35 mi.) away (Širović et al. 2007).

Other documented sounds produced by fin whales include various short tonal pulses averaging 82, 68, and 56 Hz, mostly downswept (Thompson et al. 1992); long moans with two pulse components-one at 68 Hz followed by one at 34 Hz (also typically downswept) (Cummings et al. 1986); short ~5 Hz calls, short ~100 Hz upsweeps, and 129-150 Hz simple tones (some with slight frequency modulation) (Edds 1988).

Responses to conspecific sounds have been demonstrated in a number of mysticetes, and there is no reason to believe that fin whales do not communicate similarly (Edds-Walton 1997). The low-frequency sounds produced by fin whales have the potential to travel over long distances, and it is possible that long-distance communication occurs in fin whales (Edds-Walton 1997; Payne and Webb 1971). Also, there is speculation that the sounds may function for long range echolocation of large-scale geographic targets such as seamounts, which might be used for orientation and navigation (Tyack 1999).

Although no studies have directly measured the sound sensitivity of fin whales, experts assume that fin whales are able to receive sound signals in roughly the same frequencies as the signals they produce. This suggests fin whales, like other baleen whales, are more likely to have their best hearing capacities at low frequencies, including frequencies lower than those of normal human hearing, rather than at mid- to high-frequencies (Ketten 1997).

In terms of functional hearing capability fin whales belong to the low-frequency group, which have the best hearing ranging from 7 Hz to 22 kHz (Southall et al. 2007).

Humpback Whale (*Megaptera novaeangliae*)

Status- Humpback whales are listed as depleted under the MMPA and endangered under the ESA. Based on evidence of population recovery in many areas, the species is being considered by NMFS for removal or down-listing from the United States Endangered Species List (National Marine Fisheries Service 2009b). The health of humpback whales within the Hawaiian Islands Humpback Whale National Marine Sanctuary is classified as fair (Office of National Marine Sanctuaries 2010).

In the United States North Pacific, the stock structure of humpback whales is defined based on feeding areas because of the species' fidelity to feeding grounds (Carretta et al. 2010b). The National Marine Fisheries Service has designated three stocks: (1) the Central North Pacific stock, consisting of winter and spring populations of the Hawaiian Islands that migrate to northern British Columbia and Alaska, the Gulf of Alaska, the Bering Sea, and Aleutian Islands; (2) the Western North Pacific stock, consisting of winter and spring populations off Asia that migrate to Russia and the Bering Sea and Aleutian Islands; and (3) the California, Oregon, Washington, and Mexico stock, consisting of winter and spring populations in coastal Central America and coastal Mexico that migrate to coastal California and to British Columbia in summer and fall (Allen and Angliss 2010).

HSTT Distribution and Seasonal Distribution- Humpback whales are distributed worldwide in all major oceans and most seas. They typically are found during the summer on high-latitude feeding grounds and during the winter in the tropics and subtropics around islands, over shallow banks, and along continental coasts, where calving occurs.

The Central North Pacific stock of humpback whales occurs throughout known breeding grounds in the Hawaii portion of the Study Area during winter and spring (November through April) (Allen and Angliss 2010). Peak occurrence around the Hawaiian Islands is from late February through early April (Carretta et al. 2010b; Mobley et al. 2001a). Humpback whales have been recorded acoustically throughout the spring with a peak in March near the Hawaiian Islands (Norris et al. 1999). A recent study that also used acoustic recordings near the northwestern Hawaiian Islands indicates that humpback whales were present from early December through early June (Lammers et al. 2011). During the fall-winter period, primary occurrence is expected from the coast to 50 nm offshore (Mobley et al. 2001a; Mobley 2004). The greatest densities of humpback whales (including calves) are in the four-island region consisting of Maui, Molokai, Kahoolawe, and Lanai, as well as Penguin Bank (Maldini et al. 2005; Mobley et al. 2001a) and around Kauai (Mobley 2005). During the spring-summer period, secondary occurrence is expected offshore out to 50 nm. Occurrence farther offshore, or inshore (e.g., Pearl Harbor or Honolulu Harbor), is rare. Survey results and acoustic recordings from the northwestern Hawaiian Islands suggest that humpbacks may also be wintering in the northwestern Hawaiian Island region and not just using it as a migratory corridor. It is not yet known if the humpback whales in the northwestern Hawaiian Islands represent a previously undocumented stock or if they are part of the same population that winters near the Main Hawaiian Islands.

The California, Oregon, and Washington stock of humpback whales use the waters within the southern California portion of the Study Area as a summer feeding ground. Peak occurrence occurs in the southern California portion of the Study Area from December through June (Calambokidis et al. 2001). During late summer, more humpback whales are sighted north of the Channel Islands, and limited occurrence is expected south of the northern Channel Islands (San Miguel, Santa Rosa, Santa Cruz) (Carretta et al. 2010a).

Most humpback whale sightings are in nearshore and continental shelf waters; however, humpback whales frequently travel through deep oceanic waters during migration (Calambokidis et al. 2001; Clapham and Mattila 1990), and can be expected to cross the Transit Corridor portion of the Study Area. Humpback whales migrating from breeding grounds in Hawaii to feeding grounds at higher latitudes may cross western portions of the Transit Corridor while whales migrating from breeding grounds in waters off Mexico and Central America to feeding grounds off California, Oregon, and Washington may cross eastern portions of the Transit Corridor.

HSTT Population and Abundance- The overall abundance of humpback whales in the north Pacific was recently estimated at 21,808 individuals (coefficient of variation = 0.04), confirming that this population of humpback whales has continued to increase and is now greater than some pre-whaling abundance estimates (Barlow et al. 2011). Data indicates the North Pacific population has been increasing at a rate of between 5.5% and 6.0% per year, approximately doubling every ten years (Calambokidis et al 2008). The current best estimate for the California, Oregon, and Washington stock is 2,043 (coefficient of variation = 0.10) (Carretta et al. 2010a). Based on ship surveys conducted in the summer and fall from 1991 to 2005, it is estimated that 36 humpback whales (coefficient of variation = 0.51) occur off southern California in the waters south of Point Conception (Barlow and Forney 2007).

The Central North Pacific stock has been estimated at 10,103 individuals on wintering grounds throughout the main Hawaiian Islands (Allen and Angliss 2010). The Hawaiian Islands Humpback Whale National Marine Sanctuary reported in 2010 that as many as 12,000 humpback whales migrate to Hawaiian waters each year (National Oceanic and Atmospheric Administration 2010). Based on aerial

surveys conducted around the main Hawaiian Islands, the number of humpback whales was estimated at 4,491 (Mobley et al. 2001a).

Hearing and Vocalization- Humpback whales are known to produce three classes of vocalizations: (1) "songs" in the late fall, winter, and spring by solitary males; (2) social sounds made by calves (Zoidis et al. 2008) or within groups on the wintering (calving) grounds; and (3) social sounds made on the feeding grounds (see Thompson and Richardson 1995). The best-known types of sounds produced by humpback whales are songs, which are thought to be reproductive displays used on breeding grounds only by adult males (Clark and Clapham 2004; Gabriele and Frankel 2002; Helweg et al. 1992; Matilla et al. 1987; Schevill 1964; Smith et al. 2008). Singing is most common on breeding grounds during the winter and spring months, but is occasionally heard in other regions and seasons (Clark and Clapham 2004; Gabriele and Frankel 2002; Matilla et al. 1987; McSweeney et al. 1989). Au et al. (2000) noted that humpbacks off Hawaii tended to sing louder at night compared to the day. There is geographical variation in humpback whale song, with different populations singing a basic form of a song that is unique to their own group. However, the song evolves over the course of a breeding season, but remains nearly unchanged from the end of one season to the start of the next (Payne et al. 1983). The song is an elaborate series of patterned vocalizations that are hierarchical in nature, with a series of songs ('song sessions') sometimes lasting for hours (Payne and McVay 1971). Components of the song range from below 20 Hz up to 4 kHz, with source levels measured between 151 and 189 dB re 1 microPascals-meter (µPa-m) and high-frequency harmonics extending beyond 24 kHz (Au 2001; Au et al. 2004; Maeda et al. 2000; Winn et al. 1970).

Social calls range from 20 Hz to >10 kHz, with dominant frequencies below 3 kHz (D'Vincent et al. 1985; Dunlop et al. 2008; Silber 1986; Simão and Moreira 2005). Female vocalizations appear to be simple; Simão and Moreira (2005) noted little complexity.

"Feeding" calls, unlike song and social sounds are a highly stereotyped series of narrow-band trumpeting calls. These calls 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 (U.S. Department of the Navy 2009). The fundamental frequency of feeding calls is approximately 500 Hz (D'Vincent et al. 1985; Thompson et al. 1986). The acoustics and dive profiles associated with humpback whale feeding behavior in the northwest Atlantic has been documented with acoustic recording tags (DTAGs) (Stimpert et al. 2007). Underwater lunge behavior was associated with nocturnal feeding at depth and with multiple bouts of broadband click trains that were acoustically different from toothed whale echolocation: Stimpert et al. (2007) termed these sounds "mega-clicks" which showed relatively low received levels at the DTAGs (143 to 154 dB re 1 µPa), with the majority of acoustic energy below 2 kHz.

Houser et al. (2001b) produced a predicted humpback whale audiogram using a mathematical model based on the internal structure of the ear: estimated sensitivity was from 700 Hz to 10 kHz, with maximum relative sensitivity between 2 and 6 kHz. Previously mentioned research by Au (2001, 2004) off Hawaii indicated the presence of high-frequency harmonics in vocalizations up to and beyond 24 kHz. While recognizing this was the upper limit of the recording equipment, it does not demonstrate that humpbacks can actually hear those harmonics, which may simply be correlated harmonics of the frequency fundamental in the humpback whale song. The ability of humpbacks to hear frequencies around 3 kHz may have been demonstrated in a playback study. Maybaum (1989) reported that humpback whales showed a mild response to a handheld sonar marine mammal detection and location device with frequency of 3.3 kHz at 219 dB re 1µPa-m or frequency sweep of 3.1 to 3.6 kHz (although it should be noted that this system is significantly different from the Navy's mid-frequency

hull mounted sonar). In addition, the system had some low-frequency components (below 1 kHz) which may have been an artifact of the acoustic equipment. This possible artifact may have affected the response of the whales to both the control and sonar playback conditions.

In terms of functional hearing capability, humpback whales belong to low-frequency cetaceans which have the best hearing ranging from 7 to 22 kHz (Southall et al. 2007).

Sei Whale (*Balaenoptera borealis*)

Status- The sei whale is listed as endangered under the ESA and as depleted under the MMPA. Only a single eastern North Pacific stock is recognized in the U.S. Pacific EEZ (Carretta et al. 2010b). However, some mark-recapture, catch distribution, and morphological research indicates that more than one stock exists: one between 175° W and 155° W, and another east of 155° W (Carretta et al. 2010a; Masaki 1976; Masaki 1977). The Eastern North Pacific population has been protected since 1976, but is likely still impacted by the effects of continued unauthorized takes (Carretta et al. 2010a).

HSTT Distribution and Seasonal Distribution- Sei whales are found primarily in cold temperate to subpolar latitudes. During the winter, sei whales are found from 20° N to 23° N and during summer from 35° N to 50° N (Masaki 1976; Masaki 1977; Horwood 2009; Smultea et al. 2010). They are considered absent or at very low densities in most equatorial areas.

The sei whale has been considered rare in the Hawaii portion of the Study Area based on reported sighting data and the species' preference for cool temperate waters. Sei whales were not sighted during aerial surveys conducted within 25 nm of the main Hawaiian Islands from 1993 to 1998 (Mobley et al. 2000). Secondary occurrence is expected in deep waters on the north side of the islands only (Barlow et al. 2004). The first verified sei whale sighting in the nearshore waters of the main Hawaiian Islands occurred north of Oahu in November 2007 (Smultea et al. 2008; Smultea et al. 2010) and included three subadults—the first subadult sightings in the main Hawaiian islands. These latter sightings suggest that the area north of the main Hawaiian Islands may be part of a reproductive area for North Pacific sei whales (Smultea et al. 2010). A line-transect survey conducted in February 2009 by the Cetacean Research Program surrounding the Hawaiian Islands resulted in the sighting of three Bryde's/sei whales (Oleson and Hill 2009). An additional sighting occurred in 2010 of Perret Seamount (U.S. Department of Navy 2011). On March 18, 2011 off Maui, the Hawaiian Islands Entanglement Response Network found a subadult sei whale entangled in rope and fishing gear (National Marine Fisheries Service 2011a).

Sei whales occur in the southern California portion of the Study Area, to as far south as Baja California, Mexico (Reeves et al. 1999). They are generally found feeding along the California Current (Perry et al. 1999). There are records of sightings in California waters as early as May and June, but sei whales are primarily encountered from July to September and leave California waters by mid-October. Aerial surveys conducted in October and November 2008 by the Marine Mammal Research Consultants off the southern California coast resulted in one sighting of a sei (or possibly fin) whale (Oleson and Hill 2009). Sei whales are likely present in the Transit Corridor portion of the Study Area, and are seen at least as far south as 20° N in the North Pacific Subtropical Gyre (Horwood 1987, 2009).

HSTT Population and Abundance- The best current estimate of abundance for California, Oregon, and Washington waters out to 300 nm is 126 sei whales (coefficient of variation = 0.53) (Carretta et al. 2010a). A 2002 shipboard line-transect survey of the entire U.S. EEZ off the coast of Hawaii resulted in a summer and fall abundance estimate of 77 sei whales (coefficient of variation = 1.06) (Barlow 2003). This abundance estimate is considered the best available estimate for U.S. EEZ off the coast of Hawaii,

but may be an underestimate, as sei whales are expected to be mostly at higher latitudes on their feeding grounds during this time of year (Carretta et al. 2010a). No data are available on current population trends.

Hearing and Vocalization- Recordings made in the presence of sei whales have shown that they produce sounds ranging from short, mid-frequency pulse sequences (Knowlton et al.1991; Thompson et al. 1979) to low-frequency broadband calls characteristic of mysticetes (Baumgartner et al. 2008; McDonald et al. 2005; Rankin and Barlow 2007). Off the coast of Nova Scotia, Canada, Knowlton et al. (1991) recorded two-phased calls lasting about 0.5 to 0.8 s and ranging in frequency from 1.5 to 3.5 kHz in the presence of sei whales—data similar to that reported by Thompson et al. (1979). These mid-frequency calls are distinctly different from low-frequency tonal and frequency swept calls recorded in later studies. For example, calls recorded in the Antarctic averaged 0.45 ± 0.3 s in duration at 433 ± 192 Hz, with a maximum source level of 156 ± 3.6 dB re 1 µPa-m (McDonald et al. 2005). During winter months off Hawaii, Rankin and Barlow (2007) recorded downswept calls by sei whales that exhibited two distinct low-frequency ranges of 100 to 44 Hz and 39 to 21 Hz, with the former range usually shorter in duration. Similar sei whale calls were also found near the Gulf of Maine in the northwest Atlantic, ranging from 82.3 to 34.0 Hz and averaging 1.38 s in duration (Baumgartner et al. 2008). These calls were primarily single occurrences, but some double or triple calls were noted as well. It is thought that the difference in call frequency may be functional, with the mid-frequency type serving a reproductive purpose and the low-frequency calls aiding in feeding/social communication (McDonald et al. 2005). Sei whales have also been shown to reduce their calling rates near the Gulf of Maine at night, presumably when feeding, and increase them during the day, likely for social activity (Baumgartner and Fratantoni 2008).

While no data on hearing ability for this species are available, Ketten (1997) hypothesized that mysticetes have acute infrasonic hearing. In terms of functional hearing capability, sei whales belong to low-frequency cetaceans which have the best hearing ranging from 7 Hz to 22 kHz (Southall et al. 2007). There are no tests or modeling estimates of specific sei whale hearing ranges.

Bryde's Whale (*Balaenoptera edeni*)

Status- This species is protected under the MMPA and is not listed under the ESA. The International Whaling Commission recognizes three management stocks of Bryde's whales in the North Pacific: western North Pacific, eastern North Pacific, and east China Sea (Donovan 1991), although the biological basis for defining separate stocks of Bryde's whales in the central North Pacific is not clear (Carretta et al. 2010b). Bryde's whales within the U.S. EEZ off the coast of Hawaii are divided into two areas: (1) Hawaiian waters and (2) the eastern tropical Pacific, east of 150° W and including the Gulf of California and waters off California (Carretta et al. 2010b), within the Study Area.

HSTT Distribution and Seasonal Distribution- Bryde's whales are only occasionally sighted in the waters of the Hawaiian Islands (Carretta et al. 2010b; Jefferson et al. 2008; Smultea et al. 2008). A summer/fall 2002 shipboard survey of waters within the U.S. EEZ of the Hawaiian Islands resulted in 13 Bryde's whale sightings (Barlow 2003). The first verified Bryde's whale sighting made nearshore of the main Hawaiian Islands occurred in 2007 (Smultea et al. 2008; Smultea et al. 2010). A line-transect survey conducted in February 2009 by NMFS, Pacific Island Fisheries Science Center surrounding the Hawaiian Islands resulted in the sighting of three Bryde's/sei whales (Oleson and Hill 2009). Sightings are more frequent in the northwest Hawaiian Islands than in the main Hawaiian Islands (Barlow et al. 2004; Carretta et al. 2010a; Smultea et al. 2008; Smultea et al. 2010).

Bryde's whales are only occasionally sighted in the waters of the southern California portion of the Study Area (Carretta et al. 2010a; Jefferson et al. 2008; Smultea et al. 2008). Aerial surveys conducted in October and November 2008 by the Marine Mammal Research Consultants off the southern California coast resulted in the sighting of one Bryde's whale (Oleson and Hill 2009). This was the first sighting in this area since 1991 when a Bryde's whale was sighted within 300 nm of the California coast (Barlow 1995).

Bryde's whales occur primarily in offshore oceanic waters of the North Pacific. They are distributed throughout the North Pacific Subtropical Gyre and North Pacific Transition Zone, in the Hawaiian portion of the Study Area.

HSTT Population and Abundance- Little is known of population status and trends for most Bryde's whale populations. Current genetic research confirms that gene flow among Bryde's whale populations is low and suggests that management actions treat each as a distinct entity to ensure proper conservation of biological diversity (Kanda et al. 2007). The best estimate of the eastern tropical Pacific population is 13,000 (coefficient of variation = 0.20) individuals, with only an estimated 12 (coefficient of variation = 2.0) individuals in California, Oregon, and Washington waters (Carretta et al. 2010a). A 2002 shipboard line-transect survey of the entire U.S. EEZ off the coast of Hawaii yielded an abundance estimate of 469 (coefficient of variation = 0.45) Bryde's whales (Barlow 2003), which is the best available abundance estimate for the Hawaiian stock (Carretta et al. 2010a).

Hearing and Vocalization- Bryde's whales produce low-frequency tonal and swept calls similar to those of other rorquals. Calls vary regionally and are produced in extended sequences (see Oleson et al. 2003). In the Gulf of California, low-frequency moaning sounds with slight up/down sweeps have been recorded averaging 0.4 s in duration, with most sound energy ~124 Hz, and at source levels from 152 to 174 dB re 1 µPa (Cummings et al. 1986). A captive juvenile Bryde's whale produced pulsed moans that were typically longer in duration than those recorded from adults (0.5 to 51 s), but shorter in sequence (20 to 70 pulses/s versus 60 to 130 pulses/s) and higher in frequency (200 to 900 Hz) (Edds et al. 1993). These data may represent maturation (learning and physiological) differences typical of the species, but a possible context influence (captive stranding) cannot be ruled out. In more recent recordings, most adult Bryde's whale calls contain fundamental frequencies below those of earlier data. McDonald (2006) recorded downward sweep calls (25 to 22 Hz) and 5 s, 22 Hz tonal calls off Great Barrier Island, New Zealand. Oleson et al. (2003) identified 6 call types in the eastern tropical Pacific, with 5 of the call's average frequencies between 20 and 60 Hz; 1 call type in the southern Caribbean averaging 44.3 Hz; and 3 call types in the northwest Pacific, averaging between 44.3 and 46 Hz. These lower fundamental frequencies may represent regional, seasonal, and age differences present during this study compared to earlier ones (Oleson et al. 2003). Bryde's whales have also been shown to produce calls containing multiple harmonic overtones. Barlow et al. (2006) first described tonal calls in the eastern tropical Pacific (1 to 2 s, at 50 to 53 Hz) with three clear harmonic overtones, and in the southern Caribbean (2 to 3 s, at 15 to 20 or 40 to 45 Hz) with three to five clear harmonic overtones. The majority of Bryde's whale calls in the eastern tropical Pacific, southern Caribbean and the northwestern Pacific described in Oleson et al. (2003) also contained harmonics. Heimlich et al. (2005) described five tone types from Bryde's whale vocalizations in the eastern tropical Pacific. These include two types of alternating tonal "phrases," a wideband "burst" followed by a tone that occurred in either lower (19–30 Hz) or higher (42 Hz) frequencies depending on the area, and a "harmonic tone phrase" with a fundamental frequency of 26 Hz. No vocalization exceeded 80 Hz.

While no data on hearing ability for this species are available, Ketten (1997) hypothesized that mysticetes have acute hearing at frequencies below the normal limit of human hearing. In terms of functional hearing capability Bryde's whales belong to low-frequency cetaceans which have the best hearing ranging from 7 Hz to 22 kHz (Southall et al. 2007).

Minke Whale (*Balaenoptera acutorostrata*)

Status- The minke whale is protected under the MMPA and is not listed under the ESA. Because the "resident" minke whales from California to Washington appear behaviorally distinct from migratory whales further north and those in Hawaii, minke whales in coastal waters of California, Oregon, and Washington (including Puget Sound) are considered as a separate stock from the Alaskan and Hawaiian stocks (Carretta et al. 2010a).

HSTT Distribution and Seasonal Distribution- The minke whale range is known to include the California Current and Insular Pacific-Hawaiian Large Marine Ecosystems, North Pacific Subtropical Gyre and the North Pacific Transition Zone (Miyashita and Fujise 1997; Okamura et al. 2001; Yamada 1997). The northern boundary of their range is within subarctic and arctic waters (Kuker et al. 2005). These whales generally participate in annual migrations between low-latitude breeding grounds in the winter and high-latitude feeding grounds in the summer (Kuker et al. 2005). Minke whales generally occupy waters over the continental shelf, including inshore bays, and even occasionally enter estuaries. However, records from whaling catches and research surveys worldwide indicate an open ocean component to the minke whale's habitat.

Minke whales previously were considered a rare species in Hawaiian waters due to limited sightings during visual and aerial surveys. The first documented sighting of a minke whale close to the main Hawaiian islands was made off the southwest coast of Kauai in 2005 (Norris et al. 2005, Rankin et al. 2007). Recent research suggests minke whales are somewhat common in Hawaii (Rankin et al. 2007; U.S. Department of the Navy 2011). Those found in the Hawaii portion of the Study Area are known to belong to seasonally migrating populations that feed in higher latitudes (Barlow 2006). The common minke is present in summer and fall in the southern California portion of the Study Area (Carretta et al. 2009). They often use both nearshore and offshore waters as habitats for feeding and migration to wintering areas.

HSTT Population and Abundance- The abundance estimate for minke whales, from 2005 and 2008 summer/fall ship surveys in California, Oregon, and Washington waters is approximately 478 individuals (coefficient of variation = 1.36) (Carretta et al. 2010a). There is no population estimate for the Hawaiian stock of minke whales (Carretta et al. 2010b).

Hearing and Vocalization- Recordings of minke whales encompass a wide range of frequencies that consist of both high- and low-frequency sounds (60 Hz to 20 kHz) (Mellinger et al. 2000; Thomson and Richardson 1995; Winn and Perkins 1976). The dominant frequency range is 60 Hz to >12 kHz, depending on sound type (Edds-Walton 2000; Thomson and Richardson 1995). In the northwest Atlantic, common minke whale calls consisted of a 0.4 second(s) downsweep in frequency, from ~100-200 Hz to < 90 Hz (Edds-Walton 2000), similar in both frequency and temporal characteristics to those recorded from Antarctic minkes by Schevill and Watkins (1972). Recordings near Puerto Rico showed two basic forms of pulse trains attributable to minke whales: a "speed-up" pulse train with a frequency range of 200 to 400 Hz and duration of 40 to 60 millisecond (ms); and a less common "slow-down" pulse train at 250 to 350 Hz with pulses lasting for 70 to 140 ms (Mellinger et al. 2000). The speed-up trains

were distinguished by a pulse rate increase from ~1.5 to 3 pulses/s over the course of the pulse train, whereas the slow-down pulse train rates decreased from ~4.5 to 3 pulses/s. Although markedly different in size, the southern hemisphere's dwarf minke whale produces similar vocalizations to the minke whales in the north. Gedamke et al. (2001) recorded a complex and stereotyped sound sequence from dwarf minke whales in Australia's Great Barrier Reef that spanned a frequency range of 50 to 9.4 kHz, with broadband source levels between 150 to 165 dB re 1 µPa-m. "Boings" (an onset pulse followed by a long call with initial frequency modulated upsweep) recorded in the north Pacific (Wenz 1964) have many striking similarities to the southern hemisphere vocalization described by Gedamke et al. (2001) in both structure and acoustic behavior. "Boings" are suggested to be associated with breeding displays (Mellinger et al. 2000) and were only recently identified as minke whale vocalizations (Rankin and Barlow 2005).

In terms of functional hearing capability minke whales belong to low-frequency cetaceans which have the best hearing ranging from 7 to 22 kHz (Southall et al. 2007). There are no tests or modeling estimates of specific minke whale hearing ranges.

Gray Whale (*Eschrichtius robustus*)

Status- There are two North Pacific populations of gray whales: the Western (also known as the western North Pacific or the Korean-Okhotsk population) is critically endangered and shows no apparent signs of recovery, while the Eastern Pacific population (also known as the eastern North Pacific or the California-Chukchi population) appears to have recovered from exploitation and was removed from listing under the ESA in 1994 (Swartz et al. 2006). All populations of the gray whale are protected under the MMPA; the Western Pacific population is endangered under the ESA and is depleted under the MMPA.

HSTT Distribution and Seasonal Distribution- Gray whales primarily occur in shallow waters over the continental shelf and are considered to be one of the most coastal of the great whales (Jefferson et al. 2008; Jones and Swartz 2009). Feeding grounds are generally less than 225 ft. (68 m) deep (Jones and Swartz 2009). Breeding grounds consist of subtropical lagoons (Jones and Swartz 2009). These warm water protected lagoons are more conducive to rearing calves and mating and offer protection from predation by killer whales (Jones and Swartz 2009). Females may also use the shallow lagoons to escape from harassment by courting males, which concentrate at the lagoon entrances and outer coastal areas (Jones and Swartz 2009). The three major breeding lagoons of Eastern North Pacific gray whales are in Baja California, Mexico (Alter et al. 2009; Urban-R. et al. 2003).

Eastern gray whales are frequently observed in the southern California portion of the Study Area (Carretta et al. 2000; Forney et al. 1995; Henkel and Harvey 2008; Hobbs et al. 2004), and are known to migrate along the California coast on both their northward and southward migration. Winter grounds extend from central California south along Baja California, the Gulf of California, and the mainland coast of Mexico. In the fall, whales start the southward migration from November to late December, and mainly follow the coast to Mexico. The northward migration to the feeding grounds occurs in two phases. The first phase in late January through March consists of newly-pregnant females, who go first to maximize feeding time, followed by adult females and males, then juveniles. The second phase, in April through May, consists primarily of mothers and calves who have remained in the breeding area longer, allowing calves to strengthen and rapidly increase in size before the northward migration (Jones and Swartz 2009). During aerial surveys off San Clemente Island, California eastern gray whales were the most abundant marine mammal from January through April, a period that covers both the northward and southward migrations (Carretta et al. 2000; Forney et al. 1995). Although they generally remain

mostly over the shelf during migration, some animals may be found in more offshore waters; the Transit Corridor portion of the Study Area could be a secondary range (Jones and Swartz 2009; Rugh et al. 2008).

HSTT Population and Abundance- Current abundance estimates for the Eastern North Pacific gray whale population are between 17,000 and 20,000 (Rugh et al. 2008; Swartz et al. 2006). The eastern population appears to be generally increasing, despite the 1999 event in which an unusually large number of gray whales stranded along the coast, from Mexico to Alaska (Gulland et al. 2005).

Hearing and Vocalization- Gray whales produce broadband signals ranging from 100 Hz to 4 kHz (and up to 12 kHz). The most common sounds on the breeding and feeding grounds are described as knocks, which are broadband pulses from about 100 Hz to 2 kHz and with most energy at 327 to 825 Hz (Richardson et al. 1995; Jones and Swartz 2002).

The structure of the gray whale ear is evolved for low-frequency hearing (Ketten 1992). The ability of gray whales to hear frequencies below 2 kHz has been demonstrated in playback studies (Malme et al. 1986; Moore and Clarke 2002).

Sperm Whale (*Physeter macrocephalus*)

Status- The sperm whale has been listed as endangered since 1970 under the precursor to the ESA (National Marine Fisheries Service 2009), and is depleted under the MMPA. Sperm whales are divided into three stocks in the Pacific, two of which occur in the Study Area 1) the Hawaii stock and 2) the California, Oregon, and Washington stock.

HSTT Distribution and Seasonal Distribution- The sperm whale's range occurs throughout the entire Study Area. This species is typically found in the temperate and tropical waters of the Pacific (Rice 1989). The secondary range includes the areas of higher latitudes in the northern part of the Study Area (Jefferson et al. 2008; Whitehead 2008). Although this species exhibits a preference for deeper waters (beyond the continental shelf break), some adult males are reported to consistently frequent waters with depths less than 330 ft. (100 m) and as shallow as 130 ft. (40 m) (Jefferson et al. 2008; Romero et al. 2001). Typically, sperm whale concentrations correlate with areas of high productivity. Sperm whales occur in Hawaiian Island waters and are one of the more abundant large whales found in that region (Baird et al. 2003; Mobley et al. 2000). Sperm whales are found year round in California waters (Barlow 1995; Forney and Barlow 1993), where they reach peak abundance from April through mid-June and from the end of August through mid-November (Carretta et al. 2010b).

HSTT Population and Abundance- The current best available estimate of abundance for the California, Oregon, and Washington stock is 971 (coefficient of variation = 0.31) (Carretta et al. 2010b). The current best available abundance estimate for the Hawaiian stock of sperm whales is 6,919 (coefficient of variation = 0.81) (Barlow 2003; Carretta et al. 2010b). Sperm whales within the northern-most portion of the Study Area are estimated at 26,300 (Barlow and Taylor 2005).

Hearing and Vocalization- Recordings of sperm whale vocalizations reveal that they produce a variety of sounds, such as clicks, gunshots, chirrups, creaks, short trumpets, pips, squeals and clangs (Goold 2000). Sperm whales typically produce short-duration repetitive broadband clicks with frequencies below 100 Hz to >30 kHz (Watkins 1977; see Thomson and Richardson 1995) and dominant frequencies between 1 to 6 kHz and 10 to 16 kHz. The source levels can reach 236 dB re 1 µPa-m (Møhl et al. 2003). The clicks of neonate sperm whales are very different from typical clicks of adults in that they are of low

directionality, long duration, and low-frequency (between 300 Hz and 1.7 kHz) with estimated source levels between 140 to 162 dB re 1 µPa-m (Madsen et al. 2003). Clicks are heard most frequently when sperm whales are engaged in diving and foraging behavior (Miller et al. 2004; Whitehead and Weilgart 1991).

When sperm whales are socializing, they tend to repeat series of group-distinctive clicks (codas), which follow a precise rhythm and may last for hours (Watkins and Schevill 1977). Codas are shared between individuals in a social unit and are considered to be primarily for intragroup communication (Rendell and Whitehead 2004; Weilgart and Whitehead 1997). Recent research in the south Pacific suggests that in breeding areas the majority of codas are produced by mature females (Marcoux et al. 2006). Coda repertoires have also been found to vary geographically and are categorized as dialects, similar to those of killer whales (Pavan et al. 2000; Weilgart and Whitehead 1997). For example, significant differences in coda repertoire have been observed between sperm whales in the Caribbean and those in the Pacific (Weilgart and Whitehead 1997). Three coda types used by male sperm whales have recently been described from data collected over multiple years: these include codas associated with dive cycles, socializing, and alarm (Frantzis and Alexiadou 2008).

Creaks (rapid sets of clicks) are heard most frequently when sperm whales are foraging and engaged in the deepest portion of their dives, with inter-click intervals and source levels being altered during these behaviors (Laplanche et al. 2005; Miller et al. 2004). It has been shown that sperm whales may produce clicks during 81 percent of their dive period, specifically 64 percent of the time during their descent phases (Watwood et al. 2006). In addition to producing clicks, sperm whales in some regions like Sri Lanka and the Mediterranean Sea have been recorded making what are called trumpets at the beginning of dives just prior to clicking (Teloni 2005).

Direct measures of sperm whale hearing have been conducted on a stranded neonate using the auditory brainstem response technique: the whale showed responses to pulses ranging from 2.5 to 60 kHz and highest sensitivity to frequencies between 5 to 20 kHz (Ridgway and Carder 2001). Other hearing information consists of indirect data. For example, the anatomy of the sperm whale's inner and middle ear indicates an ability to best hear high-frequency to ultrasonic hearing (Ketten 1992). The sperm whale may also possess better low-frequency hearing than other odontocetes, although not as low as many baleen whales (Ketten 1992). Reactions to anthropogenic sounds can provide indirect evidence of hearing capability, and several studies have made note of changes seen in sperm whale behavior in conjunction with these sounds. For example, sperm whales have been observed to frequently stop echolocating in the presence of underwater pulses made by echosounders and submarine sonar (Watkins and Schevill 1975; Watkins et al. 1985). In the Caribbean, Watkins et al. (1985) observed that sperm whales exposed to 3.25 to 8.4 kHz pulses (presumed to be from submarine sonar) interrupted their activities and left the area. Similar reactions were observed from artificial noise generated by banging on a boat hull (Watkins et al. 1985). André et al. (1997) reported that foraging whales exposed to a 10 kHz pulsed signal did not ultimately exhibit any general avoidance reactions: when resting at the surface in a compact group, sperm whales initially reacted strongly, and then ignored the signal completely (André et al. 1997). Thode et al. (2007) observed that the acoustic signal from the cavitation of a fishing vessel's propeller (110 dB re 1 μPa^2 between 250 Hz and 1.0 kHz) interrupted sperm whale acoustic activity and resulted in the animals converging on the vessel. The full range of functional hearing for the sperm whale is estimated to occur between approximately 150 Hz and 160 kHz, placing them among the group of cetaceans that can hear mid-frequency sounds (Southall et al. 2007).

Pygmy Sperm Whale (*Kogia breviceps*)

Status- The pygmy sperm whale is protected under the MMPA and is not listed under the ESA. Pygmy sperm whales are divided into two discrete stocks: (1) California, Oregon, and Washington waters and (2) Hawaiian waters (Carretta et al. 2010a).

HSTT Distribution and Seasonal Distribution- The pygmy sperm whale frequents more temperate habitats than the other *Kogia* species. Several studies have suggested that this species generally occurs beyond the continental shelf break (Bloodworth and Odell 2008; MacLeod et al. 2004); however, the species may also occur closer to shore over the outer continental shelf. Sightings of pygmy sperm whales are rare in Hawaii. During boat surveys between 2000 and 2003 in the main Hawaiian Islands, this species was observed, but less commonly than other species, such as the dwarf sperm whale (Baird et al. 2003; Baird 2005; Barlow et al. 2004). Nevertheless, pygmy sperm whales are one of the more commonly stranded species in the Hawaiian Islands, and this frequency of strandings indicates that the species is likely more common than sightings suggest (Maldini et al. 2005). A number of sightings of this species have been made in offshore waters along the California coast (Carretta et al. 2010a). Although deep oceanic waters may be the primary habitat for pygmy sperm whales, very few oceanic sightings offshore have been recorded within the Study Area. However, this may be because of the difficulty of detecting and identifying these animals at sea (Caldwell and Caldwell 1989; Maldini et al. 2005). Records of this species from both the western (Japan) and eastern Pacific (California) suggest that the range of this species includes the North Pacific Central Gyre, and North Pacific Transition Zone (Carretta et al. 2010a; Jefferson et al. 2008; Katsumata et al. 2004; Marten 2000; Norman et al. 2004).

HSTT Population and Abundance- Few abundance estimates have been made for this species, and too little information is available to obtain a reliable population estimate for pygmy sperm whales in western North Pacific waters (Carretta et al. 2010b). The current abundance estimate for pygmy sperm whales found along the U.S. west coast is based on the mean of two ship surveys off California, Oregon, and Washington in 2005 and 2008. The resulting abundance estimate is 579 (coefficient of variation = 1.02) individuals (Carretta et al. 2010b). The current best available abundance estimate for the Hawaiian stock of pygmy sperm whales is based on a 2002 shipboard line-transect survey of the entire Hawaiian Islands EEZ, resulting in an estimate of 7,138 (coefficient of variation = 1.12) pygmy sperm whales (Carretta et al. 2010a).

Hearing and Vocalization- Recordings of sounds produced by dwarf and pygmy sperm whales consist almost entirely of the click/pulse type; however, one study described a call made by a stranded pygmy sperm whale. A series of 'cry' type calls upsweeping from ~1.36-1.48 kHz with durations of ~0.42 s was produced either singly or in pairs by a female adult pygmy sperm whale (Thomas et al. 1990). Pygmy sperm whale clicks typically range from 60 to 200 kHz, with a dominant frequency of 120 kHz (Richardson et al. 1995). The only sound recordings for this species are from stranded individuals. A stranded pygmy sperm whale being prepared for release in the western north Atlantic emitted clicks of narrowband pulses with a mean duration of 119 microsecond (µs), interclick intervals between 40 to 70 ms, peak frequency of 130 (±0.7) kHz, and apparent peak-to-peak source level up to 175 dB re 1 µPa-m (Madsen et al. 2005). Another individual found stranded in Monterey Bay produced echolocation clicks ranging from 60 to 200 kHz, with a dominant frequency of 125 kHz (Marten 2000). A captive neonate pygmy sperm whale produced click sequences of varying repetition rates (1 to 13 clicks per 0.1 s) at ~13 kHz (Caldwell and Caldwell 1987). Data on dwarf sperm whales include recent recordings of free-ranging dwarf sperm whales off La Martinique (Lesser Antilles) that produced clicks at 13 to 33 kHz with durations of 0.3 to 0.5 s (Jérémie et al. 2006).

No information on hearing is available for the dwarf sperm whale. However, an auditory brainstem response study completed on a stranded pygmy sperm whale indicated best sensitivity between 90 to 150 kHz (Ridgway and Carder 2001). For both species, functional hearing is estimated to occur between approximately 200 Hz and 180 kHz, placing them among the group of cetaceans that can hear high-frequency sounds (Southall et al. 2007).

Dwarf Sperm Whale (*Kogia sima*)

Status- The dwarf sperm whale is protected under the MMPA and is not listed under the ESA. Dwarf sperm whales within the U.S. EEZ in the Pacific Ocean are divided into two separate areas: (1) waters off California, Oregon and Washington, and (2) Hawaiian waters (Carretta et al. 2010a).

HSTT Distribution and Seasonal Distribution- Dwarf sperm whales tend to occur over the outer continental shelf, and they may be relatively coastal in some areas with deep waters nearshore (MacLeod et al. 2004). Dwarf sperm whales have been observed in both outer continental shelf and more oceanic waters. Records of this species from both the western Pacific (Taiwan) and eastern Pacific (California) suggest that its range includes the southern portions of the California Current Large Marine Ecosystem, all waters of the North Pacific Central Gyre, the Insular Pacific-Hawaiian Large Marine Ecosystem, and the southern portion of the North Pacific Transition Zone (Carretta et al. 2010b; Jefferson et al. 2008; Wang et al. 2001; Wang and Yang 2006). During vessel surveys between 2000 and 2003 in the main Hawaiian Islands, this species was the sixth most commonly observed species, with observations typically occurring in deep water (up to 10,400 ft. [3,200 m]) (Baird et al. 2003; Baird 2005; Barlow et al. 2004). Dwarf sperm whales are one of the more commonly stranded species in the Hawaiian Islands (Maldini et al. 2005), and the frequency of strandings indicates that the species is likely more common than sightings suggest (Jefferson et al. 2008).

Along the U.S. Pacific coast, no reported sightings of this species have been confirmed as dwarf sperm whales. This may be somewhat due to their pelagic distribution, cryptic behavior (i.e., “hidden” because they are not very active at the surface and do not have a conspicuous blow), and physical similarity to the pygmy sperm whale (Jefferson et al. 2008; McAlpine 2009). However, the presence of dwarf sperm whales off the coast of California has been demonstrated by at least five dwarf sperm whale strandings in California between 1967 and 2000 (Carretta et al. 2010b). It is likely that most *Kogia* species off California are *Kogia breviceps* (Nagorsen and Stewart 1983). Although deep oceanic waters may be the primary habitat for this species, very few oceanic sightings offshore have occurred within the Study Area. The lack of sightings may be due to the difficulty of detecting and identifying these animals at sea (Jefferson et al. 2008; Maldini et al. 2005).

HSTT Population and Abundance- Limited information is available to estimate the population size of dwarf sperm whales off the U.S. west coast. There are no known records of sightings of this species despite many vessel surveys in the region. What records of sightings that do come from the west coast for *Kogia* species are likely to be of pygmy sperm whales (Carretta et al. 2010a). The current best available estimate for the Hawaiian stock of the dwarf sperm whale is from a 2002 shipboard line-transect survey of the entire Hawaiian Islands EEZ. The resulting estimate was 17,519 (coefficient of variation = 0.74) dwarf sperm whales (Carretta et al. 2010a).

Hearing and Vocalization- See Pygmy Sperm Whale section for a general description on the hearing and vocalizations of pygmy and dwarf sperm whales.

Killer Whale (*Orcinus orca*)

Status- The killer whale is protected under the MMPA, and the overall species population is not listed under the ESA. The resident population in Puget Sound is listed as endangered under the ESA and is depleted under the MMPA. The North Pacific transient stock is also depleted under the MMPA, but is not listed under the ESA. Five killer whale stocks are recognized within the Pacific U.S. EEZ, with only the eastern North Pacific transient stock (Alaska through California), the eastern North Pacific offshore stock (Southeast Alaska through California), and the Hawaiian stock occurring in the Study Area (Carretta et al. 2010b).

HSTT Distribution and Seasonal Distribution- Killer whales are found in all marine habitats from the coastal zone (including most bays and inshore channels) to deep oceanic basins and from equatorial regions to the polar pack ice zones of both hemispheres. Although killer whales are also found in tropical waters and the open ocean, they are most numerous in coastal waters and at higher latitudes (Dahlheim and Heyning 1999). The range of this species is known to include the California Current and Insular Pacific-Hawaiian Large Marine Ecosystems, the North Pacific Subtropical Gyre, and North Pacific Transition Zone. Although killer whales apparently prefer cooler waters, they have been observed in Hawaiian waters (Barlow et al. 2006; Shallenberger 1981). Sightings are infrequent in Hawaiian waters, and typically occur during winter, suggesting no resident population in Hawaii (Baird et al. 2003; Mobley et al. 2001b). Baird (2006) documented 21 sightings of killer whales within the Hawaiian Exclusive Economic Zone, primarily around the main Hawaiian Islands. There are also documented strandings for this species from the Hawaiian Islands (Maldini et al. 2005).

All three ecotypes of killer whales (i.e., residents, transients, and offshore) are known to occur (from stranding records and acoustic detection) along the entire Alaskan coast, in British Columbia and Washington inland waterways, and along the outer coasts of Washington, Oregon, and California (Barlow 1995; Calambokidis et al. 2004; Dahlheim et al. 2008; Forney et al. 1995; Ford and Ellis 1999). Although they are not commonly observed in southern California coastal areas, killer whales are found year round off the coast of Baja California. This species is known to move in and out of the Gulf of California and around the Baja California peninsula (Carretta et al. 2010b; Forney et al. 1995). This species is known to occur in deep oceanic waters off Hawaii and elsewhere in the Pacific (Carretta et al. 2010a; Miyashita et al. 1996; Wang et al. 2001). In the eastern tropical Pacific, killer whales are known to occur from offshore waters of San Diego to Hawaii and south to Peru (Barlow 2006; Ferguson 2005). Offshore killer whales are known to inhabit both the western and eastern temperate Pacific and likely have a continuous distribution across the North Pacific (Dahlheim et al. 2008).

HSTT Population and Abundance- Based on a rough estimate of the proportion of killer whales in each stock, the current best available abundance estimate for the eastern North Pacific offshore stock is 240 individuals (coefficient of variation = 0.49) and 451 individuals (coefficient of variation = 0.49) for the transient stock (Carretta et al. 2011). The current best available abundance estimate for the Hawaiian stock, based on a 2002 shipboard survey of the entire Hawaiian Islands EEZ, is 349 (coefficient of variation = 0.98) killer whales (Carretta et al. 2010a).

Hearing and Vocalization- The killer whale produces a wide variety of clicks, pulses and whistles; pulsed sounds range from 0.5 to 25 kHz (dominant frequency range: 1 to 6 kHz), and whistles range from 1.5 to 18 kHz (see Thomson and Richardson 1995). Source levels associated with social sounds (e.g., whistles and some pulses) have been calculated to range from 137 to 157 dB re 1 µPa-m (Veirs 2004). Simon et al. (2006) described a pulsed call made by Icelandic killer whales with a low-frequency (average peak

frequency of 683 ± 131 Hz), long duration (3.0 ± 1.1 s) and high intensity (source level 169 to 192 dB re 1µPa-m peak-to-peak); however, it is suggested that the call may not be used for interspecific communication, but to herd herring into dense schools for feeding. Whistles can be produced in sequences of complex, stereotypic patterns for use in various social/communication contexts (Riesch et al. 2008).

Echolocation clicks were recorded from resident killer whales off northeastern Vancouver Island, Canada while foraging on salmon: click source levels ranged from 195 to 224 dB re 1 µPa-m peak-to-peak, had a center frequency ranging from 45 to 80 kHz (bandwidths between 35–50 kHz), and durations of 80 to 120 µs (Au et al. 2004). Echolocation clicks recorded from Norwegian killer whales feeding on herring were considerably lower in source level, center frequency range, and duration than the Canadian whale clicks, ranging from 173 to 202 re 1 µPa-m peak-to-peak, 22 to 49 kHz, and 31 to 203 µs, respectively (Simon et al. 2007). Killer whales modify their vocalizations depending on social context or ecological function: for example, short-range vocalizations (less than 10 km [5 nm] range) are typically associated with social and resting behaviors, and long-range vocalizations (10 to 16 km [5 to 9 nm] range) are associated with travel and foraging (Miller 2006). Likewise, echolocation clicks are adapted to the type of fish the whales prey upon (Simon et al. 2007).

Acoustic studies of resident killer whales in British Columbia have found that there are dialects which contain highly stereotyped, repetitive discrete calls that are group-specific and shared by all group members (Ford and Fisher 1982). These dialects likely are used to maintain group identity and cohesion, and may serve as indicators of relatedness (Ford and Fisher 1983). Dialects also have been documented in killer whale populations in northern Norway (Ford 2002) and southern Alaska (Yurk et al. 2002), and are likely to occur in other locales as well (Ford 2002). Fish eating killer whales in British Columbia produced echolocation clicks 27 times more often than marine mammal-eating killer whales (Barrett-Lennard et al. 1996). Transient killer whales may emit sounds more conservatively since their prey (e.g., other marine mammal species) can oftentimes hear or "eavesdrop" on their sounds; for example, transients use passive listening as a primary means of locating prey, call less often, and frequently vocalize or use high-amplitude vocalizations only when socializing (i.e., not hunting), trying to communicate over long distances, or once an attack has been successfully completed (Barrett-Lennard et al. 1996; Deecke et al. 2005; Saulitis et al. 2005).

Behavioral and auditory evoked potential audiograms of two captive killer whales indicate that they can hear tones ranging from 1 to 120 kHz (best hearing ranging from 18 to 42 kHz), with most sensitivity at 20 kHz with a detection threshold of 36 dB re 1 µPa (Szymanski et al. 1999). The full range of functional hearing is estimated to occur between approximately 150 Hz and 160 kHz, placing them among the group of cetaceans that can hear mid-frequency sounds (Southall et al. 2007).

False Killer Whale (*Pseudorca crassidens*)

Status- The false killer whale is protected under the MMPA and is not listed under the ESA. While the species is not considered rare, few areas of high density are known. There are five recognized Pacific Islands Region management stocks of false killer whales: (1) the Hawaii insular stock includes the animals that occur in waters within 100 mi. (140 km) of the main Hawaiian Islands; (2) the Hawaii pelagic stock includes animals that inhabit waters greater than 25 mi. (40 km) from the main Hawaiian Islands; (3) the Northwest Hawaiian Islands stock includes false killer whales within the insular waters of the Northwestern Hawaiian Islands; (4) the Palmyra Atoll stock includes whales found within the U.S. EEZ of Palmyra Atoll; and (5) the American Samoa stock, which includes false killer whales found within the U.S.

EEZ of American Samoa. The Hawaii insular stock and the Hawaii pelagic stock overlap in distribution between 25 mi. (40 km) and 100 mi. (140 km) from shore.

The local Hawaii insular stock (considered resident to the main Hawaiian islands) is being proposed for listing under the ESA given the stock has been in decline. Various factors have drawn attention to the fact that there is a high risk of extinction for this population of false killer whales (Oleson et al. 2010). These include the small population size of this stock, evidence of decline of the local Hawaii stock, and several factors that are expected to adversely impact the population in the future. One of the most important factors is incidental takes by commercial fisheries; with the most recent estimates indicating that approximately eight false killer whales from the Hawaii insular and pelagic stocks are killed or seriously injured by commercial longline fisheries each year (McCracken and Forney 2010; the Northwest Hawaiian Islands stock had not yet been recognized in 2010). This number of fishery interactions was based on a 5-year average and is most likely an underestimate since it does not include any animals that were unidentified and might have been false killer whales. Due to recent evidence of a serious decline in this population (Reeves et al. 2009), a Take Reduction Team (a team of experts to study the specific topic, also referred to as a Biological Reduction Team) was formed by the National Oceanic and Atmospheric Administration on January 19, 2010 as required by the MMPA. The Take Reduction Team conducted a status review which was published in August 2010 (Oleson et al. 2010) and the draft Take Reduction Plan (also required under MMPA) for assessing ways to reduce mortality and serious injury to this population was available for public comment until October 2011.

HSTT Distribution and Seasonal Distribution- The false killer whale is regularly found within Hawaiian waters and has been reported in groups of up to 100 (Baird et al. 2003; Shallenberger 1981). This species was sighted for the first time off the east side of the Big Island of Hawaii in 2007 during a monitoring survey; a sighting of eight adults was made in the northeast corner of the Big Island (Smultea et al. 2007). Vocalizations of this species were recorded on ship-based surveys between 2000 and 2002 in the Hawaiian Islands (Barlow et al. 2008). A handful of stranding records exists for this species in the Hawaiian Islands (Maldini et al. 2005). Satellite-tracked individuals around the Hawaiian islands indicate that false killer whales can move extensively among different islands and also sometimes move from an island coast to as far as 60 mi. (96 km) offshore (Baird 2009).

False killer whales have been detected in acoustic surveys and are commonly observed in the eastern tropical Pacific (Oswald et al. 2003; Wade and Gerrodette 1993). A handful of sightings have occurred off southern California, from areas such as Monterey Bay, Santa Catalina, and the Channel Islands (Baird et al. 2009; Miller and Scheffer 1986). Sightings from vessel surveys also have occurred off Baja California, Mexico (Chivers et al. 2007). The secondary range of the false killer whale likely includes northern California (Baird et al. 2009; Jefferson et al. 2008).

HSTT Population and Abundance- Recent genetic research by Chivers et al. (2010) and survey results reported by Bradford et al. (2012) indicate that the three populations of false killer whales (insular, pelagic, and Northwest Hawaiian Islands stocks) are independent and do not interbreed.

Recent studies based on false killer whale sightings near Hawaii between 1989 and 2007 provide evidence that the Hawaii insular stock may have declined (Baird 2009b; Chivers et al. 2010). During aerial surveys conducted in 1989, three large groups of false killer whales were observed (group sizes 380, 460 and 470) on three different days (Reeves et al. 2009). When these observations are compared with encounter rates from aerial surveys conducted between 1993 and 2003, the evidence of decline is apparent (Oleson et al. 2010). In the 1989 aerial surveys, 17 percent of sightings were of false killer

whales. During the 2000-2006 boat-based surveys, the encounter rate was only 1.5 percent of sightings. The apparent decline in underscored by a decrease in the average group size from the two surveys (195 during the 1989 aerial surveys compared to 15 during the 2000-2006 boat-based surveys) (Oleson et al. 2010).

Based on the most recent analysis and surveys as presented in the Draft Pacific Stock Assessment Report: 2011 (Carretta et al. 2012), the current best estimate of the Hawaiian insular population is 151 individuals (coefficient of variation = 0.20); the current estimate of the Hawaiian pelagic population is 1,503 individuals (coefficient of variation = 0.66); and the current estimate for the newly designated Northwest Hawaiian Islands population is 522 individuals (coefficient of variation = 1.09).

Hearing and Vocalization- The dominant frequencies of false killer whale whistles range from 4 to 13.5 kHz (duration ~0.1 to 3 s) and their clicks are mostly produced between 25 to 30 kHz and 95 to 130 kHz, with click source levels typically from 200 to 228 dB re 1 µPa (Brill et al 1992; see Ketten 1998; Sanino and Fowle 2006). False killer whales recorded in the Indian Ocean produced broadband echolocation clicks with peak frequencies of ~40 kHz (centroid frequencies 30 to 70 kHz), 30 µs in duration, and estimated source levels of 201 to 225 dB re 1 µPa peak-to-peak (Madsen et al. 2004). While frequency range and duration of whistles are fairly consistent, regional differences in certain characteristics (e.g., mean frequency) have been noted in the Caribbean (Rendell et al. 1999).

False killer whales are known to produce complex tones within their vocalizations, and have been shown experimentally to be able to discriminate pure tones from complex ones containing 1 to 5 harmonic components (Yuen et al. 2007). Nachtigall and Supin (2008) found that hearing during echolocation is a very active process in false killer whales, with the animals able to make perceptual adjustments in how strongly they hear their outgoing click in relation to the returning echo. That is, the animal could perceive an object's echo at a fairly constant loudness level regardless of its size or distance, while adjusting up or down the perceived loudness of their click to maximize detection of the echo. This ability could have important relevance for feeding/foraging behavior. These results also provided evidence of a protective mechanism built into these animals' hearing system for handling the high powered source levels (>200 dB) of their clicks: measured perceptual difference between the outgoing click and a similar signal produced from a source external to the animal showed that the click was perceived as ~40 dB lower (Nachtigall and Supin 2008).

Behavioral audiograms of three captive false killer whales have been conducted. One measured hearing from 2 to 115 kHz, with resulting sensitivity at these frequencies resembling that of other odontocetes for which hearing data exist (Thomas et al. 1988). Range of best hearing spanned from 16 to 64 kHz. Another animal tested did not show responsiveness above 45 kHz, and best hearing sensitivity was between 16 and 24 kHz (Yuen et al. 2005). The researchers concluded this animal likely had age-related hearing loss that effected sensitivity at the higher frequencies as well as causing a downward shift in the best sensitivity range. The same study also measured hearing using the auditory evoked potential (auditory evoked potential) technique, which showed similar results to the behavioral measures (best sensitivity from 16 to 22.5 kHz) (Yuen et al. 2005). In the third study (Supin et al. 2003) auditory brainstem responses were recorded in a false killer whale while the animal echolocated on a target. The recording of the responses contained a duplicate set of waves. The authors suggested that one set of waves may be the response to the emitted click whereas the second wave set may be a response to the echo. While the amplitude of the two waves was comparable the intensity of the two sounds differed by more than 40 dB near the animal's head. The full range of functional hearing for this species is estimated

to occur between approximately 150 Hz and 160 kHz, placing them among the group of cetaceans that can hear mid-frequency sounds (Southall et al. 2007).

Pygmy killer Whale (*Feresa attenuata*)

Status- The pygmy killer whale is protected under the MMPA and is not listed under the ESA. For the MMPA stock assessment reports, there is a single Pacific management stock including only animals found within that portion of the U.S. EEZ surrounding the Hawaiian Islands (Carretta et al. 2010b).

HSTT Distribution and Seasonal Distribution- The pygmy killer whale is generally an open ocean deepwater species (Davis et al. 2000; Wursig et al. 2000). Sightings have been relatively frequent in the Insular Pacific-Hawaiian Large Marine Ecosystem (Barlow et al. 2004; Donahue and Perryman 2008; Pryor et al. 1965; Shallenberger 1981; Smultea et al. 2007). Six strandings have been documented from Maui and the Island of Hawaii (Carretta et al. 2010a; Maldini et al. 2005). The pygmy killer whale's range in the open ocean generally extends to the southern regions of the North Pacific Subtropical Gyre and the southern portions of the North Pacific Transition Zone. Many sightings have occurred from cetacean surveys of the eastern tropical Pacific (Au and Perryman 1985; Barlow 2006; Wade and Gerrodette 1993). Its range is generally considered to be south of 40° N and continuous across the Pacific (Donahue and Perryman 2008; Jefferson et al. 2008). This species is considered extralimital in the southern California portion of the Study Area.

HSTT Population and Abundance- Although the pygmy killer whale has an extensive global distribution, it is not known to occur in high densities in any region and thus is probably one of the least abundant of the pantropical delphinids. The current best available abundance estimate for the pygmy killer whale is 956 individuals (coefficient of variation = 0.83) derived from a 2002 shipboard survey of the Hawaiian Islands U.S. Pacific EEZ (Barlow 2006).

Hearing and Vocalization- Little is known of the acoustic abilities of the pygmy killer whale. One study has shown that they emit short duration (20 to 40 µs), broadband signals similar to other small delphinid species (Madsen et al. 2004). Their clicks have centroid frequencies (the frequency which divides the energy in the click into two equal portions) between 70 to 85 kHz with bimodal peak frequencies around 40 and 100 kHz. The estimated source levels are between 197 to 223 dB re 1 µPa-m peak-to-peak (Madsen et al. 2004). The study did not demonstrate echolocation, however; the directional clicks and the context in which they are used, is consistent with biosonar function. Interclick intervals of the pygmy killer whales' clicks were 40 to 100 ms when they were 13 to 52 m away from the hydrophone - the same as those of dolphins echolocating on targets located at a similar distance (Au, 1993; Madsen et al. 2004).

While no empirical data on hearing ability for this species are available, functional hearing is estimated to occur between approximately 150 Hz and 160 kHz, placing them among the group of cetaceans that can hear mid-frequency sounds (Southall et al. 2007).

Short-finned Pilot Whale (*Globicephala macrorhynchus*)

Status- The species is protected under the MMPA and is not listed under the ESA. For MMPA stock assessment reports, short-finned pilot whales within the Pacific U.S. EEZ are divided into two discrete, non-contiguous areas: (1) waters off California, Oregon and Washington, and (2) Hawaiian waters (Carretta et al. 2010b).

HSTT Distribution and Seasonal Distribution- The short-finned pilot whale is widely distributed throughout most tropical and warm temperate waters of the world. This species' range generally extends to the southern regions of the North Pacific Subtropical Gyre and the California Current and Insular Pacific-Hawaiian Large Marine Ecosystems. Many sightings have occurred from cetacean surveys of the eastern tropical Pacific, where the species is reasonably common (Au and Perryman 1985; Barlow 2006; Wade and Gerrodette 1993). The short-finned pilot whale occurs mainly in deep offshore waters including waters beyond the continental shelf break, in slope waters, and in areas of high topographic relief (Olson 2009). However, this species is known to mover close to shore at oceanic islands, where the insular shelf is narrow and deeper waters are found close to shore (Mignucci-Giannoni 1998; Gannier 2000). A number of studies in different regions suggest that the distribution and seasonal inshore/offshore movements of pilot whales coincide closely with the abundance of squid, their preferred prey (Bernard and Reilly 1999; Hui 1985; Payne and Heinemann 1993). Short-finned pilot whale distribution off southern California changed dramatically after the El Niño in 1982–1983, when squid did not spawn as usual in the area, and pilot whales virtually disappeared from the area for nine years (Shane 1995).

Along the U.S. Pacific coast, short-finned pilot whales are most abundant south of Point Conception (which is north of Santa Barbara, California) (Carretta et al. 2010a; Reilly and Shane 1986). A few hundred pilot whales are believed to group each winter at Santa Catalina Island (Carretta et al. 2010a; Reilly and Shane 1986), although these animals are not seen as regularly as in previous years. There are recorded strandings for this species from Oregon and Washington waters; however these waters are considered to be beyond the normal range of this species (Norman et al. 2004).

Short-finned pilot whales are known to occur in waters surrounding the Hawaiian Islands (Barlow 2006; Shallenberger 1981; Smultea et al. 2007). They are most commonly observed around the main Hawaiian Islands, are relatively abundant around Oahu and the Island of Hawaii, and are also present around the northwestern Hawaiian Islands (Barlow et al. 2006; Maldini Feinholz 2003; Shallenberger 1981). Fourteen strandings of this species have been recorded at the main Hawaiian Islands, including five mass strandings (Carretta et al. 2010b; Maldini et al. 2005).

HSTT Population and Abundance- Abundance estimates for the eastern tropical Pacific are around 100,000 and 500,000 short-finned pilot whales (Gerrodette and Forcada 2002). From at least the 1950s until the early 1980s, short-finned pilot whales were fairly abundant in nearshore waters of southern California, with an apparent resident population around Santa Catalina Island (Shane 1994). Distribution off southern California changed dramatically after the 1982-1983 El Niño (Shane 1994); however, the pilot whales appear to have returned to California waters as evidenced by an increase in sighting records and incidental fisheries by-catch (Carretta et al. 2005). Despite recent increases, populations are less abundant than in the late 1970s and early 1980s, prior to the 1982–1983 El Niño (Forney et al. 1995).

The 2005–2008 average abundance estimate for short-finned pilot whales in California, Oregon, and Washington waters, derived from two ship-based surveys, was 760 individuals (coefficient of variation = 0.64) (Carretta et al. 2010b). A 2002 shipboard survey of the entire Hawaiian Islands U.S. Pacific Exclusive Economic Zone resulted in an abundance estimate of 8,870 (coefficient of variation = 0.38) short-finned pilot whales and is considered to be the best available estimate (Barlow et al. 2006).

Hearing and Vocalization- Short-finned pilot whales are known to produce three general categories of sounds: clicks, whistles, and burst-pulsed signals, although information on this species' vocal behavior is known only from a few fragmented sources from disparate geographic regions. Short-finned pilot whale

whistles and clicks have a dominant frequency range of 2 to 14 kHz, at an estimated source level of 180 dB re 1 µPa-m (Fish and Turl 1976; see Ketten 1998). Weller et al. (1996) documented an agonistic interaction between short-finned pilot whales and sperm whales in the northern Gulf of Mexico and observed infrequent whistles and occasional burst-pulsed sounds during this encounter.

Significant differences in vocalization characteristics have been noted between the long- and short-finned pilot whales recorded from various locations worldwide (Rendell et al. 1999), with the long-finned species producing lower pitch, longer duration calls than the short-finned pilot whales. This study also found differences within groups of the same species, which other researchers have noted as well. For example, two forms of short-finned pilot whale are found along the Pacific coast of Japan (Nakahara and Amano 2001; Nakahara et al. 2003); these northern and southern groups both produce clicks, whistles, and burst-pulse signals, but the northern group of whales produced calls with a longer duration and wider frequency range when compared with the southern form (Nakahara et al. 2003). Furthermore, intra-group variation was documented for the southern form (Nakahara and Amano 2001); although whether this variation occurred at the individual or subgroup level has yet to be determined.

In the eastern tropical Pacific ocean, Oswald et al. (2003) determined that short-finned pilot whale whistles had characteristics distinctive to this species apart from other sympatric delphinids. Whistle frequency ranged 3.6 to 6.1 kHz with an average duration of 0.4 s (Oswald et al. 2003). Short-finned pilot whales were acoustically detected in Hawaiian deep waters (Norris et al. 2005); very few vocal signals were recorded from these dolphins, which suggests (coupled with their low-level of activity) that these individuals were resting. Recent studies of this species around the Canary Islands with acoustic recording tags (DTAGs) suggest that short-finned pilot whales forage at depth both at night and during the day around the islands and produce broadband clicks and buzzes consistent with biosonar-mediated foraging (Aguilar de Soto et al. 2006).

The hearing sensitivities of two short-finned pilot whales were investigated by measuring auditory evoked potentials (auditory evoked potential) generated in response to clicks and sinusoidal amplitude modulated tones (Schlundt et al. 2011). In the first whale tested, a collected and captive adult female, click evoked responses measured were structurally similar to those observed in other echolocating odontocetes. Auditory thresholds were comparable to dolphins of similar age determined with similar evoked potential methods. The region of best sensitivity was between 40 and 56 kHz, where thresholds were 78 and 79 dB re 1 µPa, respectively. The upper limit of functional hearing was between 80 to 100 kHz, and no auditory evoked potentials were detected at 113 or 160 kHz at the highest SPLs that could be generated. This upper cutoff frequency range is similar to that measured in killer whales (Szymanski et al. 1999) and in a stranded Gervais' beaked whale (Finneran et al. 2007), but substantially lower than that seen in bottlenose dolphins (~ 120 to 150 kHz) (Houser and Finneran 2006). In the second short-finned pilot whale tested, a stranded and rehabilitated, juvenile male, the only measureable threshold was 108 dB re 1 µPa at 10 kHz and was similar to the 10 kHz threshold of the adult female (107 dB re 1 µPa). Click-evoked potentials could not be measured in the second subject. The results indicate the whale had severe hearing loss in the middle and upper end of his hearing range. It is unknown whether these hearing deficits were causally responsible for his initial stranding.

Changes in vocal responses by long-finned pilot whales to both low- and high-frequency anthropogenic sounds, as well as the calls of killer whales, have been reported (e.g., Bowles et al. 1994; Jones and Rendell 2000; Rendell and Gordon 1999; Schevill 1964; Taruski 1979), which provides indirect evidence for the general hearing capabilities for this genus. Pacini et al. (2010) directly investigated the hearing

abilities of a rehabilitated, juvenile male long-finned pilot whale. A complete audiogram was collected using auditory evoked potential techniques using sinusoidally amplitude modulated tones. The results indicated that the region of best hearing was between 11.2 and 50 kHz and the subject had relatively poor high frequency hearing compared with other odontocete species. The complete audiogram had the common U-shape found in mammals and was overall similar to other odontocete audiograms (Johnson 1967; Kastelein et al. 2002; Szymanski et al. 1999; Thomas et al. 1988; Yuen et al. 2005) with a steep slope in the high frequency region and a more leveled slope in the lower frequencies. The region of best hearing was found to be between 11.2 and 50 kHz with thresholds below 70 dB re 1 µPa. The best hearing was found at 40 kHz with a 53.1 dB re 1 µPa threshold. The slope of the thresholds became very steep above 50 kHz and the poorest sensitivity was measured at both ends of the frequency spectrum with 77 dB re 1 µPa at 4 kHz and 124 dB re 1 µPa at 100 kHz.

Melon-headed Whale (*Peponocephala electra*)

Status- The melon-headed whale is protected under the MMPA and is not listed under the ESA. For the MMPA stock assessment reports, there is a single Pacific management stock including only animals found within the U.S. EEZ surrounding the Hawaiian Islands (Carretta et al. 2010a).

HSTT Distribution and Seasonal Distribution- Melon-headed whales are found worldwide in tropical and subtropical waters. They have occasionally been reported at higher latitudes, but these movements are considered to be beyond their normal range, because the records indicate these movements occurred during incursions of warm water currents (Perryman et al. 1994). Melon-headed whales are most often found in offshore deep waters but sometimes move close to shore over the continental shelf. Brownell et al. (2009) found that melon-headed whales near oceanic islands rest near shore during the day, and feed in deeper waters at night. During ship-based bird surveys in the eastern tropical Pacific, this species was observed from the U.S.-Mexico border south to Peru, typically associated with pelagic sea birds while foraging (Pitman and Ballance 1992).

The range of this species is known to include waters of the California Current and Insular Pacific-Hawaiian Large Marine Ecosystems and the North Pacific Subtropical Gyre (Jefferson et al. 2008; Perryman 2008). In the North Pacific, occurrence of this species is well known in deep waters, including the Hawaii portion of the Study Area (Au and Perryman 1985; Carretta et al. 2010a; Ferguson 2005; Perrin 1976; Wang et al. 2001). Large groups are seen regularly, especially off the Waianae coast of Oahu, the north Kohala coast of Hawaii, and the leeward coast of Lanai (Baird 2006; Shallenberger 1981). A line-transect survey conducted in February 2009 by the Cetacean Research Program surrounding the Hawaiian Islands resulted in the sighting of one melon-headed whale (Oleson and Hill 2009). A total of 14 stranding records exist for this species in the Hawaiian Islands (Carretta et al. 2010a; Maldini et al. 2005).

HSTT Population and Abundance- The current best available abundance estimate for the Hawaiian stock of melon-headed whale, derived from a 2002 shipboard survey of the entire Hawaiian Islands U.S. Pacific EEZ, is 2,950 (coefficient of variation = 1.17) (Carretta et al. 2010b).

Hearing and Vocalization- The only published acoustic information for melon-headed whales is from the southeastern Caribbean (Watkins et al. 1997). Sounds recorded included whistles and click sequences. Recorded whistles were frequency modulated (both up and down) with dominant frequencies between 8 to 12 kHz and maximum source levels of 155 dB re 1 µPa-m. Clicks and click bursts (40+ clicks with 0.1 to 0.2 s intervals) had dominant frequencies of 20 to 40 kHz and source levels up to ~165 dB re 1 µPa-m.

Sound level varied as a function of activity, with the higher sound levels associated with high action behavior.

While no empirical data on hearing ability for this species are available, functional hearing is estimated to occur between approximately 150 Hz and 160 kHz, placing them among the group of cetaceans that can hear mid-frequency sounds (Southall et al. 2007).

Long-beaked Common Dolphin (*Delphinus capensis*)

Status- Long-beaked common dolphins have only relatively recently been recognized as a species distinct from short-beaked common dolphins (Heyning and Perrin 1994). For the MMPA stock assessment reports, the California stock of long-beaked common dolphins includes animals found within about 50 nm off the coast, from central California southward to Baja, California (Carretta et al. 2011). Long-beaked common dolphins are protected under the MMPA and are not listed under the ESA.

HSTT Distribution and Seasonal Distribution- The long-beaked common dolphin appears to be restricted to waters relatively close to shore (Jefferson and Van Waerebeek 2002; Perrin 2008), apparently preferring shallower and warmer water than does the short-beaked common dolphin (Perrin 2008). Typically, the long-beaked common dolphin occurs in coastal and offshore waters of the eastern North Pacific, from the equator to about 36° N (Evans 1982; Jefferson and Van Waerebeek 2002). As noted above, the California stock range is considered to be within about 50 nm of the West Coast, from Baja California north to central California (Carretta et al. 2011). Stranding data and sighting records suggest that this species' abundance fluctuates seasonally and from year to year off California (Carretta et al. 2010b; Zagzebski et al. 2006). It is found off Southern California year round, but may be more abundant there during the warm-water months (May to October) (Bearzi 2005; Carretta et al. 2010a).

HSTT Population and Abundance- The mean abundance estimate for the California stock is based on two shipboard surveys during 2005 and 2008. The resulting estimate is 27,046 (coefficient of variation = 0.59) long-beaked common dolphins, and most of these occur in southern and central California (Carretta et al. 2010a). The best available estimate of long-beaked common dolphins in the Southern California portion of the study area during the summer and fall is 15,530 (coefficient of variation = 0.57) (Barlow and Forney 2007).

Hearing and Vocalization- Recorded *Delphinus* vocalizations (which are similar among species within this genus) include whistles, chirps, barks, and clicks; clicks and whistles have dominant frequency ranges of 23 to 67 kHz and 0.5 to 18 kHz, respectively (see Ketten 1998 for review). For example, Oswald et al. (2003) found that short-beaked common dolphins in the eastern tropical Pacific ocean have whistles with a mean frequency of 6.3 kHz, mean maximum frequency of 13.6 kHz, and mean duration of 0.8 s. Moore and Ridgway (1995) recorded whistles produced by two short–beaked common dolphins from the southern California Bight and found four main types of whistles: down/up (sweeping from 7 to 6 to 10 kHz), short up (sweeping quickly from 6 to10 kHz), up/down (sweeping from 7 to 20 to 10 kHz), and long up (sweeping from 7 to 19 kHz). Maximum source levels have been reported at ~180 dB 1 µPa m for common dolphin sounds recorded up to 40 kHz (Fish and Turl 1976).

Griffiths (2009) reported that the range of whistle frequencies emitted by short-beaked common dolphins in the eastern tropical Pacific ocean (3.2 to 44.3 kHz) were generally broader than those emitted in the southern Irish Sea (3.4 to 23.5 kHz). Water column depth and time of day were found to have a significant influence on amount of whistling (Griffiths 2009). Likewise, short-beaked common

dolphins near the British Isles were recorded whistling more frequently in the early morning and late evening (Goold 2000).

Popov and Klishin (1998) recorded auditory brainstem responses from a short-beaked common dolphin that had stranded off the coast of Russia in the Black Sea. Best sensitivity was observed at 60 to 70 kHz, with responses evoked up to 152 kHz. At this maximum frequency, the stimulus sound level required to evoke a response was 127 dB re 1 µPa received level. Sensitivity decreased more quickly at the higher frequencies than the lower ones, with the resulting U-shaped audiogram for this species similar to that of other dolphins (Finneran et al. 2009; Popov and Supin 1990). While no empirical data on hearing ability exists for the long-beaked common dolphin, functional hearing for both the short- and long-beaked common dolphin is estimated to occur between approximately 150 Hz and 160 kHz, placing them among the group of cetaceans that can hear mid-frequency sounds (Southall et al. 2007).

Short-beaked Common Dolphin (*Delphinus delphis*)

Status- This species is protected under the MMPA and is not listed under the ESA. For the MMPA stock assessment reports, there is a single Pacific management stock including only animals found within the U.S. EEZ of California, Oregon, and Washington (Carretta et al. 2010b).

HSTT Distribution and Seasonal Distribution- Short-beaked common dolphins are found in the California Current Large Marine Ecosystem throughout the year, distributed between the coast and at least 345 mi. (555 km) from shore. Based on systematic ship surveys conducted off the U.S. west coast from 1991 to 2005, the short-beaked common dolphin was the most abundant species found off California (Barlow and Forney 2007). In general, the northward extent of short-beaked common dolphin distribution appears to vary from year to year and with changing oceanographic conditions (Barlow 1995; Carretta et al. 2010a; Forney and Barlow 1998). Common dolphins in some populations appear to prefer to travel along bottom topographic features, such as escarpments and seamounts (Bearzi 2003; Evans 1994; Hui 1979). Short-beaked common dolphins are routinely sighted in upwelling-modified waters of the eastern tropical Pacific (Au and Perryman 1985; Ballance and Pitman 1998; Reilly 1990). This species prefers areas with large seasonal changes in surface temperature and thermocline depth (the point between warmer surface waters and colder deep waters) (Au and Perryman 1985).

HSTT Population and Abundance- As noted above, the short-beaked common dolphin is the most abundant cetacean species off California (Barlow and Forney 2007; Forney et al. 1995). Short-beaked common dolphin abundance off California has increased dramatically since the late 1970s and coincides with a smaller decrease in abundance in the eastern tropical Pacific, suggesting a large-scale northward shift in the distribution of this species in the eastern North Pacific (Forney et al. 1995; Forney and Barlow 1998). The California, Oregon, and Washington stock has a current population estimate of 411,211 individuals (coefficient of variation = 0.21) (Carretta et al. 2010a).

Hearing and Vocalization- See Long-beaked Common Dolphin for a general description of short- and long-beaked common dolphin hearing and vocalization.

Common Bottlenose Dolphin (*Tursiops truncatus*)

Status- The common bottlenose dolphin is protected under the MMPA and is not listed under the ESA. For the MMPA stock assessment reports, bottlenose dolphins within the Study Area are divided into seven stocks: (1) California coastal stock, (2) California, Oregon and Washington offshore stock, (3) Kauai

and Niihau, (4) Oahu, (5) the 4-Islands region, (6) Hawaii Island, and (7) the Hawaii pelagic stock (Carretta et al. 2010a).

HSTT Distribution and Seasonal Distribution- Common bottlenose dolphins are found most commonly in coastal and continental shelf waters of tropical and temperate regions of the world. They occur in most enclosed or semi-enclosed seas, and are often found in bays, lagoons, channels, and river mouths. This species is known to inhabit both shallow, murky, estuarine waters and also deep, clear offshore waters in oceanic regions (Jefferson et al. 2008; Wells et al. 2009).

Common bottlenose dolphins are common throughout the Hawaiian Islands, and they are typically observed throughout the main islands and from the Island of Hawaii to Kure Atoll within 5 mi. (8 km) of the coast (Baird et al. 2009; Shallenberger 1981). In the Hawaiian Islands, this species is found in both shallow coastal waters and deep offshore waters (Baird et al. 2003). The offshore variety is typically larger than the inshore. Twelve stranding records from the main Hawaiian Islands exist (Maldini Feinholz 2003; Maldini et al. 2005). Common bottlenose dolphin vocalizations have been documented during acoustic surveys, and the species has been commonly sighted during aerial surveys in the Hawaiian Islands (Barlow et al. 2004; Barlowet al. 2008; Mobley et al. 2000).

During surveys off California, offshore bottlenose dolphins were generally found at distances greater than 1.9 mi. (3 km) from the coast and throughout the southern portion of the California Current Large Marine Ecosystem (Bearzi et al. 2009; Carretta et al. 2010b). Sighting records off California and Baja California suggest continuous distribution of offshore bottlenose dolphins in these regions. Aerial surveys during winter/spring 1991–1992 and shipboard surveys in summer/fall 1991 indicated no seasonality in distribution (Barlow 1995; Carretta et al. 2010b; Forney et al. 1995).

California coastal bottlenose dolphins are found within about 0.6 mi. (1 km) of shore, generally from Point Conception to as far south as San Quintin, Mexico (Carretta et al. 1998; Defran and Weller 1999). With the increase in water temperatures off California due to El Niño, coastal common bottlenose dolphins have been consistently sighted off central California and as far north as San Francisco. The dolphins in the nearshore waters of San Diego, California differ somewhat from other coastal populations of this species in distribution, site fidelity, and school size (Bearzi 2005; Defran and Weller 1999). Common bottlenose dolphins are known to occur year round in both coastal and offshore waters of Monterey Bay, Santa Monica Bay, San Diego Bay, and San Clemente Island, California (Bearzi 2005; Bearzi et al. 2009; Carretta et al. 2000; Henkel and Harvey 2008; Maldini Feinholz 1996). In southern California, animals are found within 1,640 ft. (500 m) of the shoreline 99 percent of the time and within 820 ft. (250 m) of the shoreline 90 percent of the time (Hanson and Defran 1993).

HSTT Population and Abundance- The current best available abundance estimate of the Hawaiian Islands Stock Complex of common bottlenose dolphins comes from a ship survey of the entire Hawaiian Islands U.S. Pacific Exclusive Economic Zone in 2002. The resulting abundance estimate is 3,215 (coefficient of variation = 0.59) bottlenose dolphins (Barlow et al. 2006). Abundance estimates for the five stocks identified within the Hawaiian Islands Stock Complex are provided in Table 3-1.

The best available abundance estimate for the California, Oregon, and Washington offshore stock of common bottlenose dolphins is 1,006 (coefficient of variation = 0.48) (Carretta et al. 2010a). The most recent abundance estimate for the California coastal stock of common bottlenose dolphins is based on photographic mark-recapture surveys conducted along the coast of San Diego, California in 2004 and 2005. The population estimate is 323 dolphins (coefficient of variation = 0.13) (Carretta et al. 2010a;

Dudzik et al. 2006). This estimate does not reflect the finding that approximately 35 percent of dolphins encountered lack identifiable dorsal fin marks; thus the true population size is estimated to be 450 to 500 animals (Carretta et al. 2010b; Defran and Weller 1999).

Hearing and Vocalization- Bottlenose dolphins emit pulsed sounds (including clicks and burst-pulses) at a wide variety of frequency and source levels, with high frequency clicks (>90 kHz) commonly used in echolocation, and source levels up to 230 dB re 1 µPa peak-to-peak (see Au 1993). Narrow-band, continuous sounds (whistles) are emitted from 0.8 to 24 kHz (frequency of maximum energy 3.5 to 14.5 kHz) with source levels of 125 to 173 dB re 1 µPa-m (see Ketten 1998). Both whistles and clicks have been demonstrated to vary geographically in terms of overall vocal activity, group size, and specific context (e.g., feeding, milling, traveling, and socializing) (Jones and Sayigh 2002; Zaretsky et al. 2005). For example, preliminary research indicates that characteristics of whistles from populations in the northern Gulf of Mexico significantly differ (e.g., in frequency and duration) from those in the western north Atlantic (Zaretsky et al. 2005). Whistles are primarily associated with communication and can serve to identify specific individuals (i.e., signature whistles) (Caldwell and Caldwell 1965; Janik et al. 2006). Up to 52 percent of whistles produced by bottlenose dolphin groups with mother-calf pairs can be classified as signature whistles (Cook et al. 2006). Sound production is also influenced by group type (single or multiple individuals), habitat, and behavior (Nowacek 2005). In some regions, bray calls (low-frequency vocalizations; majority of energy below 2 kHz) are used when capturing fish, specifically sea trout and Atlantic salmon (Janik 2000). Additionally, whistle production has been observed to increase while feeding (Acevedo-Gutiérrez and Stienessen 2004).

A wide range of research has been conducted on bottlenose dolphin echolocation ability, revealing a very dynamic process in which dolphins are able to exert a certain level of control over various parameters of signal transmission. For example, both amplitude and frequency of clicks can be deliberately adjusted, as shown experimentally with a trained dolphin at a fixed station (Moore and Pawloski 1993); however, the highest source-level amplitudes associated with high (120 kHz) and low (60 kHz) frequency clicks differ: at 60 kHz, an average sound pressure level (SPL) of 197 dB re 1 µPa was noted, and at 120 kHz, SPL averaged 209 dB re 1 µPa, indicating limitations of energy output based on signal frequency. Dolphins swimming in the open ocean showed a wide range in their choice of click frequency used during an open-ocean target detection task (range = 20 to 120 kHz) (Houser et al. 2009). Bottlenose dolphins also appear to have a limited ability to both steer and modify the width of their echolocation beam, allowing for a more dynamic inspection of their immediate and peripheral environment (Moore et al. 2008). Dolphins are also able to extract mental representations about object shape from objects inspected using their echolocation (Herman et al. 1998; Pack and Herman 1995). Furthermore, that information can be translated to the visual modality even for novel presentations of object pairs. This was demonstrated by successful performance by a trained dolphin in match-to-sample tasks involving pairings of objects presented within and across the visual and echoic sensory systems. In other match-to-sample studies involving pairs of trained dolphins (Gregg et al. 2007; Xitco and Roiblat 1996), researchers found that bottlenose dolphins can passively gather target information by passively "listening" to the echoes produced by another's echolocation clicks.

A full audiogram for the bottlenose dolphin was conducted behaviorally and revealed a functional hearing range of 75 Hz to 150 kHz, with good sensitivity between 15 to 110 kHz (Johnson 1967). Turl (1993) reported that bottlenose dolphins could detect sounds at frequencies as low as 50 to 150 Hz; however, it was suspected that the dolphin was detecting particle velocity or some combination of pressure and velocity. The audiogram of the bottlenose dolphin shows that best sensitivity occurs near 50 kHz at a detection threshold level of ~45 dB re 1 µPa (Finneran and Houser 2006; Houser and

Finneran 2006; Nachtigall et al. 2000). Below the maximum sensitivity, thresholds increased (indicating less sensitivity) continuously up to a level of 137 dB re 1 µPa at 75 Hz; above 50 kHz, thresholds increased slowly up to a level of 55 dB re 1 µPa at 100 kHz, then increased rapidly above this to about 135 dB re 1 µPa at 150 kHz. Bottlenose dolphin hearing sensitivity varies with age and sex, with a progressive loss of high frequency hearing with age, and with males exhibiting an earlier onset of hearing loss than females (Houser and Finneran 2006). The full range of functional hearing is estimated to occur between approximately 75 Hz and 160 kHz, placing them among the group of cetaceans that can hear mid-frequency sounds (Southall et al. 2007).

Studies of the bottlenose dolphin peripheral hearing system have been conducted through investigation of sound reception sites about the head intracranially (Bullock et al. 1968), behaviorally (i.e., using trained, captive animals under stimulus control; Brill et al. 2001), and through the use of the auditory brainstem response (ABR) technique (Popov et al. 2007). Results from all three methods showed good agreement and support the audiometric data presented in the previous paragraph: sites of best sensitivity varied based on signal frequency, with the lower jaw area more sensitive to higher frequencies (Brill et al. 2001; Bullock et al. 1968; Popov et al. 2007) and the area about the external auditory meatus more sensitive to the lower frequencies (Brill et al. 2001; Popov et al. 2007). Inner ear anatomy of this species has been described by Ketten (1992), and electrophysiological experiments suggest that the bottlenose dolphin brain has a dual analysis system: one specialized for ultrasonic clicks and another for lower-frequency sounds, such as whistles (Ridgway 2000).

Temporary threshold shifts (TTS) in hearing have been experimentally induced in captive bottlenose dolphins using a variety of noises (e.g., broad-band, single and intermittent tones, impulsive signals) (Finneran et al, 2000; Finneran et al. 2002; Finneran et al. 2005; Finneran et al. 2010; Finneran and Schlundt 2010; Mooney et al. 2009a, b; Nachtigall et al. 2003; Ridgway et al. 1997; Schlundt et al. 2000). Some major findings from these TTS studies include the following: Auditory effects of noise primarily depend on the exposure SPL, duration, and frequency, as well as the hearing test frequency; SPLs required to induce TTS for long duration sounds are lower than those required for shorter duration sounds; the largest amounts of TTS generally occur one-half to one octave above the exposure frequency; over limited time ranges, the growth and recovery of TTS often appear linear with the logarithm of time; sound exposure level (SEL) provides a useful metric for predicting TTS growth; and the relationship between SEL and TTS breaks down as the exposure duration increases, specifically, for two exposures with equal SELs, the exposure with the longer duration will tend to produce a larger TTS.

In specific TTS studies, masked thresholds temporarily increased in trained bottlenose dolphins tested in San Diego bay after exposure to 1-s pure tones at 194 to 201 dB re 1 µPa at 3 kHz, 192 dB re 1 µPa at 10 kHz, 193 to 196 dB re 1 µPa at 20 kHz, and 182 dB re 1 µPa at 75 kHz No TTS was observed after exposures at 0.4 kHz at the highest level tested, 193 dB re 1 µPa (Ridgway et al.1997; Schlundt et al. 2000). TTS has been induced with exposure to a 3 kHz, 1-second tones with sound exposure level (SEL) of 197 dB re 1 μPa^2-s, and with 3 kHz 2 to 8 s tones at levels of 195 dB re 1 μPa^2-s and above (Finneran et al. 2005). Studies using octave band noise (4 to 11 kHz) for 50 minutes induced TTS at 179 dB re 1 µPa (Nachtigall et al. 2003). Finneran et al. (2010) measured TTS in a bottlenose dolphin exposed to both single and multiple 3-kHz tones with durations of 16 s and SPLs of 192 dB re 1 µPa. The multiple tones were separated by 224 s of silence, resulting in duty cycle of approximately 7 percent. The resulting growth and recovery of TTS data confirm the potential for accumulation of TTS across multiple exposures and for recovery of hearing during the quiet intervals between exposures.

No temporary shifts in masked-hearing thresholds were observed in bottlenose dolphins after exposure to impulsive underwater sounds with waveforms resembling distant signatures of underwater explosions at the highest impulse level generated ~500 kg at 1.7 km, peak pressure 70 kiloPascals (kPa) (Finneran et al. 2000); however, disruptions of the animals' trained behaviors began to occur at exposures corresponding to 5 kg at 9.3 km and 5 kg at 1.5 km. Finneran et al. (2002) used a behavioral response paradigm to measure masked underwater hearing thresholds in a bottlenose dolphin before and after exposure to single underwater impulsive sounds produced from a seismic watergun. No masked threshold shift was observed in the dolphin at the highest exposure conditions: 207 kPa peak pressure, 228 dB re 1 µPa peak-to-peak pressure, and 188 dB re 1 $\mu Pa^2 \cdot s$ total energy flux.

Preliminary research indicates that TTS and recovery after noise exposure are frequency dependent and that an inverse relationship exists between exposure time and sound pressure level associated with exposure (Mooney et al. 2009a, b; Finneran et al. 2010). Preliminary data from Finneran and Schlundt (2010) provide evidence of frequency-specific differences in TTS onset and growth after the 3-kHz and 20-kHz exposures. At 20 kHz, where hearing sensitivity is better, TTS began at a lower exposure level compared to the 3-kHz exposures. Specifically, if a TTS of 6 dB measured 4 minutes post-exposure is used as a threshold for the onset of TTS, SPLs corresponding to onset-TTS after 16-s exposures at 3 and 20 kHz would be 179 and 169 dB re 1 µPa, respectively. Additionally, TTS at 20 kHz grew at a faster rate, so that the amount of TTS induced from 20-kHz exposures became increasingly large compared to that from 3-kHz exposures. TTS growth rates over the linear portions of the best-fit curves revealed slopes of 0.21 to 0.27 dB/dB at 3 kHz compared to 1.2 dB/dB at 20 kHz. As a result, expected TTS at 4 minutes post-exposure for a 16-s, 190 dB SPL tone at 3 kHz based on the present 3 kHz data would be 9 dB, while at 20 kHz the predicted TTS would be 28 dB at 4 minutes post-exposure. This clearly demonstrates that damage risk criteria for dolphins exposed to underwater noise should account for the exposure frequency, and criteria developed for lower frequencies (e.g., 3 kHz) may underestimate the amount of TTS if applied to higher frequencies (e.g., 20 kHz), where sensitivity is better.

Pantropical Spotted Dolphin (*Stenella attenuata*)

Status- The species is protected under the MMPA and is not listed under the ESA. For the MMPA stock assessment reports, pantropical spotted dolphins are considered under a single management stock which includes animals found in the Hawaiian Islands and in adjacent international waters. However, data from distribution patterns and morphological differences have been used to establish two stocks, the dolphins around Hawaii and those found in the eastern tropical Pacific (Dizon et al. 1994; Perrin 1975 ; Perrin et al. 1994).

HSTT Distribution and Seasonal Distribution- The pantropical spotted dolphin is distributed in offshore tropical and subtropical waters of the Pacific, Atlantic, and Indian Oceans between about 40° N and 40° S (Baldwin, Gallagher et al. 1999; Perrin 2008). The species is much more abundant in the lower latitudes of its range. It is found mostly in deeper offshore waters but does approach the coast in some areas (Jefferson et al. 2008; Perrin 2001). Based on known habitat preferences and sighting data, the primary occurrence for the pantropical spotted dolphin in the Insular Pacific-Hawaiian Large Marine Ecosystem is between 330 and 13,122 ft. (100 to 4000 m) depth. This area of primary occurrence also includes a continuous band connecting all the main Hawaiian Islands, Nihoa, and Kaula, taking into account possible inter-island movements. Secondary occurrence is expected from the shore to 330 ft. (100 m), as well as seaward of 13,120 ft. (4,000 m). In the open ocean, this species ranges from 25° N (Baja California, Mexico) to 17° S (southern Peru) (Perrin and Hohn 1994). Au and Perryman (1985)

noted that the species occurs primarily north of the Equator, off southern Mexico, and westward along 10° N.

HSTT Population and Abundance- Morphological and coloration differences and distribution patterns have been used to establish that the spotted dolphins around Hawaii belong to a stock that is distinct from those in the eastern tropical Pacific (Carretta et al. 2010a). The best available estimate of abundance for the pantropical spotted dolphin within the Hawaiian Islands U.S. Pacific EEZ is 8,978 individuals (coefficient of variation = 0.48) (Barlow 2006).

Hearing and Vocalization- Pantropical spotted dolphin whistles range from 3.1 to 21.4 kHz (Thomson and Richardson 1995). Click source levels between 212 (± 5) dB re 1 µPa-m (peak-to-peak), and a bandwidth of 79.8 (±35.9) kHz, have been recorded for pantropical spotted dolphins (Schotten et al. 2004). Echolocation clicks measured in wild Atlantic spotted dolphins (a close relative of the pantropical spotted dolphin) showed two separate ranges of 40 to 50 kHz and a high-frequency peak between —to 130 kHz, with a source level of 210 dB re 1 µPa-m (Au and Herzing 2003).

Studying the ear anatomy of the pantropical spotted dolphin, Ketten (1992, 1997) found that they have ear anatomy similar to other delphinids. While no empirical data on hearing ability for this species are available, functional hearing is estimated to occur between approximately 150 Hz and 160 kHz, placing them among the group of cetaceans that can hear mid-frequency sounds (Southall et al. 2007).

Striped Dolphin (*Stenella coerulealba*)

Status- This species is protected under the MMPA and is not listed under the ESA. In the eastern North Pacific, NMFS divides striped dolphin management stocks within the U.S. Pacific EEZ into two separate areas, (1) waters off California, Oregon, and Washington, and (2) waters around Hawaii (Carretta et al. 2010a).

HSTT Distribution and Seasonal Distribution- Striped dolphins are generally restricted to oceanic regions and are seen close to shore only where deep water approaches the coast. In some areas (e.g., the eastern tropical Pacific), they are mostly associated with convergence zones and regions of upwelling (Au and Perryman 1985; Reilly 1990). In the eastern tropical Pacific, striped dolphins inhabit areas with large seasonal changes in surface temperature and thermocline depth, as well as seasonal upwelling (Au and Perryman 1985; Reilly 1990). In some areas, this species appears to avoid waters with sea temperatures less than 68°F (20°C) (Felix et al. 1998; Van Waerebeek).

The striped dolphin regularly occurs around the Insular Pacific-Hawaiian Large Marine Ecosystem, although sightings are relatively infrequent (Carretta et al. 2010b). A comprehensive shipboard survey of the Hawaiian U.S. Pacific EEZ resulted in 15 sightings of striped dolphins (Barlow et al. 2004). Based on sighting records (Barlow 2006), this species occurs primarily in deeper water (approximately 547 ft. [1,000 m]). Striped dolphins are occasionally sighted closer to shore in Hawaii, so an area of secondary occurrence is expected from a depth range of 55 to 547 ft. (100 to 1,000 m). Occurrence patterns are assumed to be the same throughout the year (Mobley et al. 2000).

In and near the California Current Large Marine Ecosystem, striped dolphins are found mostly offshore and are much more common in the warm-water period (summer/fall), although they are found there throughout the year. During summer/fall surveys, striped dolphins were sighted within 100 to 300 nm of the California coast. Based on sighting records, striped dolphins appear to have a continuous distribution in offshore waters from California to Mexico (Carretta et al. 2010a). The striped dolphin also occurs far

offshore, in waters affected by the warm Davidson Current as it flows northward (Archer 2009; Jefferson et al. 2008).

HSTT Population and Abundance- The best available estimate of abundance for the Hawaiian stock of the striped dolphin is 13,143 individuals (coefficient of variation = 0.46) (Carretta et al. 2010a). The current best abundance estimate of the California, Oregon, and Washington stock is 10,908 (coefficient of variation = 0.34) striped dolphins (Barlow 2006).

Hearing and Vocalization- Little is known of the acoustic abilities of striped dolphins. Striped dolphin whistles range from 6 to at least 24 kHz, with dominant frequencies ranging from 8 to 12.5 kHz (see Thomson and Richardson 1995).

Kastelein et al. (2003), using standard psychoacoustic techniques, measured a striped dolphin's range of most sensitive hearing to be 29 to 123 kHz, with maximum sensitivity occurring at 64 kHz. Hearing ability became less sensitive below 32 kHz and above 120 kHz. The full audiogram for this animal showed hearing ability ranged from 0.5 to 160 kHz. The full range of functional hearing for the species, therefore, is estimated to occur between approximately 150 Hz and 160 kHz, placing them among the group of cetaceans that can hear mid-frequency sounds (Southall et al. 2007).

Spinner Dolphin (*Stenella longirostris*)

Status- The spinner dolphin is protected under the MMPA and the species is not listed under the ESA. The eastern spinner dolphin (*Stenella longirostris orientalis*) is listed as depleted under the MMPA. Hawaiian spinner dolphins are considered a separate stock from those involved in the tuna purse-seine fishery in the eastern tropical Pacific (Dizon et al. 1994). Under the MMPA, there are six stocks found within the U.S. Exclusive Economic Zone of the Hawaiian Islands: (1) Hawaii Island, (2) Oahu/4-islands, (3) Kauai/Niihau, (4) Pearl & Hermes Reef, (5) Kure/Midway, and (6) Hawaii Pelagic, including animals found both within the Hawaiian Islands EEZ and in adjacent international waters (Carretta et al. 2010b).

HSTT Distribution and Seasonal Distribution- Spinner dolphins occur year round throughout the Insular Pacific-Hawaiian Large Marine Ecosystem, with primary occurrence from the shore to the 13,122 ft. (4000 m) depth. This takes into account offshore resting habitat and offshore feeding areas. Spinner dolphins are expected to occur in shallow water resting areas (about 162 ft. [50 m] deep or less) throughout the middle of the day, moving into deep waters offshore during the night to feed. Primary resting areas are along the west side of Hawaii, including Makako Bay, Honokohau Bay, Kailua Bay, Kealakekua Bay, Honaunau Bay, and Kauhako Bay, and off Kahena on the southeast side of the island (Östman-Lind et al. 2004). Along the Waianae coast of Oahu, Hawaii, spinner dolphins rest along Makua Beach, Kahe Point, and Pokai Bay during the day (Lammers 2004). Kilauea Bay on Kauai is also a popular resting bay for Hawaiian spinner dolphins (U.S. Department of the Navy 2006). An area of secondary occurrence is seaward of 2,187 fathoms (ftm) (4,000 m). Although sightings have been recorded around the mouth of Pearl Harbor, Hawaii, spinner dolphin occurrence is rare there (Lammers 2004). Occurrence patterns are assumed to be the same throughout the year. Recent data on the genetic comparison of animals in the Hawaiian archipelago found significant distinctions between spinner dolphins sampled at different island locations, resulting in the identification of six separate Hawaiian Islands EEZ stocks as noted above.

HSTT Population and Abundance- Hawaiian spinner dolphins belong to a separate stock than those animals found in the Eastern Tropical Pacific. There are currently no published estimates of abundance

for each of the six identified stocks; the best available estimate of abundance for the Hawaiian Islands EEZ is 3,351 individuals (coefficient of variation = 0.74) (Barlow 2006).

Hearing and Vocalization- Lammers et al. (2003) measured social calls from spinner dolphins in Hawaii. Burst pulses (a sound most likely used for communication, as opposed to echolocation clicks used for sensing the environment) were beyond the range of human hearing ultrasonic, often with little or no energy below 20 kHz. Pulse peak frequency was 32.3 (±12.5) kHz. Average whistle frequency was 13.8 (±2.3) kHz, with a 25 kHz maximum, and harmonics up to 100 kHz. Bazúa-Durán and Au (2002) measured Hawaiian spinner dolphin whistles that ranged in frequency from 2 and 22 kHz, with an average mid-frequency of 13 kHz and an average maximum of 16 kHz. These whistles ranged in duration from 0.05 to 1.28 s (mean=0.49 s). Rossi-Santos et al. (2008) recorded six discernible types of calls from spinner dolphins off the Brazilian coast; these varied in duration from 0.050 to 2.29 s and ranged between 200 Hz and 9.31 kHz. Such differences between calls for spinner dolphins in Brazil and Hawaii could reflect differences in dolphin ecology and behavior (Camargo and Bellini 2007; Rossi-Santos et al. 2008). Spinner dolphin echolocation clicks likely range up to at least 65 kHz (see Richardson et al. 1995). Schotten et al. (2004) recorded click source levels of 208 (±5) dB re 1 µPa-m peak-to-peak in free-ranging spinner dolphins. Whistles from Hawaiian spinner dolphins that were within 20 m of hydrophones ranged from ~149 to 156 dB re 1 µPa (Lammers Au 2003).

No empirical data on hearing ability for this species are available, although the full range of hearing may extend down to 150 Hz as reported for other small odontocetes and up to at least 65 kHz based on their echolocation clicks (see Richardson et al. 1995; Bazúa-Durán and Au 2002).

Rough-toothed Dolphin (*Steno bredanensis*)

Status- This species is protected under the MMPA and is not listed under the ESA. Rough-toothed dolphins are among the most widely distributed species of tropical dolphins, but little information is available regarding population status (Jefferson et al. 2008; Jefferson 2009). There is a single Pacific management stock including only animals found within the U.S. EEZ surrounding the Hawaiian Islands (Carretta et al. 2010b).

HSTT Distribution and Seasonal Distribution- The occurrence of this species is well known in deep ocean waters off Hawaii (Baird et al. 2008; Barlow et al. 2008; Carretta et al. 2010a; Pitman and Stinchcomb 2002; Shallenberger 1981,). A recent ship survey in the Hawaiian Islands found that sighting rates were highest in depths greater than 4,920 ft. (1,500 m) and re-sightings were frequent, indicating the possibility of a small population with high site fidelity (Baird et al. 2008). This species has been observed as far northwest as French Frigate Shoals (Carretta et al. 2010a). Eight strandings have been reported from the Hawaiian Islands of Maui, Oahu, and Hawaii (Maldini et al. 2005). Although there have been several strandings of this species in central and southern California between 1977 and 2002 (Zagzebski et al. 2006), there have been no sightings of this species during multiple ship surveys off the U.S. west coast (Barlow and Forney 2007).

HSTT Population and Abundance- Rough-toothed dolphins are among the most widely distributed species of tropical dolphins, but little information is available regarding population status (Jefferson et al. 2008; Jefferson 2009). The current best available abundance estimate for the Hawaiian stock of rough-toothed dolphins derives from a 2002 shipboard line-transect survey of the entire Hawaiian Islands U.S. Pacific Exclusive Economic Zone, resulting in an estimate of 8,709 individuals (coefficient of variation = 0.45) (Barlow 2006).

Hearing and Vocalization- The rough-toothed dolphin produces a variety of sounds, including broadband echolocation clicks, barks, and whistles (Yu et al. 2003). Free-ranging rough-toothed dolphin click trains were recorded near the Canary Islands, most of which contained clicks at 120 kHz (Gotz et al. 2006); while in captivity, clicks have been measured as high as 208 kHz (Norris and Evans 1967). Whistles (<1 s) have a wide frequency range of 0.3 kHz to greater than 24 kHz but dominate in the 2 to 14 kHz range (Miyazaki and Perrin 1994; Oswald et al. 2007; Yu et al. 2003). Echolocation clicks have a frequency range of 0.1 to 200 kHz, with a peak of about 25 kHz and duration of less than 250 µs.

Auditory evoked potential measurements performed on six individuals involved in a mass stranding event on Hutchinson Island, Florida in August 2004 (Cook et al. 2006) showed that rough-toothed dolphins can hear from 5 to 80 kHz (80 kHz was the upper limit tested) and probably higher frequencies. Functional hearing is estimated to occur between approximately 150 Hz and 160 kHz, placing them among the group of cetaceans that can hear mid-frequency sounds (Southall et al. 2007).

Pacific White-sided Dolphin (*Lagenorhynchus obliquidens*)

Status- This species is not listed under the ESA but is protected under the MMPA. Morphological studies indicate that two different populations of Pacific white-sided dolphins exist off California (Lux et al. 1997). However, the population boundaries are dynamic, and there is no reliable way to distinguish animals from the two populations in the field. Thus, these two populations are managed by NMFS as a single stock, the California, Oregon, and Washington stock (Carretta et al. 2010a). Genetic analysis has shown some variation between Pacific white-sided dolphins known to occur off Baja California, and those found off the coast of Point Conception, California (Carretta et al. 2010a; Lux et al. 1997). Acoustic studies have also supported a distinction between these two populations off California (Soldevilla et al. 2008).

HSTT Distribution and Seasonal Distribution- The Pacific white-sided dolphin is found in cold, temperate waters across the northern rim of the Pacific Ocean (Carretta et al. 2010b; Jefferson et al. 2008; Ferguson 2005; Reeves et al. 2002). The species is most common in temperate waters over the outer continental shelf and slope. It is also known to inhabit inshore regions of southeast Alaska, British Columbia, and Washington, and occurs seasonally off southern California (Brownell et al. 1999; Forney and Barlow 1998). Sighting records and captures in open sea driftnets indicate that this species also occurs in oceanic waters well beyond the shelf and slope (Ferrero and Walker 1996; Leatherwood et al. 1984). Salvadeo et al. (2010) concluded that the occurrence of the Pacific white-sided dolphin has decreased by approximately 10 times per decade since the 1980s in the Gulf of California. Off the California coast, Forney and Barlow (1998) found significant north/south shifts in the seasonal distribution of Pacific white-sided dolphin, with the animals moving north into Oregon and Washington waters during summer (arriving by May), and showing an increased abundance in the Southern California Bight in winter (November to April). Off the California coast, the species is found mostly at the outer edge of the continental shelf and slope and does not frequently move into shallow coastal waters.

HSTT Population and Abundance- Based on recent surveys off the U.S. west coast, the abundance of the California, Oregon, and Washington stock of Pacific white-sided dolphins has been estimated at 26,930 individuals (coefficient of variation = 0.28) (Carretta et al. 2010a). No long-term trends have been proposed based on historical and recent visual surveys of this species (Carretta et al. 2010b). This species is not known to occur in the Hawaii portion of the Study Area.

Hearing and Vocalization- Little is known of the acoustic abilities of Pacific white-sided dolphins. They vocalize in the frequency range of ~6 to 15 kHz (see Thomson and Richardson 1995).

While no empirical data on hearing ability for this species are available, functional hearing is estimated to occur between approximately 150 Hz and 160 kHz, placing them among the group of cetaceans that can hear mid-frequency sounds (Southall et al. 2007).

Northern Right Whale Dolphin (*Lissodelphis borealis*)

Status- This species it is not listed under the ESA but is protected by the MMPA. Dizon et al. (1994) examined a small sample of northern right whale dolphin specimens to determine whether there were different populations along the west coast of North America and in pelagic waters of the central North Pacific. Although no evidence of separate populations was found, separate stocks are assumed to exist. The management stock in U.S. waters consists of a single California, Oregon, and Washington stock (Carretta et al. 2010a).

HSTT Distribution and Seasonal Distribution- The northern right whale dolphin occurs in cool-temperate to subarctic waters of the North Pacific Ocean, from the west coast of North America to Japan and Russia. This species occurs in oceanic waters and along the outer continental shelf and slope, normally in waters colder than 68°F (20°C) (Jefferson and Lynn 1994; Leatherwood and Walker 1979). Northern right whale dolphins generally move nearshore only in areas where the continental shelf is narrow or where productivity on the shelf is especially high (Smith et al. 1986). Off California, this species is known to occur year round, but abundance and distribution vary seasonally. This species is most abundant off central and northern California in relatively nearshore waters in winter (Dohl et al. 1983). Soldevilla et al. (2006) noted frequent sightings in shelf and offshore waters of southern California. Leatherwood and Walker (1979) reported frequent sightings around prominent banks and seamounts, such as Tanner and Cortes banks off southern California (Lipsky 2009). In the cool water period, the peak abundance of northern right whale dolphins in the southern California portion of the Study Area corresponds closely with the peak abundance of squid (Forney and Barlow 1998). This species is not known to occur in the Hawaii portion of the Study Area.

In the warm water period, the northern right whale dolphin moves northward, as water temperatures increase, into waters off of Oregon and Washington and is not as abundant in southern California waters (Barlow 1995; Forney et al. 1995; Forney and Barlow 1998; Leatherwood and Walker 1979). As noted by Leatherwood and Walker (1979), a few sightings south of Point Conception occurred during summer, well seaward of the continental shelf, in the vicinity of the Transit Corridor. Primary areas of occurrence include all of the Channel Islands within and adjacent to the Study Area. Leatherwood and Walker (1979) reported observation of this species off Pyramid Head, San Clemente Island, and Catalina Island, which are important squid fishing grounds in southern California.

HSTT Population and Abundance- The current best estimate of abundance for the California, Oregon, and Washington stock is 8,334 individuals (coefficient of variation = 0.40), with no indication of an increase or decrease in abundance (Carretta et al. 2010a).

Fraser's Dolphin (*Lagenodelphis hosei*)

Status- Fraser's dolphin is protected under the MMPA and is not listed under the ESA. For the MMPA stock assessment reports, there is a single Pacific management stock including only animals found within the U.S. EEZ surrounding the Hawaiian Islands (Carretta et al. 2010b).

HSTT Distribution and Seasonal Distribution- Fraser's dolphin is a tropical, deep water, oceanic species, except where deep water approaches the coast (Dolar 2008). Fraser's dolphins have only recently been documented within the Insular Pacific-Hawaiian Large Marine Ecosystem. The first published sightings were during a 2002 cetacean survey (Barlow 2006; Carretta et al. 2010a). There are no records of strandings of this species in the Hawaiian Islands (Maldini et al. 2005); however, Fraser's dolphin vocalizations have been documented in the Hawaiian Islands (Barlow et al. 2004; Barlow et al. 2008). It is not known whether Fraser's dolphins found in Hawaiian waters are part of the same population that occurs in the eastern tropical Pacific (Carretta et al. 2010a). In the offshore eastern tropical Pacific, this species occurs in association with upwelling-modified waters (Au and Perryman 1985; Reilly 1990). The range of this species includes deep oceanic waters of the North Pacific Subtropical Gyre and the Insular Pacific-Hawaiian Large Marine Ecosystem as well as other locations in the Pacific (Aguayo and Sanchez 1987; Ferguson 2005; Miyazaki and Wada 1978). This species is not known to occur in the Southern California portion of the Study Area.

HSTT Population and Abundance- Fraser's dolphin is not considered to be extremely abundant in any region in the world, although there is little concern regarding its global conservation status (Dolar 2008; Jefferson et al. 2008). The current best available abundance estimate for the Hawaiian stock of Fraser's dolphin derives from a 2002 shipboard survey of the entire Hawaiian Islands U.S. Pacific EEZ, resulting in an estimate of 10,226 (Barlow 2006).

Hearing and Vocalization- Little is known of the acoustic abilities of Fraser's dolphins. In the southeast Caribbean, both broadband clicks and whistles were recorded from a group of about 60 Fraser's dolphins (Watkins et al. 1994). Concurrent behavioral observations suggest these dolphins use clicks for echolocation similar to that of other delphinids (e.g., during feeding behavior such as fish herding/hunting) and whistles for information sharing. Whistles were frequency modulated and ranged from 4 to 24 kHz, lasting from 0.1 to 2 s (Watkins et al. 1994). In the Gulf of Mexico, two types of whistles were described: 8 or 12 kHz, 'long duration' (0.5 s) single calls; and 12 kHz, 'short duration' (0.2 s) repetitive (3 to 5) calls (all values are averages, with overall whistle frequency spanning 7.6 to 13.4 kHz) (Leatherwood et al. 1993).

While no empirical data on hearing ability for this species are available, functional hearing is estimated to occur between approximately 150 Hz and 160 kHz, placing them among the group of cetaceans that can hear mid-frequency sounds (Southall et al. 2007).

Risso's Dolphin (*Grampus griseus*)

Status- Risso's dolphin is protected under the MMPA and is not listed under the ESA. For the MMPA stock assessment reports, Risso's dolphins within the Pacific U.S. EEZ are divided into two separate stocks: (1) Risso's dolphins occurring in waters off California, Oregon, and Washington, and (2) Risso's dolphins occurring in Hawaiian waters (Carretta et al. 2010a).

HSTT Distribution and Seasonal Distribution- The range of this species in the Pacific is known to include the North Pacific Subtropical Gyre and the California Current and Insular Pacific-Hawaiian Large Marine Ecosystems. Several studies have documented that Risso's dolphins are found offshore, along the continental slope, and over the outer continental shelf (Baumgartner 1997; Canadas et al. 2002; Cetacean and Turtle Assessment Program 1982; Davis et al. 1998; Green et al. 1992; Kruse et al. 1999; Mignucci-Giannoni 1998;). Risso's dolphins are also found over submarine canyons (Mussi et al. 2004).

Occurrence of this species is well known in deep open ocean waters off Hawaii, and in other locations in the Pacific (Au and Perryman 1985; Carretta et al. 2010b; Leatherwood et al. 1980; Miyashita 1993; Miyashita et al. 1996; Wang et al. 2001). Risso's dolphins are considered uncommon in Hawaiian waters (Shallenberger 1981). During a 2002 survey of the Hawaiian Islands U.S. Pacific EEZ, seven sightings were reported; in addition, two sightings were reported from recent aerial surveys in the Hawaiian Islands (Barlow 2006; Mobley et al. 2000). During a Navy training event in Hawaii in February 2011, a pod of Risso's dolphins was observed (U.S. Department of the Navy 2011c). Five stranding records exist from the main Hawaiian Islands (Maldini et al. 2005).

Off California, Risso's dolphins are commonly seen over the slope and in offshore waters (Carretta et al. 2010a; Forney et al. 1995; Jefferson et al. 2008). This species is frequently observed in the waters surrounding San Clemente Island, California. They are generally present year round in southern California, but are more abundant in the cold-water months, suggesting a possible seasonal shift in distribution (Carretta et al. 2000; Forney and Barlow 1998; Soldevilla 2008). Several stranding records have been documented for this species in central and southern California between 1977 and 2002 (Zagzebski et al. 2006).

HSTT Population and Abundance- This is a widely distributed species that occurs in all major oceans, and although no global population estimates exist, it is generally considered to be one of the most abundant of the large dolphins. The mean abundance for California, Oregon, and Washington waters, based on surveys between 2005 and 2008, was 6,272 (coefficient of variation = 0.30) Risso's dolphins (Carretta et al. 2010a). The current best available abundance estimate for the Hawaiian stock of Risso's dolphin derives from a 2002 shipboard survey of the entire Hawaiian Islands U.S. Pacific Exclusive Economic Zone. The resulting abundance estimate was 2,372 (coefficient of variation = 0.97) Risso's dolphins (Barlow 2006).

Hearing and Vocalization- Corkeron and Van Parijs (2001) recorded a variety of Risso's dolphin vocalizations off the coast of Newcastle, Australia. Vocalizations included broadband clicks (6 to 22 kHz; 4 to 49.3 s), barks (2 to 20 kHz; 0.2 to 7.4 s), buzzes (2.1 to >22 kHz; 2 s), grunts (400 to 800 Hz; 4 s), chirps (2 to 4 kHz; 1.3 s), 5 whistle types (4 to 21.3 kHz; 1.6 to 4.9 s), and simultaneous whistle and burst-pulse sounds (3.8 to 20.1 kHz; 8.0 s). The combined whistle and burst pulse sound has only been recorded from Risso's dolphins (Corkeron and Van Parijs 2001). Risso's dolphins have been shown to produce echolocation clicks (40 to 70 µs duration) with a frequency range of 27.4 to 104.7 kHz (mean of 47.9 kHz) and estimated source levels up to 216 dB re 1 µPa (Philips et al. 2003). Soldevilla et al. (2008; 2010) found that Risso's dolphins oftentimes produce click bouts consisting of low variability clicks that contain unique peak/notch patterns in the 22 to 39 kHz frequency range. Clicks were produced more often at night in the Southern California Bight than during the day, possibly reflective of nighttime feeding behavior (Soldevilla et al. 2010).

Nachtigall et al. (1995) measured hearing in an adult Risso's dolphin in a natural setting (included natural background noise) using behavioral methods. The adult hearing ranged from 1.6 to 100 kHz and was most sensitive between 8 to 64 kHz. The auditory brainstem response (auditory brainstem response) technique was used to measure hearing in a stranded infant Risso's dolphin (Nachtigall et al. 2005). Hearing ranged from 4 to 150 kHz, with best sensitivity at 90 kHz. The full range of functional hearing for this species is estimated to occur between approximately 150 Hz and 160 kHz, placing them among the group of cetaceans that can hear mid-frequency sounds (Southall et al. 2007).

Dall's Porpoise (*Phocoenoidea dalli*)

Status- This species is protected under the MMPA and is not listed under the ESA. Dall's porpoise is managed as two stocks: (1) a California, Oregon, and Washington stock and (2) an Alaskan stock (Allen and Angliss 2010; Carretta et al. 2010a).

HSTT Distribution and Seasonal Distribution- This species is typically found in waters at temperatures less than 63°F (17°C) with depths of more than 590 ft. (180 m) (Forney 2000; Houck and Jefferson 1999; Reeves et al. 2002). Coastal waters are generally considered a secondary habitat for this species, except in some deep inshore waters of the Pacific Northwest. Groups are sometimes found more than 685 mi. (1,100 km) offshore. In the southern California portion of the Study Area, Dall's porpoises are sighted seasonally, mostly during winter (Forney and Barlow 1998). Inshore/offshore movements off southern California have been reported, with individuals remaining inshore in fall and moving offshore in the late spring (Houck and Jefferson 1999). Seasonal movements have also been noted off Oregon and Washington, with higher densities of Dall's porpoises sighted offshore in winter and spring and inshore in summer and fall (Green et al. 1992). This species is not known to occur in the Hawaii portion of the Study Area.

HSTT Population and Abundance- Dall's porpoise is one of the most common odontocete species in North Pacific waters (Calambokidis et al. 2004; Ferrero and Walker 1999; Jefferson 1991;; Williams and Thomas 2007; Zagzebski et al. 2006). Population structure within North American waters has not been well studied. An estimated 42,000 (coefficient of variation = 0.33) individuals are present off the coast of California, Oregon, and Washington (Carretta et al. 2010b).

Cuvier's Beaked Whale (*Ziphius cavirostris*)

Status- Cuvier's beaked whale is protected under the MMPA and is not listed under the ESA. Cuvier's beaked whale stocks are defined for three separate areas within Pacific U.S. waters: (1) Alaska, (2) California, Oregon, and Washington, and (3) Hawaii (Carretta et al. 2010b).

HSTT Distribution and Seasonal Distribution- Cuvier's beaked whales have an extensive range that includes all oceans, from the tropics to the polar waters of both hemispheres. In the Study Area, they are found mostly offshore in deeper waters off California and Hawaii (MacLeod and Mitchell 2006; Mead 1989; Ohizumi and Kishiro 2003; Wang et al. 2001). Cuvier's beaked whales are generally sighted in water depths greater than 655 ft.(200 m) and are frequently recorded in waters deeper than 3,280 ft.(1,000 m) (Falcone et al. 2009; Jefferson et al. 2008). This species' range is known to include all waters of the California Current and Insular Pacific-Hawaiian Large Marine Ecosystems, the North Pacific Subtropical Gyre, and the North Pacific Transition Zone (Jefferson et al. 2008; MacLeod et al. 2006).

A line-transect survey conducted in February 2009 by the Cetacean Research Program surrounding the Hawaiian Islands resulted in the sighting of two Cuvier's beaked whales (Oleson and Hill 2009). In the Hawaiian Islands, five strandings have been reported from Midway Island, Pearl and Hermes Reef, Oahu, and the Island of Hawaii (Maldini et al. 2005; Shallenberger 1981). Sightings have been reported off the Hawaiian Islands of Lanai, Maui, Hawaii, Niihau, and Kauai, supporting the hypothesis that there is a resident population found in the Hawaiian Islands (Baird et al. 2010; Carretta et al. 2010a; Mobley et al. 2000; Shallenberger 1981). Cuvier's beaked whale is the most commonly encountered beaked whale off U.S. Pacific coast from Alaska to Baja California. There are no apparent seasonal changes in distribution (Carretta et al. 2010a; Mead 1989; Pitman et al. 1988). However, Mitchell (1968) reported strandings, from Alaska to Baja California, to be most abundant between February and September. Repeated

sightings of the same individuals have been reported off San Clemente Island in southern California, which indicates some level of site fidelity (Falcone et al. 2009).

HSTT Population and Abundance- The current best available abundance estimate for California, Oregon, and Washington waters for Cuvier's beaked whale is 2,143 (coefficient of variation = 0.65) animals (Carretta et al. 2010b). The current best available abundance estimate for the Hawaiian stock is 15,242 (coefficient of variation = 1.43), based on a 2002 shipboard line-transect survey of the Hawaiian Islands U.S. Pacific Exclusive Economic Zone (Barlow 2006).

Hearing and Vocalization- There is some specific information on the sound production capability of *Berardius*, *Hyperoodon*, *Mesoplodon*, and *Ziphius* beaked whale species. Whistles recorded from free-ranging Cuvier's beaked whales (*Ziphius cavirostris*) off Greece ranged in frequency from 8 to 12 kHz, with an upsweep of about 1 s (Manghi et al. 1999), while pulsed sounds had a narrow peak frequency of 13 to 17 kHz, average duration of 1.08 ms, and were emitted in a series of ~35 to 105 pulses over 15 to 44 s (Frantzis et al. 2002). Short whistles and chirps from a stranded subadult Blainville's beaked whale (*Mesoplodon densirostris*) ranged in frequency from slightly less than 1 to almost 6 kHz (Caldwell and Caldwell 1971). Recent studies incorporating DTAGs (miniature sound and orientation recording tag) attached to Blainville's beaked whales in the Canary Islands and Cuvier's beaked whales in the Ligurian Sea recorded high-frequency echolocation clicks (duration: 175 µs for Blainville's and 200 to 250 µs for Cuvier's) with dominant frequency ranges from about 20 to over 40 kHz (limit of recording system was 48 kHz) and only at depths greater than 200 m (656 ft.) (Johnson et al. 2004; Madsen et al. 2005; Tyack et al. 2006; Zimmer et al. 2005). Mid-frequency sounds, including a frequency-modulated, pure tone and three FM and amplitude modulated, pulsed sounds (between 6 and 16 kHz) were attributed to three cow/calf pairs of Blainville's beaked whales during shipboard visual and acoustic surveys near the Hawaiian islands (Rankin and Barlow 2007). Higher frequency sounds were recorded at Cross Seamount, southwest of Hawaii, the most common of which had a linear frequency upsweep from 35 to 100 kHz, an interpulse interval of 0.11 s and duration of at least 932 µs (McDonald et al. 2009). The sounds were attributed to either a geographic variant of Cuvier's or Blainville's beaked whales, Longman's beaked whale (*Mesoplodon*/*Indopacetus pacificus*) or a beaked whale not yet known to occur in the region. The source level of the Blainville's beaked whales' clicks are estimated to have a range of 200 to 220 dB re 1 µPa-m peak-to-peak (Johnson et al. 2004), while Zimmer et al. (2005) estimates that Cuvier's beaked whales have a maximum source level of 214 dB re 1 µPa-m peak-to-peak.

Gervais' beaked whales (*Mesoplodon europaeus*) recorded in the Bahamas produced clicks with a dominant frequency of 30 to 50 kHz and duration of 200 µs (Gillespie et al. 2009). Species identification was based on a combination of visual cues as well as genetic analysis of biopsy samples collected while the animals were surfaced (Gillespie et al. 2009).

Baird's beaked whales (*Berardius bairdii*) have been recorded west of the Oregon coast and off the Baja California peninsula . Recordings from the more northerly group consisted of whistle sequences produced over 4 to 12 s, most of which were frequency modulated and ranged from 4 to 8 kHz. A more complete data set was obtained from the Baja group, and consisted of 'clicks', 'irregular pulse series', and 'click bursts'. 'Clicks' were produced either singly or in short series of 1 to 9 clicks, with average click duration of 463 µs. Maximum peak frequency for most of the clicks ranged from 22 to 25 kHz, but 35 to 45 kHz was also common. The highest frequency of any of the clicks recorded was 129 kHz. 'Irregular pulse series' sounds consisted of sequences containing 119 pulses on average, with mean pulse duration of 310 µs. Maximum peak frequency for most of the pulses was 23 kHz, with the highest frequency recorded at 134 kHz. For 'click bursts', individual clicks within the bursts were not recordable (clicks

were too compressed). The bursts were produced serially, usually about 17 bursts per series. The dominant frequency was 23 to 24.6 kHz, and nothing over 90 kHz was noted for these sounds.

Northern bottlenose whale (*Hyperoodon ampullatus*) sounds recorded by Hooker and Whitehead (2002) were predominantly clicks, with two major types of click series. Loud clicks were produced by whales socializing at the surface and were rapid with short and variable interclick intervals. The frequency spectrum was often multimodal, and peak frequencies ranged between 2 to 22 kHz (mean of 11 kHz). Clicks received at low amplitude (produced by distant whales, presumably foraging at depth) were generally unimodal frequency spectra with a mean peak frequency of 24 kHz and a 3 dB bandwidth of 4 kHz. Winn et al. (1970) recorded sounds from northern bottlenose whales that were not only comprised of clicks but also whistles that they attributed to northern bottlenose whales. However, the whistles may have been from long-finned pilot whales (*Globicephala melas*) that were in the area at the time of the recordings (Hooker and Whitehead 2002).

From anatomical examination of their ears, it is presumed that beaked whales are predominantly adapted to best hear ultrasonic frequencies (Ketten 2000; MacLeod 1999). Beaked whales have well-developed semi-circular canals (typically for vestibular function but may function differently in beaked whales) compared to other cetacean species, and they may be more sensitive than other cetaceans to low-frequency sounds (Ketten 2000; MacLeod 1999). Drawing from data obtained via computerized tomography scans of Cuvier's, Blainville's, Sowerby's (*Mesoplodon bidens*), and Gervais' beaked whale heads, Ketten (2000) noted that beaked whale ears have anomalously well-developed vestibular elements and heavily reinforced (large bore, strutted) Eustachian tubes, possibly imparting special resonances and acoustic sensitivities.

Auditory evoked potential techniques were used to measure the hearing abilities of two Gervais' beaked whales. Cook et al. (2006) measured the hearing of a juvenile male that live-stranded in Florida in 2004. The hearing range of the juvenile whale was 5 to 80 kHz, with greatest sensitivity at 40 and 80 kHz (Cook et al. 2006). Equipment limitations prevented testing at frequencies above 80 kHz. Finneran et al. (2009) measured the hearing of an adult female Gervais' beaked whale (also live-stranded in Florida) at frequencies ranging from 20 to 160 kHz. Results showed that best sensitivity was at 40 kHz, and the upper limit of functional hearing was 80 to 90 kHz. No response was detected at $\geq$100 kHz, with age-related hearing loss cited as a possible factor (Finneran et al. 2009). The full range of functional hearing for beaked whales, therefore, is estimated to occur between approximately 150 Hz and 160 kHz, placing them among the group of cetaceans that can hear mid-frequency sounds (Southall et al. 2007).

Baird's Beaked Whale (*Berardius bairdii*)

Status- Baird's beaked whale is protected under the MMPA and is not listed under the ESA. Baird's beaked whale stocks are defined for the two separate areas within U.S. Pacific waters: (1) Alaska and (2) California, Oregon, and Washington (Carretta et al. 2010a).

HSTT Distribution and Seasonal Distribution- Baird's beaked whales appear to occur mainly in deep waters over the continental slope, near oceanic seamounts and areas with submarine escarpments. In the western North Pacific, the species is known to prefer depths ranging from 3,280 to 9,840 ft. (1,000 and 3,000 m), where fish that live on or near the bottom of the ocean are abundant (Ohizumi et al. 2003). Baird's beaked whales may be seen close to shore where deep water approaches the coast of North America (Jefferson et al. 2008; Kasuya 2009). The Baird's beaked whale range is known to include the California Current Large Marine Ecosystem and the North Pacific Transition Zone. This species is not

known to occur in the Hawaii portion of the Study Area. Distribution of Baird's beaked whales in the central North Pacific, as well as their winter habitats, are not well known, but this species is generally found in the colder waters of the North Pacific, ranging from off Baja California, Mexico, to the Aleutian Islands of Alaska (Jefferson et al. 2008; MacLeod et al. 2006).

The continental shelf margins from the California coast to 125° West (W) longitude were recently identified as key areas for beaked whales (MacLeod et al. 2006). Baird's beaked whale is found mainly north of 28° N in the eastern Pacific (Kasuya et al. 1997; Reeves et al. 2003). Along the U.S. Pacific coast, Baird's beaked whales are seen primarily along the continental slope, from late spring to early fall (Carretta et al. 2010b; Green et al. 1992). Baird's beaked whales are sighted less frequently and are presumed to be farther offshore during the colder water months of November through April (Carretta et al. 2010b).

HSTT Population and Abundance- The minimum population estimate for the California, Oregon, and Washington stock of the Baird's beaked whale is 907 (coefficient of variation = 0.49) (Carretta et al. 2010b). This species is rarely sighted during surveys along the U.S. Pacific coast, and does not appear to occur in high densities anywhere in U.S. waters (Barlow et al. 2004; Forney 2007).

Hearing and Vocalization- See Cuvier's Beaked Whale section for a general description of beaked whale hearing and vocalization.

Longman's Beaked Whale (*Indopacetus pacificus*)

Status- Longman's beaked whale is protected under the MMPA and is not listed under the ESA. Longman's beaked whale is rare, and, until recently, was considered to be the world's rarest cetacean; the spade-toothed whale now holds that honor (Dalebout et al. 2003; Pitman 2008). Only one Pacific stock, the Hawaiian stock, is identified (Carretta et al. 2010a).

HSTT Distribution and Seasonal Distribution- Worldwide, Longman's beaked whales normally inhabit continental slope and deep oceanic waters (greater than 655 to 6,560 ft. [200 to 2,000 m]), and are only occasionally reported in waters over the continental shelf (Canadas et al. 2002; Ferguson et al. 2006; MacLeod et al. 2006; Pitman 2008; Waring et al. 2001;;). This species is not known to occur in the SOCAL portion of the Study Area. Longman's beaked whales generally are found in warm tropical waters, with most sightings occurring in waters with sea surface temperatures warmer than 78 °F (26°C) (Anderson et al. 2006; MacLeod et al. 2006). Records of this species indicate presence in the eastern, central, and western Pacific, including waters off the coast of Mexico. Within the Study Area, the range of Longman's beaked whale generally includes the Insular Pacific-Hawaiian Large Marine Ecosystems and the North Pacific Subtropical Gyre (Gallo-Reynoso and Figueroa-Carranza 1995; Jefferson et al. 2008; MacLeod et al. 2006).

Sighting records for this species indicate presence in waters to the west of the Hawaiian Islands (four Longman's beaked whales were observed during the 2002 Hawaiian Islands Cetacean and Ecosystem Assessment also known as the HICEAS survey [Barlow et al. 2004]) and to the northwest of the Hawaiian archipelago (23°42'38" N and 176°33'78" W). During a more recent 2010 HICEAS survey, there were multiple sightings of Longman's beaked whale. One known record exists of a stranding of this species in the Hawaiian Islands (Maldini et al. 2005).

HSTT Population and Abundance- Based on 2002 surveys of the Hawaiian Islands EEZ, the best available abundance estimate of the Hawaiian stock is 1,007 (coefficient of variation = 1.26) individuals (Barlow 2006).

Hearing and Vocalization- See Cuvier's Beaked Whale section for a general description of beaked whale hearing and vocalization.

Mesoplodont Beaked Whales (*Mesoplodon spp.*)

Status- Mesoplodon beaked whales are difficult to distinguish in the field. They are pelagic, spending most of their time in deep water far from shore, and dive for long periods. Six species of *Mesoplodon* may occur off the coast of Southern California: Blainville's beaked whale (*M. densirostris*), Hubb's beaked whale (*M. carlhubbsi*), Perrin's beaked whale (*M. perrini*), pygmy beaked whale (*M. peruvianus*), Stejneger's beaked whale (*M. stejnegeri*), and ginkgo-toothed beaked whale (*M. ginkgodens*) (Carretta et al. 2011). Until better methods are developed for distinguishing the different *Mesoplodon* species from one another, the California/Oregon/Washington stock is defined to include all *Mesoplodon* populations. However, NMFS recognizes a Hawaiian stock of Blainville's beaked whale based on resightings and genetic analysis of individuals around the Hawaiian Islands. The other species of *Mesoplodon* beaked whales present in SOCAL (Perrin's, pygmy, Stejneger's, Hubb's, and ginkgo-toothed beaked whales) are not known to be present in Hawaiian waters. *Mesoplodon* beaked whales are protected under the MMPA and are not listed under the ESA.

HSTT Distribution and Seasonal Distribution- Worldwide, beaked whales normally inhabit continental slope and deep oceanic waters (greater than 656 feet (ft.) (200 meters [m]) (Canadas et al. 2002; Ferguson et al. 2006; MacLeod et al. 2006; Pitman 2008; Waring et al. 2001). They are occasionally reported in waters over the continental shelf (Pitman and Stinchcomb 2002).

Blainville's beaked whales are one of the most widely distributed within the *Mesoplodon* genus (Jefferson et al. 2008; MacLeod et al. 2006). They are found mostly offshore in deeper waters along the California coast, Hawaii, Fiji, Japan, and Taiwan, as well as throughout the eastern tropical Pacific (Leslie et al. 2005; MacLeod and Mitchell 2006; Mead 1989). There are a handful of known records of Blainville's beaked whale from the coast of California and Baja California, Mexico, but the species does not appear to be common in this portion of the Study Area (Carretta et al. 2010a; Mead 1989; Pitman et al. 1988).

Blainville's beaked whales are regularly found in Hawaiian waters (Baird et al. 2003; Baird et al. 2006; Barlow et al. 2004), typically at water depths deeper than 3,280 ft. (1,000 m) along the continental slope (Barlow et al. 2006; Schorr et al. 2010). A Blainville's beaked whale has been detected off the coast of Oahu, Hawaii for prolonged periods annually, and this species continually returns to the same site off the west coast of the Island of Hawaii (McSweeney et al. 2007). Blainville's beaked whales' vocalizations have been detected on acoustic surveys in the Hawaiian Islands, and stranding records are available for the region (Maldini et al. 2005; Rankin and Barlow 2007). A recent tagging study off the island of Hawaii found the movements of a Blainville's beaked whale to be restricted to the waters of the west and north side of the island (Baird et al. 2010)

Hubbs' beaked whale distribution is generally associated with the deep subarctic current system along the Pacific coast of North America (Mead et al. 1982; Mead 1989). MacLeod et al. (2006) speculated that the distribution might be continuous across the North Pacific between about 30° N and 45° N, but this

remains to be confirmed. Mead (1989) speculated that the Hubbs' beaked whales' range includes the northernmost portion of the Study Area off California.

Perrin's beaked whale distribution generally includes deep waters off the Pacific coast of North America (MacLeod et al. 2006). Perrin's beaked whale is known only from five stranded specimens along the California coastline (Dalebout et al. 2002; MacLeod et al. 2006). Stranded animals previously identified as Hector's beaked whale from the eastern North Pacific, specifically the California coast, have been reclassified as Perrin's beaked whale (Dalebout et al. 2002; Mead 1981; Mead and Baker 1987; Mead 1989;). While this stranding pattern suggests an eastern North Pacific Ocean distribution, too few records exist for this to be conclusive (Dalebout et al. 2002). The five stranding records are from 1975 to 1997 and include two at U.S. Marine Corps Base Camp Pendleton (33°15' N, 117°26' W), and one each at Carlsbad, (33°07' N, 117°20' W), Torrey Pines State Reserve (32°55' N, 117°15' W), and Monterey (36°37' N, 121°55' W) (Dalebout et al. 2002; Mead 1981), all of which are in California.

Pygmy beaked whale distribution is based on stranding data from the Pacific coast of Mexico; this species' range is thought to include deep waters off the Pacific coast of North America (Aurioles and Urban-Ramirez 1993; Jefferson et al. 2008; Urban-Ramirez and Aurioles-Gamboa 1992). The only records of the pygmy beaked whale north of the eastern tropical Pacific are from stranding records from Bahia de La Paz, Mexico (Aurioles and Urban-Ramirez 1993; Urban-Ramirez and Aurioles-Gamboa 1992). This species was first described in 1991 from stranded specimens from Peru and since then, strandings have been recorded along the coasts of both North and South America at Mexico, Peru, and Chile (Pitman and Lynn 2001; Reyes et al. 1991; Sanino et al. 2007). Based on sightings and strandings, the pygmy beaked whale is presumed to be found only in the eastern tropical Pacific and is one of the most frequently sighted *Mesoplodon* species found there. MacLeod et al. (2006) suggested that the pygmy beaked whale occurs in the eastern Pacific from about 30° N to about 30° S and so may be present in the SOCAL portion of the HSTT Study Area but not in Hawaiian waters.

Stejneger's beaked whale appears to prefer cold temperate and subpolar waters (Loughlin and Perez 1985; MacLeod et al. 2006). This species has been observed in waters ranging in depth from 2,395 to 5,120 ft. (730 to 1,560 m) on the steep slope of the continental shelf (Loughlin and Perez 1985). Stejneger's beaked whales are not considered to regularly occur in Southern California coastal waters (Jefferson et al. 2008; MacLeod et al. 2006). The farthest south this species has been recorded in the eastern Pacific is Cardiff, California (33° N), but this is considered an extralimital occurrence (Loughlin and Perez 1985; Mead 1989; MacLeod et al. 2006).

Ginko-toothed beaked whale distribution likely includes deep waters off the Pacific coast of North America. The handful of known records of the ginkgo-toothed beaked whale are from strandings, one of which occurred in California (Jefferson et al. 2008; MacLeod and D'Amico 2006).

There have been few sightings of *Mesoplodon* species off Southern California; therefore, seasonal occurrence in the study area cannot be determined.

HSTT Population and Abundance- The combined estimate of abundance for all species of *Mesoplodon* beaked whales in California, Oregon, and Washington waters out to 300 nm (555 km) is 1,024 (coefficient of variation = 0.77) (Carretta et al. 2010a). Population size of *Mesoplodon* beaked whales off Southern California is estimated to be 132 (CV=0.96) individuals (Barlow and Forney 2007).

The current best available abundance estimate for Blainville's beaked whale in Hawaiian waters is 2,872 (coefficient of variation = 1.25) (Barlow 2006).

Hearing and Vocalization- See Cuvier's Beaked Whale section for a general description of beaked whale hearing and vocalization.

California Sea Lion (*Zalophus californianus*)

Status- The California sea lion is protected under the MMPA and is not listed under the ESA. The California sea lion previously included three subspecies: *Zalophus californianus wollebaeki,* found on the Galapagos Islands; *Zalophus californianus japonicas,* found in Japan, but now believed extinct; and *Zalophus californianus californianus,* found from southern Mexico to southwestern Canada (Carretta et al. 2010a). These are now given the status of full species *Zalophus californianus*, the California sea lion, and is separated into three separate stocks for management purposes: the United States stock, which begins at the U.S.-Mexico border and extends northward into Canada; the western Baja California stock, which extends from the U.S.-Mexico border to the southern tip of the Baja California peninsula; and the Gulf of California stock, which includes the Gulf of California from the southern tip of the Baja California peninsula and across to the mainland and extends to southern Mexico (Carretta et al. 2010a).

HSTT Distribution and Seasonal Distribution- The California sea lion occurs in the eastern North Pacific from Puerto Vallarta, Mexico, through the Gulf of California and north along the west coast of North America to the Gulf of Alaska (Barlow et al. 2008; Jefferson et al. 2008; Maniscalco et al. 2004). California sea lions are usually found in waters over the continental shelf and slope; however, they are also known to occur in deep, oceanic waters farther offshore, such as Guadalupe Island, Alijos Rocks off Baja California (Jefferson et al. 2008; Zavala-Gonzalez and Mellink 2000). In the non-breeding season (fall-winter), adult and subadult males migrate northward along the coast of California to Washington and return south the following spring (Lowry and Forney 2005). Females and juveniles also disperse somewhat, but tend to stay in the southern California area (Lowry and Forney 2005; Melin and DeLong 2000; Thomas et al. 2010). California sea lions from the west coast of the Baja California peninsula also migrate to southern California during fall and winter (Lowry and Forney 2005). There is a general distribution shift northwest in fall and southeast during winter and spring, probably in response to changes in prey availability (Carretta et al. 2010b).

During summer, California sea lions congregate near rookery islands and specific open-water areas. The primary rookeries off the coast of the United States are on San Nicolas, San Miguel, Santa Barbara, and San Clemente Islands (Carretta et al. 2000; Le Boeuf and Bonnell 1980; Lowry et al. 1992; Lowry and Forney 2005). Haul-out sites are also found on Santa Catalina Island in the Southern California Bight (Le Boeuf 2002). California sea lions can be found in the California Current Large Marine Ecosystem, using deeper waters as a secondary habitat (Barlow et al. 2008; Jefferson et al. 2008; Lander et al. 2010).

Tagged California sea lions from Monterey Bay and San Nicolas Island demonstrated that adult males can travel more than 175 mi. (450 km) from shore during longer foraging trips; however, females and subadults normally stay within 25 mi. (65 km) of the coast (Thomas et al. 2010). During the breeding season, most individuals stay within 20 mi. (50 km) of the rookery islands (Melin and DeLong 2000). Individuals breeding on the Channel Islands typically feed over the continental shelf and remain within 60 mi. (150 km) of the islands. Tagging results showed that lactating females foraging along the coast would travel as far north as Monterey Bay and offshore where water depths reached 3,280 ft. (1,000 meter) (Henkel and Harvey 2008; Melin and DeLong 2000). During the non-breeding season, most occurrences are over the continental slope or farther offshore; during the breeding season, most occurrences are over the continental shelf or closer to shore (Melin and DeLong 2000). The California sea lion is not known to occur in the Hawaii portion of the study area.

HSTT Population and Abundance- The California sea lion is the most abundant pinniped along the California coast. The estimated population size of the U.S. stock of the California sea lion is 238,000 (Carretta et al. 2010a). Overall, the California sea lion population is abundant and generally increasing (Carretta et al. 2010a; Jefferson et al. 2008). In spite of the robustness of the overall species population, the abundance of California sea lions has declined over the last decade in the Gulf of California, Mexico. Recent time-series data analysis supported the hypothesis that the Gulf of California has four subpopulations of California sea lions, most of which exhibit lower-than-expected growth rates and two of which have high probabilities of extinction within the next 50 years (Ward et al. 2010).

Northern Fur Seal (*Callorhinus ursinus*)

Status- The northern fur seal is not listed under the ESA. Two stocks of northern fur seals are recognized in U.S. water: (1) an eastern Pacific stock and (2) a San Miguel Island stock (Carretta et al. 2010b). The eastern Pacific stock is listed as depleted under the MMPA, while the San Miguel Island stock is protected under the MMPA but is not considered depleted (Carretta et al. 2010b).

HSTT Distribution and Seasonal Distribution- The range of the northern fur seal is known to include the North Pacific Transition Zone and California Current Large Marine Ecosystem (Gentry 2009; Jefferson et al. 2008). Northern fur seals range throughout the North Pacific along the North American west coast, from California (32° N) to the Bering Sea, and west to the Okhotsk Sea and Honshu Island, Japan (36° N) (Baird and Hanson 1997; Carretta et al. 2010b). Northern fur seals are typically found beyond the continental shelf break in waters over the continental slope (Gentry 2009; Sterling and Ream 2004).

In California waters, the northern fur seal can be found on San Miguel Island, nearby Castle Rock, the Farallon Islands, and occasionally San Nicolas Island during summer (Baird and Hanson 1997; Pyle et al. 2001). Northern fur seal colonies are at Adams Cove on San Miguel Island and on Castle Rock, an offshore island 0.4 mi. (1.1 km) northwest of San Miguel Island (Stewart et al. 1993). Although both stocks are found off California during fall and winter, animals from the San Miguel Island stock remain in or near the area throughout the year (Koski et al. 1998). Most northern fur seals, excluding those of the San Miguel Island stock, migrate along continental margins from low-latitude winter foraging areas to northern breeding islands (Gentry 2009; Ragen et al. 1995). They leave the breeding islands in November and concentrate over continental margins waters of the North Pacific in January and February, where they have access to vast, predictable food supplies Northern fur seals are not known to occur in the Hawaii portion of the study area.

HSTT Population and Abundance- The current population estimate for the San Miguel Island stock is 9,968 (Carretta et al. 2010b). Abundance at San Miguel Island has increased steadily over the past four decades, except for two severe declines associated with El Niño-Southern Oscillation events in 1993 and 1998 (Carretta et al. 2010b).

Guadalupe Fur Seal (*Arctocephalus townsendi*)

Status- The Guadalupe seal is listed as threatened under the ESA and depleted under the MMPA. Guadalupe fur seals were hunted nearly to extinction during the 1800s. All individuals alive today are recent descendants from one breeding colony at Guadalupe Island, Mexico, and are considered a single stock (Carretta et al. 2010a).

HSTT Distribution and Seasonal Distribution- The Guadalupe fur seal is typically found along shorelines where large rocks are abundant, often at the base of large cliffs. They are also known to inhabit caves,

which provide protection and cooler temperatures, especially during the warm breeding season (Belcher and Lee 2002). Before intensive hunting decreased their numbers, Guadalupe fur seals ranged from Monterey Bay, California, to the Revillagigedo Islands, Mexico (Aurioles-Gamboa and Camacho-Rios 2007). Guadalupe fur seals are most common at Guadalupe Island, Mexico, their primary breeding ground (Melin and Delong 1999). A second rookery was found in 1997 at the San Benito Islands off Baja California (Maravilla-Chavez and Lowry 1999). Adult and juvenile males have been observed at San Miguel Island, California, since the mid-1960s, and in the late 1990s, a pup was born on the island (Melin and Delong 1999). Sightings have also occurred at Santa Barbara, San Nicolas, and San Clemente Islands (Stewart 1981; Stewart et al. 1993).

Guadalupe fur seals can be found in deeper waters of the California Current Large Marine Ecosystem (Hanni et al. 1997; Jefferson et al. 2008). Adult males, juveniles, and non-breeding females may live at sea during some seasons or for part of a season (Reeves et al. 1992). The movements of Guadalupe fur seals at sea are generally unknown, but strandings have been reported in northern California and as far north as Washington (Etnier 2002). The northward movement of this species possibly has resulted from an increase in its population (Etnier 2002). Guadalupe fur seals may migrate at least 230 mi. (600 km) from their rookery sites, based on observations of individuals in the Southern California Bight (Seagars 1984; Stewart et al. 1993). Females with pups are restricted to rookery areas because they must return to nurse their pups. Males typically undertake some form of seasonal movement either after the breeding season or during the winter, when prey availability is reduced (Arnould 2009). Several observations suggest that this species travels alone or in small groups of fewer than five (Belcher and Lee 2002; Seagars 1984).

HSTT Population and Abundance- A 1993 population estimate of all age classes in Mexico was 7,408 (Carretta et al. 2010a). There is no population estimate for Guadalupe fur seals occurring in United States waters.

Hawaiian Monk Seal (*Monachus schauinslandi*)

Status- The Hawaiian monk seal was listed as endangered under the ESA in 1976 (National Marine Fisheries Service 1976) and is listed as depleted under the MMPA. The species is considered a high priority for recovery, based on the high magnitude of threats, the high recovery potential, and the potential for economic conflicts while implementing recovery actions (National Marine Fisheries Service 2007). Hawaiian monk seals are managed as a single stock. There are six main reproductive subpopulations distinguished by location: (1) French Frigate Shoals, (2) Laysan Island, (3) Lisianski Island, (4) Pearl and Hermes Reef, (5) Midway Island, and (6) Kure Atoll in the northwestern Hawaiian Islands with small numbers also occurring at Necker, Nihoa, and the main Hawaiian Islands. The approximate area encompassed by the northwestern Hawaiian Islands was designated as the Papahanaumokuakea National Marine Monument in 2006.

A recovery plan for the Hawaiian monk seal was completed in 1983 and was revised in 2007 (National Marine Fisheries Service 2007). In 1986, critical habitat was designated for 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 to a depth of 10 ft. (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 northwestern Hawaiian Islands (National Marine Fisheries Service 1986). In 1988, the critical habitat was extended to include Maro Reef and waters around previously recommended areas out to the 20 ft. (36.6 m) isobath (National Marine Fisheries Service 1988). In order

to reduce the probability of direct interaction between Hawaiian-based long-line fisheries and monk seals, a Protected Species Zone was put into place in the northwestern Hawaiian Islands, prohibiting long-line fishing in this zone. In 2000, the waters from 3 to 50 nm around the northwestern Hawaiian Islands were designated the northwestern Hawaiian Islands Coral Reef Ecosystem Reserve, and specific restrictions were placed on human activities there (Antonelis et al. 2006).

In July of 2008, NMFS received a petition requesting that the critical habitat in the northwestern Hawaiian Islands be expanded to include Sand Island at Midway and ocean waters out to a depth of 500 m and that the following critical habitat be added in the main Hawaiian Islands: key beach areas, sand spits and islets, including all beach crest vegetation to its deepest extent inland, lagoon waters, inner reef waters, and ocean waters to a depth of 200 m. In October 2008, NMFS published a 90-day finding in response to the petition, announcing that a revision to the current critical habitat designation may be warranted (National Marine Fisheries Service 2009b). These Hawaiian monk seal critical habitat areas are shown in Figure 3.4 1.

In June 2009, NMFS published a 12-month finding stating that it intended to revise critical habitat for the Hawaiian monk seal (National Marine Fisheries Service 2009a). In June of 2011, NMFS proposed that the critical habitat in the northwestern Hawaiian Islands be expanded to include Sand Island at Midway and ocean waters out to a depth of 500 m. This included six new extensive areas in the main Hawaiian Islands while excluding the following areas from designation because the national security benefits of exclusion outweighed the benefits of inclusion, and the exclusion would not result in extinction of the species: Kingfisher Underwater Training area in marine areas off the northeast coast of Niihau; Pacific Missile Range Facility Main Base at Barking Sands, Kauai; Pacific Missile Range Facility Offshore Areas in marine areas off the western coast of Kauai; the Naval Defensive Sea Area and Puuloa Underwater Training Range in marine areas outside Pearl Harbor, Oahu; and the Shallow Water Minefield Sonar Training Range off the western coast of Kahoolawe in the Maui Nui area (National Marine Fisheries Service 2011b).

HSTT Distribution and Seasonal Distribution- The Hawaiian monk seal is the only endangered marine mammal whose range is entirely within the United States (National Marine Fisheries Service 2007). Found only in the Hawaiian Islands chain, this is the only seal species to live year round in tropical waters (Donohue and Foley 2007). Hawaiian monk seals can be found throughout the Hawaiian Island chain in the Insular Pacific-Hawaiian Large Marine Ecosystem. Sightings have also occasionally been reported on nearby island groups south of the Hawaiian Island chain, such as Johnston Atoll, Wake Island, and Palmyra Atoll (Carretta et al. 2010a; Gilmartin and Forcada 2009; Jefferson et al. 2008; National Marine Fisheries Service 2009). The six main breeding sites are in the northwestern Hawaiian Islands: (1) Kure Atoll, (2) Midway Islands, (3) Pearl and Hermes Reef, (4) Lisianski Island, (5) Laysan Island, and (6) French Frigate Shoals. Smaller breeding sites are on Necker Island and Nihoa Island, and monk seals have been observed at Gardner Pinnacles and Maro Reef. A small breeding population of monk seals is found throughout the main Hawaiian Islands, where births have been documented on most of the major islands, especially Kauai (Gilmartin and Forcada 2009; National Marine Fisheries Service 2007; National Marine Fisheries Service 2009).

Combined ground and aerial surveys in the main Hawaiian Islands in 2000 and 2001 showed the number of seals to be greatest at the remote northwestern island of Niihau. More seals have been documented on the islands of Kauai, Oahu, and Molokai than on Maui and Lanai and the Island of Hawaii (30 to 40 versus 5 to 10, respectively) (National Marine Fisheries Service Pacific Islands Regional Office 2010). Based on one study, on average, 10 to 15 percent of the monk seals migrate among the northwestern

Hawaiian Islands and the main Hawaiian Islands (Carretta et al. 2010a). Another source suggests that 36 percent of the main Hawaiian Island seals travel between islands throughout the year (Littnan 2010).

HSTT Population and Abundance- Population dynamics at the different locations in the northwestern Hawaiian Islands and the main Hawaiian Islands has varied considerably (Antonelis et al. 2006). The overall trend has been a steady decline, with the total number of Hawaiian monk seals decreasing from a 2007 estimate of 1,146 individuals (Littnan 2010). In the northwestern Hawaiian Islands, where most seals reside, the decline in abundance is approximately 4 percent per year. While this decline has been occurring in the northwestern Hawaiian Islands, the number of documented sightings and annual births in the main Hawaiian Islands has increased since the mid-1990s (Baker 2004). In the main Hawaiian Islands, a minimum abundance of 45 seals was found in 2000, and this increased to 52 in 2001 (Baker 2004). In 2009, 113 individual seals were identified in the main Hawaiian Islands based on flipper tag ID numbers or unique natural markings. NMFS researchers currently estimate the total number in the main Hawaiian Islands to be around 150 animals (Littnan 2010).

Possible links between the spatial distribution of primary productivity in the northwestern Hawaiian Islands and trends of Hawaiian monk seal abundance have been assessed for the past 40-plus years. Results demonstrate that monk seal abundance trends are affected by the quality of local environmental conditions (including sea surface temperature, vertical water column structure, and integrated chlorophyll) (Schmelzer 2000). Limited prey availability may be restricting the recovery of the northwestern Hawaiian Islands monk seals (Baker 2008; Brillinger et al. 2006; Carretta et al. 2010a). Studies performed on pup survival rate in the northwestern Hawaiian Islands between 1995 and 2004 showed severe fluctuations between 40 percent and 80 percent survival in the first year of life. Survival rates between 2004 and 2008 showed an increase at Lisianski Island and Pearl, Hermes, Midway, and Kure Atoll and a decrease at French Frigate Shoals and Laysan Island. Larger females have a higher survival rate than males and smaller females (Baker 2008).

Estimated chances of survival from weaning to age one are higher in the main Hawaiian Islands (77 percent) than in the northwestern Hawaiian Islands (42 to 57 percent) (Littnan 2010). The estimated main Hawaiian Islands intrinsic rate of population growth is greater as well, when compared to northwestern Hawaiian Islands estimates (1.13 versus 0.89 to 0.98, respectively) (Littnan 2010). If current trends continue, abundances in the northwestern Hawaiian Islands and main Hawaiian Islands will equalize in approximately 9 years (Littnan 2010). There are a number of possible reasons why pups in the main Hawaiian Islands are faring better. One is that the per capita availability of prey may be higher in the main Hawaiian Islands, due to the low monk seal population (Baker and Johanos 2004). Another may have to do with the structure of the marine communities. In the main Hawaiian Islands, the seals have less competition with other top predators, like large sharks, jacks, and other fish, which may enhance their foraging success (Baker and Johanos 2004; Parrish et al. 2008). A third factor may be the limited amount of suitable foraging habitat in the northwestern Hawaiian Islands (Stewart et al. 2006). While foraging conditions are better in the main Hawaiian Islands than in the northwestern Hawaiian Islands, health hazards from exposure to pollutants and infectious disease agents associated with terrestrial animals pose risks not found in the northwestern Hawaiian Islands (Littnan et al. 2007). Despite these risks, a self-sustaining subpopulation in the main Hawaiian Islands could improve the monk seal's long-term prospects for recovery (Baker and Johanos 2004; Carretta et al. 2005; Marine Mammal Commission 2003).

Northern Elephant Seal (*Mirounga angustirostris*)

Status- The northern elephant seal is protected under the MMPA and is not listed under the ESA. The northern elephant seal population has recovered dramatically after being reduced to perhaps no more than 10 to 100 animals surviving in Mexico in the 1890s (Carretta et al. 2010b; Hoelzel 1999; Stewart et al. 1994). Movement and some genetic interchange occur among rookeries, but most elephant seals return to the rookeries where they were born to breed and thus may have limited genetic differentiation (Carretta et al. 2010b). There are two distinct populations of northern elephant seals: (1) a breeding population in Baja California, Mexico, and (2) a breeding population on U.S. islands off California. Northern elephant seals found in the Study Area are from the California breeding population.

HSTT Distribution and Seasonal Distribution- The northern elephant seal is found only in the North Pacific Ocean and occurs almost exclusively in the eastern and central North Pacific. With most of their prey found in pelagic waters, the northern elephant seal is often found in deep, offshore waters (Jefferson et al. 2008; Stewart and DeLong 1995). Breeding takes place on offshore islands and mainland rookeries from central Baja California, Mexico, to northern California (Carretta et al. 2010b; Jefferson et al. 2008; Stewart et al. 1993). In California, elephant seals breed in the southern Channel Islands (Stewart et al. 1994). There are large rookeries on San Miguel and San Nicolas Islands and smaller rookeries on Santa Barbara and San Clemente Islands (Stewart et al. 1993; Stewart and DeLong 1994; Stewart et al. 1994). Elephant seals use these islands as rookeries from late December to February, and to molt from April to July. Some evidence indicates that elephant seals may be expanding their pupping range northward, possibly in response to continued population growth (Hodder et al. 1998). Hodder et al. (1998) noted a possible emerging breeding colony at Shell Island off Cape Arago in southern Oregon. Other northern mainland breeding rookeries include Año Nuevo, Point Reyes and Cape San Martin (Stewart et al. 1994).

Northern elephant seals are found in coastal areas and deeper waters of the California Current Large Marine Ecosystem (Carretta et al. 2010b; Jefferson et al. 2008). The foraging range of northern elephant seals extends thousands of kilometers offshore from the breeding range into the central North Pacific Transition Zone; however, their range is not considered to be continuous across the Pacific (Simmons et al. 2010; Stewart and Huber 1993). Adult males and females segregate while foraging and migrating (Simmons et al. 2010; Stewart and DeLong 1995; Stewart 1997). Adult females mostly range west to about 173° W, between the latitudes of 40° N and 45° N, whereas adult males range farther north into the Gulf of Alaska and along the Aleutian Islands to between 47° N and 58° N (Le Boeuf et al. 2000; Stewart and Huber 1993; Stewart and DeLong 1995). Adults stay offshore during migration, while juveniles and subadults are often seen along the coasts of Oregon, Washington, and British Columbia (Stewart et al. 1993).

Northern elephant seals occur in Hawaiian waters only rarely as extralimital vagrants. The most far-ranging individual appeared on Nijima Island off the Pacific coast of Japan in 1989 (Kiyota et al. 1992). This demonstrates the great distances that these animals are capable of covering. The few records of northern elephant seals in the Hawaiian Islands indicate that movements beyond their normal range occur. A female, an immature male, and mature male were sighted on Midway Island in the northwestern Hawaiian Islands in 1978 (Tomich 1986). On 2 January 2006, an elephant seal was discovered on Molokai and reported to be the second confirmed sighting since 2001 (National Marine Fisheries Service 2006) This same elephant seal was encountered again on 11 January 2006 along the Kona coast of Hawaii at Kawaihae Beach and later at the Kona Village Resort. The juvenile male seal was captured and returned to California by the National Marine Fisheries Service.

HSTT Population and Abundance- The population estimate for the California stock is 124,000 (Carretta et al. 2010b). The population in California continues to increase, but the Mexican stock appears to be stable or slowly decreasing (Carretta et al. 2010b; Stewart et al. 1994).

Harbor Seal (*Phoca vitulina*)

Status- The harbor seal is protected under the MMPA and is not listed under the ESA. Two subspecies of harbor seals are recognized in the Pacific: *Phoca vitulina richardii* in the eastern Pacific and *Phoca vitulina stejnegeri* in the western Pacific (Burns 2008; Jefferson et al. 2008).

HSTT Distribution and Seasonal Distribution- The harbor seal is one of the most widely-distributed seals, found in nearly all temperate coastal waters of the northern hemisphere including in temperate to cold waters of the North Pacific (Jefferson et al. 2008). Harbor seals, while primarily aquatic, also use the coastal terrestrial environment, where they haul-out of the water periodically. Harbor seals are a coastal species, rarely found more than 7.7 mi. (20 km) from shore, and frequently occupying bays, estuaries, and inlets (Baird 2001). Individual seals have been observed several kilometers upstream in coastal rivers (Baird 2001). The subspecies *Phoca vitulina richardii* inhabits nearshore coastal and estuarine areas from Baja California, Mexico, to the Pribilof Islands in Alaska. In California, approximately 400 to 600 harbor seal haul-out sites are widely distributed along the mainland and on offshore islands (Lowry and Forney 2005).Harbor seals have not been observed on the mainland coast of Los Angeles, Orange, and northern San Diego Counties (Henkel and Harvey 2008; Lowry et al. 2008). This species is not known to occur in the Hawaii portion of the Study Area.

HSTT Population and Abundance- The global population estimate of harbor seals is approximately 300,000 to 500,000. An estimated 242,000 of the *Phoca vitulina richardii* subspecies occur along the West Coast from southern California to Alaska and in the Bering Sea-an estimate that does not include a small number of seals in Mexico (Allen and Angliss 2010; Carretta et al. 2010b). The harbor seal population in California is estimated at 34,233 individuals (Carretta et al. 2010b).

Hearing and Vocalization- Harbor seals produce a variety of low-frequency, in-air vocalizations including snorts, grunts, snarls, belching sounds and growls, while pups make individually unique calls for mother recognition (main energy at 350 Hz) (see Bigg 1982; Thomson and Richardson 1995). Adult males also produce several underwater sounds such as roars, bubbly growls, grunts, groans, and creaks during the breeding season (Hanggi and Schusterman 1994). The roar is one of the primary vocalizations used by male harbor seals, and has a mean frequency of 547 Hz (mean frequency range is 280–810 Hz) (Hanggi and Shusterman 1994) and may function in defining underwater territories. Harbor seal roars measured in the northeast Atlantic were produced at frequencies a bit lower (mean frequency = 280 Hz $\pm$74), with vocalization length ranging from ~6 to 24 s (mean = 15 s) (Bjørgesæter et al. 2004). Hanggi and Schusterman (1994) found that there is individual variation in the dominant frequency range of sounds between different males, and Van Parijs et al. (2003) reported oceanic, regional, population, and site-specific levels of variation (i.e., could represent vocal dialects) between males. Khan et al. (2006) reported that captive harbor seal pups generated broadband calls of an aggressive nature, and 'mother-attraction' calls with fundamental frequencies around 200 to 600 Hz.

Harbor seals hear nearly as well in air as underwater (Kastak and Schusterman 1998). Harbor seals are capable of hearing frequencies from 1 to 75 kHz in water (most sensitive at frequencies between 0.5 kHz and 60 kHz using behavioral response testing) and from 0.25 to 30 kHz in air (most sensitive from 6 to 16 kHz using behavior and auditory brainstem response testing) (Kastelein et al. 2009; Richardson 1995;

Southall et al. 2007; Terhune and Turnbull 1995; Wolski et al. 2003). Despite the absence of an external ear flap, harbor seals are capable of directional hearing in air, giving them the ability to mask out background noise (Holt and Schusterman 2007). Underwater sound localization was demonstrated by Bodson et al. (2006).

During in-air auditory threshold testing, a harbor seal was inadvertently exposed to intermittent broadband continuous construction noise (sandblasting; 90 to 105 dB re 20 µPa unweighted in the seal's enclosure) for 6 to 7 hours per day for 6 days. A temporary threshold shift (TTS) of 8 dB was noted at 100 Hz with complete recovery approximately 1 week following exposure (Kastak and Schusterman 1996). Kastak et al. (1999) determined that underwater noise of moderate intensity (65 to 75 dB above the animal's hearing threshold at 100, 500 and 1000 Hz) and continuous duration of 20 min is sufficient to induce a small TTS of 4.8 dB in harbor seals. TTS for the harbor seal was assessed at 2.5 kHz and 3.53 kHz (exposure level was 80 and 95 dB above threshold) (Kastak et al. 2005): data indicated that the range of TTS onset would be between 183 and 206 dB re 1 μPa^2 s.

5 TAKE AUTHORIZATION REQUESTED

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

In this application, the United States (U.S.) Department of the Navy (Navy) requests one 5-year Letter of Authorization (LOA) for the take of marine mammals incidental to proposed training activities in the HSTT Study Area for the period from January 2014 through January 2019, and one 5-year LOA for the take of marine mammals incidental to proposed testing activities in the HSTT Study Area for the period from January 2014 to January 2015. The term "take," as defined in Section 3 (16 U.S.C. § 1362 (13)) 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 (potential disturbance).

The National Defense Authorization Act of Fiscal Year 2004 (PL 108-136) amended the definition of "harassment" as applied to military readiness activities or scientific research activities conducted by or on behalf of the federal government, consistent with Section 104(c)(3) [16 U.S.C. § 1374(c)(3)]. The Fiscal Year 2004 National Defense Authorization Act adopted the definition of "military readiness activity" as set forth in the Fiscal Year 2003 National Defense Authorization Act (PL 107-314). Military training and testing activities within the HSTT Study Area compose of military readiness activities as that term is defined in PL 107-314 because training and testing activities constitute "training and operations of the Armed Forces that relate to combat" and "adequate and realistic testing of military equipment, vehicles, weapons, and sensors for proper operation and suitability for combat use." For military readiness activities, the relevant definition of harassment is any act that:

- Injures or has the significant potential to injure a marine mammal or marine mammal stock in the wild ("Level A harassment"); or
- Disturbs or is likely to disturb a marine mammal or marine mammal stock in the wild by causing disruption of natural behavioral patterns including, but not limited to, migration, surfacing, nursing, breeding, feeding, or sheltering to a point where such behavioral patterns are abandoned or significantly altered ("Level B harassment") [16 U.S.C. § 1362(18)(B)(i) and (ii)].

The HSTT Environmental Impact Statement (EIS)/Overseas Environmental Impact Statement (OEIS) considered all training and testing activities proposed to occur in the Study Area that have the potential to result in the MMPA defined take of marine mammals. The stressors associated with these activities included the following:

- Acoustic (sonar and other active non-impulse sources, explosives, pile driving, swimmer defense airguns, weapons firing, launch and impact noise, vessel noise, aircraft noise)
- Energy (electromagnetic devices)
- Physical disturbance or strikes (vessels, in-water devices, military expended materials, seafloor devices)
- Entanglement (fiber optic cables, guidance wires, parachutes)
- Ingestion (munitions, military expended materials other than munitions)
- Indirect stressors (risk to monk seals from Navy California sea lions from the transmission of disease or parasites)

The Navy determined that three stressors could potentially result in the incidental taking of marine mammals from training and testing activities within the Study Area: (1) non-impulsive stressors (sonar

and other active acoustic sources), (2) impulsive stressors (explosives, pile driving and removal), and (3) vessel strikes. Non-impulsive and impulsive stressors have the potential to result in incidental takes of marine mammals by harassment, injury, or mortality. Vessel strikes have the potential to result in incidental take from direct injury and/or mortality.

5.1 INCIDENTAL TAKE REQUEST FOR TRAINING ACTIVITIES

5.1.1 IMPULSIVE AND NON-IMPULSIVE SOURCES

A detailed analysis of effects due to marine mammal exposures to impulsive and non-impulsive sources in the HSTT Study Area is presented in Chapter 6 (Number and Species Taken). Based on the model and post-model analysis described in Chapter 6, Table 5-1 summarizes the Navy's final take request for training activities for an annual maximum year (a notional 12-month period when all annual and non-annual events could occur) and the summation over a five year period (annual events occurring five times and non-annual events occurring three times). Table 5-2 summarizes the Navy's final take request for training activities by species from the modeling estimates. Derivation of these values is described in more detail within Chapter 6.

While the Navy does not anticipate any marine mammal strandings or that the mortalities predicted by the acoustic modeling will occur, the Navy requests annual authorization for take by mortality of up to seven small odontocetes (i.e., dolphins) and pinnipeds to include any combination of such species as shown in the Study Area species list (Table 3-1). While the Navy does not anticipate any beaked whale strandings or mortalities from sonar and other active sources, in order to account for unforeseen circumstances that could lead to such effects the Navy requests the annual take, by mortality, of two beaked whales as part of training activities (Table 3-1.

Table 5-1: Summary of Annual and 5-Year Take Request for Training Activities

MMPA Category	Source	Training Activities	
		Annual Authorization Sought	**5-Year Authorization Sought**
Mortality	Impulse	7 mortalities applicable to any small odontocete or pinniped species	35 mortalities applicable to any small odontocete or pinniped species over five years
	Unspecified[1]	2 mortalities to beaked whales[1]	10 mortalities to beaked whales over five years[1]
	Vessel strike	No more than 4 large whale mortalities in any given year[2]	No more than 12 large whale mortalities over five years over five years[2]
Level A	Impulse and Non-Impulse	266 - Species specific data shown in Table 5-2	1,314 - Species specific data shown in Table 5-2
Level B	Impulse and Non-Impulse	1,691,123 - Species specific data shown in Table 5-2	8,398,931 - Species specific data shown in Table 5-2

[1] For Training: The Navy's NAEMO model idid not quantitatively predict these mortalities. Navy, however, is seeking this particular authorization given sensitivities these species may have to anthropogenic activities. Request includes 2 Ziphidae beaked whale annually to include any combination of Cuvier's beaked whale, Baird's beaked whale, Longman's beaked whale, and unspecified Mesoplodon sp. (not to exceed 10 beaked whales total over the 5-year length of requested authorization).

[2] For Training: Navy cannot quantifiably predict that proposed takes from training will be of any particular species, and therefore seeks take authorization for any combination of large whale species (gray whale, fin whale, blue whale, humpback whale, Bryde's whale, sei whale, minke whale, or sperm whale), but of the 4 takes per year no more than 2 of any one species of blue whale, fin whale, humpback whale, sei whale, or sperm whale is requested.

5.1.2 VESSEL STRIKE TAKE REQUEST FROM TRAINING ACTIVITIES

Vessel strike to marine mammals is not associated with any specific training activity but rather a limited, sporadic, and accidental result of Navy vessel movement within the Study Area. In order to account for the accidental nature of vessel strikes to large whales in general, and the potential risk from any vessel movement within the HSTT Study Area (Figure 1-1), the Navy is seeking take authorization in the event a Navy vessel strike does occur while conducting training during the five-year period of NMFS' final authorization. A detailed analysis of strike data is contained in Section 6.3.4 (Estimated Take of Large Whales by Vessel Strike). The Navy's take authorization request is based on the probabilities of whale strikes suggested by the data from NMFS Southwest Regional Office (SWRO), NMFS Pacific Islands Regional Office (PIRO), the Navy, and the calculations detailed in Chapter 6 of this application. The number of Navy and commercial whale strikes for which the species has been positively identified suggests that the probability of striking a gray whale in the SOCAL Range Complex and humpback whale in the HRC is greater than striking other species. However, since species identification has not been possible in most vessel strike cases, the Navy cannot quantifiably predict what species may be taken. Therefore, the Navy seeks take authorization by vessel strike for any combined number of large whale species to include gray whale, fin whale, blue whale, humpback whale, Bryde's whale, sei whale, minke whale, or sperm whale. In terms of this LOA application, the Navy requests takes of large marine mammals over the course of the five years of the HSTT regulations from training activities as discussed below:

- The take by vessel strike during training activities in any given year of no more than four large whales total of any combination of species including gray whale, fin whale, blue whale, humpback whale, Bryde's whale, sei whale, minke whale, or sperm whale. The four takes per year requested would be no more than two of any one species of blue whale, fin whale, humpback whale, sei whale, or sperm whale in any given year.
- The take by vessel strike of no more than 12 large whales from training activities over the course of the five years of the HSTT regulations.

Over a period of 20 years from 1991 to 2010 there have been a total of 16 Navy vessel strikes in SOCAL, and five Navy vessel strikes in HRC. It should be noted that two of the five HRC Navy strikes were by <40-foot workboats vice larger Navy ships. In terms of the 16 consecutive 5-year periods in the last 20 years, no single 5-year period exceeded ten whales struck within SOCAL and HRC (periods from 2000-2004 and 2001-2005). For Navy vessel strikes in SOCAL, there were six consecutive 5-year periods with six or more whales struck (1997-2001, 1998-2002, 1999-2003, 2000-2004, 2001-2005, and 2002-2006), and no more than 3 whales struck in the last 5-year period from 2006-2010. No whales have been struck by Navy vessels in SOCAL since 2009. For Navy vessel strikes in the HRC for the same time period, there was one 5-year period when three whales were struck (2003-2007), seven periods when two whales were struck, five periods when one whale was struck, and three periods when no whales were struck. Within the data set analyzed for HRC through 2010, no whales have been struck by a Navy vessel since 2008. Also as discussed in Chapter 6, the Poisson probability of striking as many as two large whales in the SOCAL portion of the HSTT is only 14% per year, and the probability of striking two large whales in the HRC portion of the HSTT is only 2%.

Table 5-2: Species Specific Take Requests from Modeling Estimates of Impulsive and Non-Impulsive Source Effects for All Training Activities

Species	Stock	ANNUALLY			TOTAL OVER 5-YEAR RULE		
		Level B	Level A	Mortality	Level B	Level A	Mortality
Blue whale	Eastern North Pacific	4,145	0	0	20,725	0	0
	Central North Pacific	180	0	0	834	0	0
Fin whale	California, Oregon, & Washington	1,528	0	0	7,640	0	0
	Hawaiian	191	0	0	891	0	0
Humpback whale	California, Oregon, & Washington	1,081	0	0	5,405	0	0
	Central North Pacific	8,192	0	0	40,960	0	0
Sei whale	Eastern North Pacific	146	0	0	730	0	0
	Hawaiian	484	0	0	2,266	0	0
Sperm whale	California, Oregon, & Washington	1,958	0	0	9,790	0	0
	Hawaiian	1,374	0	0	6,130	0	0
Guadalupe fur seal	Mexico	2,603	0	0	13,015	0	0
Hawaiian monk seal	Hawaiian	1,292	0	0	6,334	0	0
Bryde's whale	Eastern Tropical Pacific	112	0	0	560	0	0
	Hawaiian	137	0	0	637	0	0
Gray whale	Eastern North Pacific	9,560	2	0	47,800	10	0
Minke whale	California, Oregon, & Washington	359	0	0	1,795	0	0
	Hawaiian	447	0	0	2,235	0	0
Baird's beaked whale	California, Oregon, & Washington	4,420	0	0	22,100	0	0
Blainville's beaked whale	Hawaiian	10,316	0	0	48,172	0	0
Bottlenose dolphin	California coastal	521	0	0	2,605	0	0
	California, Oregon & Washington offshore	26,618	0	0	133,090	0	0
	Hawaii Stock Complex	5,163	0	0	22,895	0	0
Cuvier's beaked whale	California, Oregon, & Washington	13,353	0	0	66,765	0	0
	Hawaiian	52,893	0	0	248,025	0	0
Dwarf sperm whale	Hawaiian	22,359	46	0	101,291	214	0
Dall's porpoise	California, Oregon, & Washington	36,891	47	0	184,455	235	0
False killer whale	Hawaii Insular	49	0	0	220	0	0
	Hawaii Pelagic	480	0	0	2,116	0	0

Table 5-2: Species Specific Take Requests from Modeling Estimates of Impulsive and Non-Impulsive Source Effects for All Training Activities (continued)

Species	Stock	ANNUALLY			TOTAL OVER 5-YEAR RULE		
		Level B	Level A	Mortality	Level B	Level A	Mortality
False killer whale	Northwest Hawaiian Islands	177	0	0	776	0	0
Fraser's dolphin	Hawaiian	2,009	0	0	8,809	0	0
Killer whale	Eastern North Pacific offshore/transient	321	0	0	1,605	0	0
	Hawaiian	182	0	0	822	0	0
Kogia spp.	California	12,943	33	0	64,715	165	0
Long-beaked common dolphin	California	73,113	2	0	365,565	10	0
Longman's beaked whale	Hawaiian	3,666	0	0	17,296	0	0
Melon-headed whale	Hawaiian	1,511	0	0	6,733	0	0
Mesoplodon beaked whales[1]	California, Oregon, & Washington	1,994	0	0	9,970	0	0
Northern right whale dolphin	California, Oregon, & Washington	51,596	1	0	257,980	5	0
Pacific white-sided dolphin	California, Oregon, & Washington	38,467	1	0	192,335	5	0
Pantropical spotted dolphin	Hawaiian	10,887	0	0	48,429	0	0
Pygmy killer whale	Hawaiian	571	0	0	2,603	0	0
Pygmy sperm whale	Hawaiian	229	0	0	1,093	0	0
Risso's dolphin	California, Oregon, & Washington	86,564	1	0	432,820	5	0
	Hawaiian	1,085	0	0	4,887	0	0
Rough-toothed dolphin	Hawaiian	5,131	0	0	22,765	0	0
Short-beaked common dolphin	California, Oregon, & Washington	999,282	70	3*	4,996,410	350	15*
Short-finned pilot whale	California, Oregon, & Washington	308	0	0	1,540	0	0
	Hawaiian	9,150	0	0	40,760	0	0
Spinner dolphin	Hawaii Stock Complex	2,576	0	0	11,060	0	0
Striped dolphin	California, Oregon, & Washington	3,545	0	0	17,725	0	0
	Hawaiian	3,498	0	0	15,422	0	0
California sea lion	U.S. Stock	126,961	25	4*	634,805	125	20*
Northern fur seal	San Miguel Island	20,083	5	0	100,415	25	0
Harbor seal	California	5,906	11	0	29,530	55	0
Northern elephant seal	California Breeding	22,516	22	0	112,580	110	0

1 Mesoplodon spp. in SOCAL for the undifferentiated occurrence of five Mesoplodon species (M. carlhubbsi, M. ginkgodens, M. perrini, M. peruvianus, M. stejnegeri but does not include Blainville's beaked whale listed separately above.
* These mortalities are considered in the take request for training activities in Table 5-1 as an unspecified "any small odontocete and pinniped species"

5.2 INCIDENTAL TAKE REQUEST FOR TESTING ACTIVITIES

5.2.1 IMPULSIVE AND NON-IMPULSIVE SOURCES

A detailed analysis of effects due to marine mammal exposures to impulsive and non-impulsive sources in the HSTT Study Area is presented in Chapter 6 (Numbers and Species Taken). Based on the model and post-model analysis described in Chapter 6, Table 5-3 summarizes the Navy's final take request for testing activities for an annual maximum year and the summation over a five-year period. Table 5-4 summarizes the Navy's take request by species. Derivation of these values is described in more detail within Chapter 6.

While the Navy does not anticipate any mortalities predicted for testing activities by the acoustic modeling will occur, the Navy requests annual authorization for take by mortality of up to 19 small odontocetes (i.e., dolphins) and pinnipeds to include any combination of such species as shown in the Study Area species list (Table 3-1) as part of testing activities using impulsive sources.

Table 5-3: Summary Of Annual and 5-Year Take Request for Testing Activities

MMPA Category	Source	Testing Activities	
		Annual Authorization Sought	5-Year Authorization Sought
Mortality	Impulse	19 mortalities applicable to any small odontocete or pinniped species	95 mortalities applicable to any small odontocete or pinniped species over five years
	Vessel strike	No more than 2 large whale mortalities in any given year[1]	No more than 3 large whale mortalities over five years over five years[1]
Level A	Impulse and Non-Impulse	145 - Species specific data shown in Table 5-4	725 - Species specific data shown in Table 5-4
Level B	Impulse and Non-Impulse	238,880 - Species specific data shown in Table 5-4	1,194,400 - Species specific data shown in Table 5-4

[1] Navy cannot quantifiably predict that the proposed takes from testing (a total of 2 in a given year or over the course of 5-years) will be of any particular species, and therefore seeks take authorization for any combination of large whale species (gray whale, fin whale, blue whale, humpback whale, Bryde's whale, sei whale, minke whale, or sperm whale), but of the 2 takes in any given year, no more than 1 of each species of blue whale, fin whale, humpback whale, sei whale, or sperm whale is requested.

5.2.2 VESSEL STRIKE TAKE REQUEST FROM TESTING ACTIVITIES

The Navy does not anticipate vessel strikes of marine mammals would occur during testing activities in the HSTT Study Area in any given year. Most testing conducted in the Study Area that involves surface ships is conducted on Navy ships. Therefore, the vessel strike take request for training activities will cover those activities. For the smaller number of testing activities not conducted in conjunction with fleet training, the Navy requests a smaller number of takes resulting incidental to vessel strike.However, in order to account for the accidental nature of vessel strikes to large whales in general, and potential risk from any vessel movement within the HSTT Study Area (Figure 1-1), the Navy is seeking take authorization in the event a Navy vessel strike does occur while conducting testing during the five year period of NMFS' final authorization as follows:

- The take by vessel strike during testing activities in any given year of no more than two large whales total of any combination of species including gray whale, fin whale, blue whale, humpback whale, Bryde's whale, sei whale, minke whale, or sperm whale. The two takes per year requested would be no more than one of any species of blue whale, fin whale, humpback whale, sei whale, or sperm whale in any given year.
- The take by vessel strike of no more than 3 large whales from testing activities over the course of the five years of the HSTT regulations.

Table 5-4: Species Specific Take Requests from Modeling Estimates of Impulsive and Non-Impulsive Source Effects for All Testing Activities

Species	Stock	ANNUALLY			TOTAL OVER 5-YEAR RULE		
		Level B	Level A	Mortality	Level B	Level A	Mortality
Blue whale	Eastern North Pacific	413	0	0	2,065	0	0
	Central North Pacific	15	0	0	75	0	0
Fin whale	California, Oregon, & Washington	202	0	0	1,010	0	0
	Hawaiian	23	0	0	115	0	0
Humpback whale	California, Oregon, & Washington	101	0	0	505	0	0
	Central North Pacific	820	0	0	4,100	0	0
Sei whale	Eastern North Pacific	21	0	0	105	0	0
	Hawaiian	30	0	0	150	0	0
Sperm whale	California, Oregon, & Washington	146	0	0	730	0	0
	Hawaiian	117	0	0	585	0	0
Guadalupe fur seal	Mexico	269	0	0	1,345	0	0
Hawaiian monk seal	Hawaiian	358	0	0	1,790	0	0
Bryde's whale	Eastern Tropical Pacific	5	0	0	25	0	0
	Hawaiian	13	0	0	65	0	0
Gray whale	Eastern North Pacific	2,570	1	0	12,850	5	0
Minke whale	California, Oregon, & Washington	49	0	0	245	0	0
	Hawaiian	30	0	0	150	0	0
Baird's beaked whale	California, Oregon, & Washington	1,045	0	0	5,225	0	0
Blainville's beaked whale	Hawaiian	960	0	0	4,800	0	0
Bottlenose dolphin	California coastal	769	0	0	3,845	0	0
	California, Oregon & Washington offshore	2,407	0	0	12,035	0	0
	Hawaii Stock Complex	337	0	0	1,685	0	0
Cuvier's beaked whale	California, Oregon, & Washington	2,319	0	0	11,595	0	0
	Hawaiian	4,549	0	0	22,745	0	0
Dwarf sperm whale	Hawaiian	2,376	28	0	11,880	140	0
Dall's porpoise	California, Oregon, & Washington	5,215	32	0	26,075	160	0
False killer whale	Hawaii Insular	4	0	0	20	0	0
	Hawaii Pelagic	37	0	0	185	0	0

Table 5-4: Species Specific Take Requests from Modeling Estimates of Impulsive and Non-Impulsive Source Effects of All Testing Activities (continued)

Species	Stock	ANNUALLY			TOTAL OVER 5-YEAR RULE		
		Level B	Level A	Mortality	Level B	Level A	Mortality
False killer whale	Northwest Hawaiian Islands	14	0	0	70	0	0
Fraser's dolphin	Hawaiian	45	0	0	225	0	0
Killer whale	Eastern North Pacific offshore/transient	53	0	0	265	0	0
	Hawaiian	14	0	0	70	0	0
Kogia spp.	California	1,232	6	0	6,160	30	0
Long-beaked common dolphin	California	47,851	2	0	239,255	10	0
Longman's beaked whale	Hawaiian	436	0	0	2,180	0	0
Melon-headed whale	Hawaiian	124	0	0	620	0	0
Mesoplodon beaked whales[1]	California, Oregon, & Washington	345	0	0	1,725	0	0
Northern right whale dolphin	California, Oregon, & Washington	5,729	1	0	28,645	5	0
Pacific white-sided dolphin	California, Oregon, & Washington	4,924	1	0	24,620	5	0
Pantropical spotted dolphin	Hawaiian	685	2	0	3,425	10	0
Pygmy killer whale	Hawaiian	61	0	0	305	0	0
Pygmy sperm whale	Hawaiian	117	1	0	585	5	0
Risso's dolphin	California, Oregon, & Washington	8,739	1	0	43,695	5	0
	Hawaiian	113	0	0	565	0	0
Rough-toothed dolphin	Hawaiian	410	0	0	2,050	0	0
Short-beaked common dolphin	California, Oregon, & Washington	122,748	40	13*	613,740	200	65*
Short-finned pilot whale	California, Oregon, & Washington	79	0	0	395	0	0
	Hawaiian	797	0	0	3,985	0	0
Spinner dolphin	Hawaii Stock Complex	167	1	0	835	5	0
Striped dolphin	California, Oregon, & Washington	998	0	0	4,990	0	0
	Hawaiian	269	1	0	1,345	5	0
California sea lion	U.S. Stock	13,038	17	6*	65,190	85	30*
Northern fur seal	San Miguel Island	1,088	3	0	5,440	15	0
Harbor seal	California	892	3	0	4,460	15	0
Northern elephant seal	California Breeding	2,712	5	0	13,560	25	0

1 Mesoplodon spp. in SOCAL for the undifferentiated occurrence of five Mesoplodon species (M. carlhubbsi, M. ginkgodens, M. perrini, M. peruvianus, M. stejnegeri but does not include Blainville's beaked whale listed separately above.
* These mortalities are considered in the take request for testing activities in Table 5-3 as an unspecified "any small odontocete and pinniped species"

6 NUMBER AND SPECIES TAKEN

By age, sex, and reproductive condition (if possible), the number of marine mammals (by species) that may be taken by each type of taking identified in paragraph (a)(5) of this section, and the number of times such takings by each type of taking are likely to occur.

6.1 ESTIMATED TAKE OF MARINE MAMMALS BY IMPULSIVE AND NON-IMPULSIVE SOURCES

Given the scope of the United States (U.S.) Department of the Navy (Navy) activities at sea and the current state of the science regarding marine mammals, there is no known method to determine or predict the age, sex, reproductive condition of the various species of marine mammals predicted to be taken as a result of the proposed Navy training and testing. There are 43 marine mammal species known to exist in the Hawaii-Southern California Training and Testing (HSTT) Study Area and these species are in 73 stocks managed by National Marine Fisheries Service (NMFS) or United States Fish and Wildlife Service (USFWS) as presented in Table 3-1. The method for estimating the number and types of take is described in the sections below beginning with presentation of the criteria used for each type of take followed by the method for quantifying exposures of marine mammals to sources of energy exceeding those threshold values.

6.1.1 CONCEPTUAL FRAMEWORK FOR ASSESSING EFFECTS FROM SOUND-PRODUCING ACTIVITIES

This conceptual framework describes the different types of effects that are possible and the potential relationships between sound stimuli and long-term consequences for the individual and population. The conceptual framework is central to the assessment of acoustic-related effects and is consulted multiple times throughout the process. It describes potential effects and the pathways by which an acoustic stimulus or sound-producing activity can potentially affect animals. The conceptual framework qualitatively describes costs to the animal (e.g., expended energy or missed feeding opportunity) that may be associated with specific reactions. Finally, the conceptual framework outlines the conditions that may lead to long-term consequences for the individual and population if the animal cannot fully recover from the short-term effects.

An animal is considered “exposed” to a sound if the received sound level at the animal’s location is above the background ambient noise level within a similar frequency band. A variety of effects may result from exposure to sound-producing activities. The severity of these effects can vary greatly between minor effects that have no real cost to the animal, to more severe effects that may have lasting consequences. Whether a marine animal is significantly affected must be determined from the best available scientific data regarding the potential physiological and behavioral responses to sound-producing activities and the possible costs and long-term consequences of those responses.

The major categories of potential effects are:

- Direct trauma
- Auditory fatigue
- Auditory masking
- Behavioral reactions
- Physiological stress

Direct trauma refers to injury to organs or tissues of an animal as a direct result of an intense sound wave or shock wave impinging upon or passing through its body. Potential impacts on an animal’s

internal tissues and organs are assessed by considering the characteristics of the exposure and the response characteristics of the tissues. Trauma can be mild and fully recoverable, with no long-term repercussions to the individual or population, or more severe, with the potential for lasting effects or, in some cases, mortality.

Auditory fatigue may result from over-stimulation of the delicate hair cells and tissues within the auditory system. The most familiar effect of auditory fatigue is hearing loss, also called a noise-induced threshold shift, meaning an increase in the hearing threshold.

Audible natural and artificial sounds can potentially result in auditory masking, a condition that occurs when noise interferes with an animal's ability to hear other sounds. Masking occurs when the perception of a sound is interfered with by a second sound, and the probability of masking increases as the two sounds increase in similarity and the masking sound increases in level. It is important to distinguish auditory fatigue, which persists after the sound exposure, from masking, which only occurs during the sound exposure.

Marine animals naturally experience physiological stress as part of their normal life histories. Changing weather and ocean conditions, exposure to diseases and naturally occurring toxins, lack of prey availability, social interactions with conspecifics (members of the same species), and interactions with predators all contribute to the stress a marine animal naturally experiences. The physiological response to a stressor, often termed the stress response, is an adaptive process that helps an animal cope with changing external and internal environmental conditions. However, too much of a stress response can be harmful to an animal, resulting in physiological dysfunction. In some cases, naturally occurring stressors can have profound impacts on animals. Sound-producing activities have the potential to provide additional stress, which must be considered, not only for its direct impact on an animal's behavior but also for contributing to an animal's chronic stress level.

A sound-producing activity can cause a variety of behavioral reactions in animals ranging from very minor and brief, to more severe reactions such as aggression or prolonged flight. The acoustic stimuli can cause a stress reaction (i.e., startle or annoyance); they may act as a cue to an animal that has experienced a stress reaction in the past to similar sounds or activities, or that acquired a learned behavioral response to the sounds from conspecifics. An animal may choose to deal with these stimuli or ignore them based on the severity of the stress response, the animal's past experience with the sound, and the other stimuli that are present in the environment. If an animal chooses to react to the acoustic stimuli, then the behavioral responses fall into two categories: alteration of natural behavior patterns or avoidance. The specific type and severity of these reactions helps determine the costs and ultimate consequences to the individual and population.

6.1.1.1 Flowchart

Figure 6-6 is a flowchart that diagrams the process used to evaluate the potential effects on marine animals from sound-producing activities. The shape and color of each box on the flowchart represent either a decision point in the analysis (green diamonds); specific processes such as responses, costs, or recovery (blue rectangles); external factors to consider (purple parallelograms); and final outcomes for the individual or population (orange ovals and rectangles).

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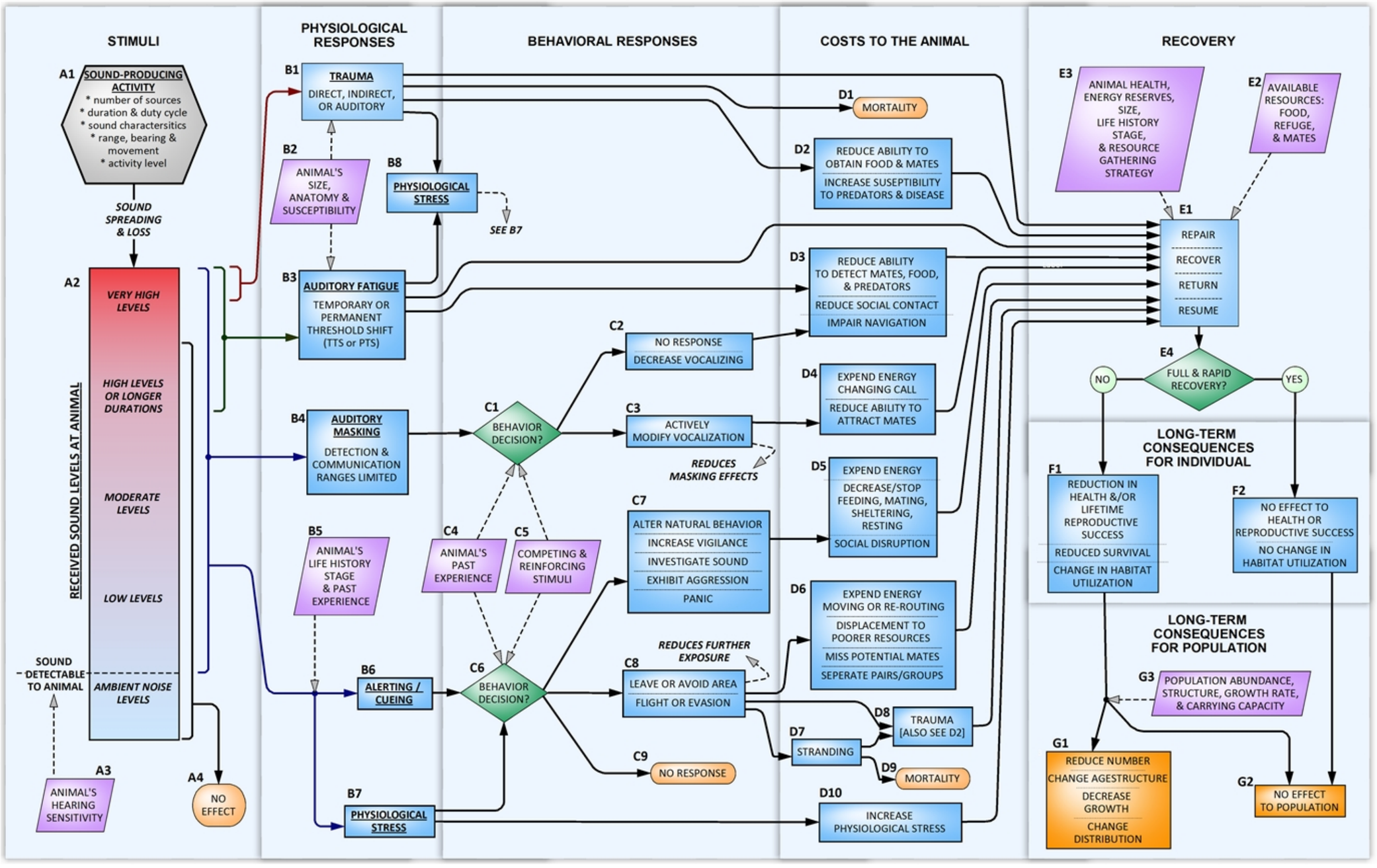

Figure 6-1. Flow Chart of the Evaluation Process of Sound-Producing Activities

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Each box is labeled for reference throughout the following sections. For simplicity, sound is used here to include not only acoustic waves but also shock waves generated from explosive sources. The supporting text clarifies those instances where it is necessary to distinguish between the two phenomena.

Box A1, the Sound-Producing Activity, is the source of the sound stimuli and therefore the starting point in the analysis. Each of the five major categories of potential effects (i.e., direct trauma, auditory fatigue, masking, behavioral response, and stress) are presented as pathways that flow from left to right across the diagram. Pathways are not exclusive, and each must be followed until it can be concluded that an animal is not at risk for that specific effect. The vertical columns show the steps in the analysis used to examine each of the effects pathways. These steps proceed from the Stimuli, to the Physiological Responses, to any potential Behavioral Responses, to the Costs to the Animal, to the Recovery of the animal, and finally to the Long-Term Consequences to the Individual and Population.

6.1.1.2 Stimuli

The first step in predicting whether a sound-producing activity is capable of causing an effect on a marine animal is to define the Stimuli experienced by the animal. The Stimuli include the Sound-Producing Activity, the surrounding acoustical environment, the characteristics of the sound when it reaches the animal, and whether the animal can detect the sound.

Sounds emitted from a sound-producing Activity (Box A1) travel through the environment to create a spatially variable sound field. There can be any number of individual sound sources in a given activity, each with its own unique characteristics. For example, a Navy training exercise may involve several ships and aircraft, several types of sonar, and several types of ordnance. Each of the individual sound sources has unique characteristics: source level, frequency, duty cycle, duration, and rise-time (i.e., impulsive vs. non-impulsive). Each source also has a range, depth/altitude, bearing and directionality, and movement relative to the animal. Environmental factors such as temperature, salinity, bathymetry, bottom type, and sea state all impact how sound spreads through the environment and how sound decreases in amplitude between the source and the receiver (individual animal). Mathematical calculations and computer models are used to predict how the characteristics of the sound will change between the source and the animal under a range of realistic environmental conditions for the locations where sound-producing activities occur.

The details of the overall activity may also be important to place the potential effects into context and help predict the range of severity of the probable reactions. The overall activity level (e.g., number of ships and aircraft involved in exercise); the number of sound sources within the activity; the activity duration; and the range, bearing, and movement of the activity relative to the animal are all considered.

The received sound at the animal and the number of times the sound is experienced (i.e., repetitive exposures) (Box A2) determines the range of possible effects. Sounds that are higher than the ambient noise level and within an animal's hearing sensitivity range (Box A3) have the potential to cause effects. Very high exposure levels may have the potential to cause trauma; high-level exposures, long-duration exposures, or repetitive exposures may potentially cause auditory fatigue; lower-level exposures may potentially lead to masking; all perceived levels may lead to stress; and many sounds, including sounds that are not detectable by the animal, will have no effect (Box A4).

6.1.1.3 Physiological Responses

Physiological responses include direct trauma, hearing loss, auditory masking, and stress. The magnitude of the involuntary response is predicted based on the characteristics of the acoustic stimuli and the characteristics of the animal (species, susceptibility, life history stage, size, and past experiences).

6.1.1.4 Trauma

Physiological responses to sound stimulation may range from mechanical vibration (with no resulting adverse effects) to tissue trauma (injury). Direct trauma (Box B1) refers to the direct injury of tissues and organs by sound waves impinging upon or traveling through an animal's body. Marine animals' bodies, especially their auditory systems, are well adapted to large hydrostatic pressures and large, but relatively slow, pressure changes that occur with changing depth. However, mechanical trauma may result from exposure to very-high-amplitude sounds when the elastic limits of the auditory system are exceeded or when animals are exposed to intense sounds with very rapid rise times, such that the tissues cannot respond adequately to the rapid pressure changes. Trauma to marine animals from sound exposure requires high received levels. Trauma effects therefore normally only occur with very-high-amplitude, often impulsive, sources, and at relatively close range, which limits the number of animals likely exposed to trauma-inducing sound levels.

Direct trauma includes both auditory and non-auditory trauma. Auditory trauma is the direct mechanical injury to hearing-related structures, including tympanic membrane rupture, disarticulation of the middle ear ossicles, and trauma to the inner ear structures such as the organ of Corti and the associated hair cells. Auditory trauma differs from auditory fatigue in that the latter involves the overstimulation of the auditory system at levels below those capable of causing direct mechanical damage. Auditory trauma is always injurious but can be temporary. One of the most common consequences of auditory trauma is hearing loss (see below).

Non-auditory trauma can include hemorrhaging of small blood vessels and the rupture of gas-containing tissues such as the lung, swim bladder, or gastrointestinal tract. After the ear (or other sound-sensing organs), these are usually the most sensitive organs and tissues to acoustic trauma. An animal's size and anatomy are important in determining its susceptibility to trauma (Box B2), especially non-auditory trauma. Larger size indicates more tissue to protect vital organs that might be otherwise susceptible (i.e., there is more attenuation of the received sound before it impacts non-auditory structures). Therefore, larger animals should be less susceptible to trauma than smaller animals. In some cases, acoustic resonance of a structure may enhance the vibrations resulting from noise exposure and result in an increased susceptibility to trauma. Resonance is a phenomenon that exists when an object is vibrated at a frequency near its natural frequency of vibration, or the particular frequency at which the object vibrates most readily. The size, geometry, and material composition of a structure determine the frequency at which the object will resonate. The potential for resonance is determined by comparing the sound frequencies with the resonant frequency and damping of the tissues. Because most biological tissues are heavily damped, the increase in susceptibility from resonance is limited.

Vascular and tissue bubble formation resulting from sound exposure is a hypothesized mechanism of indirect trauma to marine animals. The risk of bubble formation from one of these processes, called rectified diffusion, is based on the amplitude, frequency, and duration of the sound (Crum and Mao 1996) and an animal's tissue nitrogen gas saturation at the time of the exposure. Rectified diffusion is the growth of a bubble that fluctuates in size because of the changing pressure field caused by the sound wave. An alternative, but related hypothesis, has also been suggested: stable microbubbles could be destabilized by high-level sound exposures such that bubble growth then occurs through static

diffusion of gas out of gas-supersaturated tissues. Bubbles have also been hypothesized to result from changes in the dive behavior of marine mammals as a result of sound exposure (Jepson et al. 2003a). Vascular bubbles produced by this mechanism would not be a physiological response to the sound exposure, but a cost to the animal because of the change in behavior (see Costs to the Animal in this section). Under either of these hypotheses, several things could happen: (1) bubbles could grow to the extent that vascular blockage (emboli) and tissue hemorrhage occur; (2) bubbles could develop to the extent that a complement immune response is triggered or the nervous tissue is subjected to enough localized pressure that pain or dysfunction occurs; or (3) the bubbles could be cleared by the lung without negative consequence to the animal. Although rectified diffusion is a known phenomenon, its applicability to diving marine animals exposed to sound is questionable; animals would need to be highly supersaturated with gas and very close to a high-level sound source (Crum et al. 2005). The other two hypothesized phenomena are largely theoretical and have not been demonstrated under realistic exposure conditions.

6.1.1.5 Auditory Fatigue

Auditory fatigue is a reduction in hearing ability resulting from overstimulation to sounds. The mechanisms responsible for auditory fatigue differ from auditory trauma and may consist of a variety of mechanical and biochemical processes, including physical damage or distortion of the tympanic membrane and cochlear hair cell stereocilia, oxidative stress-related hair cell death, changes in cochlear blood flow, and swelling of cochlear nerve terminals resulting from glutamate excitotoxicity (Henderson et al. 2006; Kujawa and Liberman 2009). Although the outer hair cells are the most prominent target for fatigue effects, severe noise exposures may also result in inner hair cell death and loss of auditory nerve fibers (Henderson et al. 2006). Auditory fatigue is possibly the best studied type of effect from sound exposures in marine and terrestrial animals, including humans. The characteristics of the received sound stimuli are used and compared to the animal's hearing sensitivity and susceptibility to noise (Box A3) to determine the potential for auditory fatigue.

Auditory fatigue manifests itself as hearing loss, called a noise-induced threshold shift. A threshold shift may be either permanent threshold shift (PTS), or temporary threshold shift (TTS). Note that the term "auditory fatigue" is often used to mean a TTS; however, in this analysis, a more general meaning to differentiate fatigue mechanisms (e.g., metabolic exhaustion and distortion of tissues) from auditory trauma mechanisms (e.g., physical destruction of cochlear tissues occurring at the time of exposure) is used.

The distinction between PTS and TTS is based on whether there is a complete recovery of hearing sensitivity following a sound exposure. If the threshold shift eventually returns to zero (the animal's hearing returns to pre-exposure value), the threshold shift is a TTS. If the threshold shift does not return to zero but leaves some finite amount of threshold shift, then that remaining threshold shift is a PTS. Figure 6-7 shows one hypothetical threshold shift that completely recovers, a TTS, and one that does not completely recover, leaving some PTS.

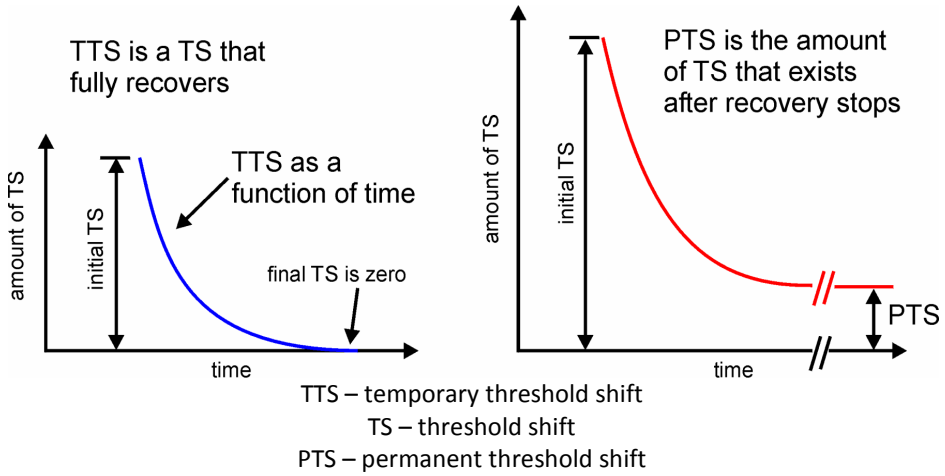

Figure 6-2. Two Hypothetical Threshold Shifts

The relationship between TTS and PTS is complicated and poorly understood, even in humans and terrestrial mammals, where numerous studies failed to delineate a clear relationship between the two. Relatively small amounts of TTS (e.g., less than 40–50 dB measured 2 minutes after exposure) will recover with no apparent long-term effects; however, terrestrial mammal studies revealed that large amounts of TTS (e.g., approximately 40 dB measured 24 hours after exposure) can result in permanent neural degeneration, despite the hearing thresholds returning to normal (Kujawa and Liberman 2009). The amounts of TTS induced by Kujawa and Liberman were described as being "at the limits of reversibility." It is unknown whether smaller amounts of TTS can result in similar neural degeneration, or if effects would translate to other species such as marine animals.

The amplitude, frequency, duration, and temporal pattern of the sound exposure are important parameters for predicting the potential for auditory fatigue. Duration is particularly important because auditory fatigue is exacerbated with prolonged exposure time. The frequency of the sound also plays an important role in susceptibility to hearing loss. Experiments show that animals are most susceptible to fatigue (Box B3) within their most sensitive hearing range. Sounds outside of an animal's audible frequency range do not cause fatigue.

The greater the degree of threshold shift, the smaller the ocean space within which an animal can detect biologically relevant sounds and communicate. This is referred to as reducing an animal's "acoustic space." This reduction can be estimated given the amount of threshold shift incurred by an animal.

6.1.1.6 Auditory Masking

Auditory masking occurs if the noise from an activity interferes with an animal's ability to detect, understand, or recognize biologically relevant sounds of interest (Box B4). "Noise" refers to unwanted or unimportant sounds that mask an animal's ability to hear "sounds of interest." A sound of interest refers to a sound that is potentially being detected. Sounds of interest include those from conspecifics such as offspring, mates, and competitors; echolocation clicks; sounds from predators; natural, abiotic sounds that may aid in navigation; and reverberation, which can give an animal information about its location and orientation within the ocean.

The frequency, received level, and duty cycle of the sound determine the potential degree of auditory masking. Similar to hearing loss, the greater the degree of masking, the smaller the ocean space within which an animal can detect biologically relevant sounds.

6.1.1.7 Physiological Stress

If a sound is detected (i.e., heard or sensed) by an animal, a stress response can occur (Box B7); or the sound can cue or alert the animal (Box B6) without a direct, measurable stress response. If an animal suffers trauma or auditory fatigue, a physiological stress response will occur (Box B8). A stress response is a physiological change resulting from a stressor that is meant to help the animal deal with the stressor. The generalized stress response is characterized by a release of hormones (Reeder and Kramer 2005); however, it is now acknowledged that other chemicals produced in a stress response (e.g., stress markers) exist. For example, a release of reactive oxidative compounds, as occurs in noise-induced hearing loss (Henderson et al. 2006), occurs in response to some acoustic stressors. Stress hormones include those produced by the sympathetic nervous system, norepinephrine and epinephrine (i.e., the catecholamines), which produce elevations in the heart and respiration rate, increase awareness, and increase the availability of glucose and lipid for energy. Other stress hormones are the glucocorticoid steroid hormones cortisol and aldosterone, which are produced by the adrenal gland. These hormones are classically used as an indicator of a stress response and to characterize the magnitude of the stress response (Hennessy et al. 1979). Oxidative stress occurs when reactive molecules, called reactive oxygen species, are produced in excess of molecules that counteract their activity (i.e., antioxidants).

An acute stress response is traditionally considered part of the startle response and is hormonally characterized by the release of the catecholamines. Annoyance type reactions may be characterized by the release of either or both catecholamines and glucocorticoid hormones. Regardless of the physiological changes that make up the stress response, the stress response may contribute to an animal's decision to alter its behavior. Alternatively, a stimulus may not cause a measurable stress response but may act as an alert or cue to an animal to change its behavior. This response may occur because of learned associations; the animal may have experienced a stress reaction in the past to similar sounds or activities (Box C4), or it may have learned the response from conspecifics. The severity of the stress response depends on the received sound level at the animal (Box A2); the details of the sound-producing activity (Box A1); the animal's life history stage (e.g., juvenile or adult; breeding or feeding season) (Box B5); and the animal's past experience with the stimuli (Box B5). These factors will be subject to individual variation, as well as variation within an individual over time.

An animal's life history stage is an important factor to consider when predicting whether a stress response is likely (Box B5). An animal's life history stage includes its level of physical maturity (i.e., larva, infant, juvenile, sexually mature adult) and the primary activity in which it is engaged such as mating, feeding, or rearing/caring for young. Animals engaged in a critical life activity such as mating or feeding may have a lesser stress response than an animal engaged in a more flexible activity such as resting or migrating (i.e., an activity that does not necessarily depend on the availability of resources). The animal's past experiences with the stimuli or similar stimuli are another important consideration. Prior experience with a stressor may be of particular importance because repeated experience with a stressor may dull the stress response via acclimation (St.Aubin and Dierauf 2001) or increase the response via sensitization.

6.1.1.8 Behavioral Responses

Any number of behavioral responses can result from a physiological response. An animal "decides" how it will behave in response to the stimulus based on a number of factors in addition to the severity of the

physiological response. An animal's experience with the sound (or similar sounds), the context of the acoustic exposure, and the presence of other stimuli contribute to determining its reaction from a suite of possible behaviors.

Behavioral responses fall into two major categories: alterations in natural behavior patterns and avoidance. These types of reactions are not mutually exclusive, and many overall reactions may be combinations of behaviors or a sequence of behaviors. Severity of behavioral reactions can vary drastically between minor and brief reorientations of the animal to investigate the sound, to severe reactions such as aggression or prolonged flight. The type and severity of the behavioral response will determine the cost to the animal.

6.1.1.9 Trauma and Auditory Fatigue

Direct trauma and auditory fatigue increases the animal's physiological stress (Box B8), which feeds into the stress response (Box B7). Direct trauma and auditory fatigue increase the likelihood or severity of a behavioral response and increase an animal's overall physiological stress level (Box D10).

6.1.1.10 Auditory Masking

A behavior decision is made by the animal when the animal detects increased background noise, or possibly when the animal recognizes that biologically relevant sounds are being masked (Box C1). An animal's past experience with the sound -producing activity or similar acoustic stimuli can affect its choice of behavior during auditory masking (Box C4). Competing and reinforcing stimuli may also affect its decision (Box C5).

An animal can choose a passive behavioral response when coping with auditory masking (Box C2). It may simply not respond and keep conducting its current natural behavior. An animal may also decide to stop calling until the background noise decreases. These passive responses do not present a direct energetic cost to the animal; however, auditory masking will continue, depending on the acoustic stimuli.

An animal can choose to actively compensate for auditory masking (Box C3). An animal can vocalize more loudly to make its signal heard over the masking noise. An animal may also shift the frequency of its vocalizations away from the frequency of the masking noise. This shift can actually reduce the masking effect for the animal and other animals that are "listening" in the area. For example, in marine mammals, vocalization changes have been reported from exposure to anthropogenic noise sources such as sonar, vessel noise, and seismic surveying. Changes included mimicry of the sound, cessation of vocalization, increases and decreases in vocalization length, increases and decreases in vocalization rate, and increases in vocalization frequency and level, while other animals showed no significant changes in the presence of anthropogenic sound.

An animal's past experiences can be important in determining what behavior decision it may make when dealing with auditory masking (Box C4). Past experience can be with the sound-producing activity itself or with similar acoustic stimuli. For example, an animal may learn over time the best way to modify its vocalizations to reduce the effects of masking noise.

Other stimuli present in the environment can influence an animal's behavior decision (Box C5). These stimuli can be other acoustic stimuli not directly related to the sound-producing activity; they can be visual, olfactory, or tactile stimuli; the stimuli can be conspecifics or predators in the area; or the stimuli can be the strong drive to engage in a natural behavior. Competing stimuli tend to suppress any potential behavioral reaction. For example, an animal involved in mating or foraging may not react with

the same degree of severity as it may have otherwise. Reinforcing stimuli reinforce the behavioral reaction caused by acoustic stimuli. For example, awareness of a predator in the area coupled with the acoustic stimuli may illicit a stronger reaction than the acoustic stimuli itself otherwise would have. The visual stimulus of seeing ships and aircraft, coupled with the acoustic stimuli, may also increase the likelihood or severity of a behavioral response.

6.1.1.11 Behavioral Reactions and Physiological Stress

A physiological stress response (Box B7) such as an annoyance or startle reaction, or a cueing or alerting reaction (Box B6) may cause an animal to make a behavior decision (Box C6). Any exposure that produces an injury or auditory fatigue is also assumed to produce a stress response (Box B7) and increase the severity or likelihood of a behavioral reaction. Both an animal's past experience (Box C4) and competing and reinforcing stimuli (Box C5) can affect an animal's behavior decision. The decision can result in three general types of behavioral reactions: no response (Box C9), area avoidance (Box C8), or alteration of a natural behavior (Box C7).

Little data exist that correlate specific behavioral reactions with specific stress responses. Therefore, in practice the likely range of behavioral reactions is estimated from the acoustic stimuli instead of the magnitude of the stress response. It is assumed that a stress response must exist to alter a natural behavior or cause an avoidance reaction. Estimates of the types of behavioral responses that could occur for a given sound exposure can be determined from the literature.

An animal’s past experiences can be important in determining what behavior decision it may make when dealing with a stress response (Box C4). Past experience can be with the sound-producing activity itself or with similar sound stimuli. Habituation is the process by which an animal learns to ignore or tolerate stimuli over some period of time and return to a normal behavior pattern, perhaps after being exposed to the stimuli with no negative consequences. A habituated animal may have a lesser behavioral response than the first time it encountered the stimuli. Sensitization is when an animal becomes more sensitive to a set of stimuli over time, perhaps as a result of a past, negative experience with the stimuli or similar stimuli. A sensitized animal may have a stronger behavioral response than the first time it encountered the stimuli.

Other stimuli (Box C5) present in the environment can influence an animal’s behavior decision (Box C6). These stimuli can be other acoustic stimuli not directly related to the sound-producing activity, such as visual stimuli; the stimuli can be conspecifics or predators in the area, or the stimuli can be the strong drive to engage or continue in a natural behavior. Competing stimuli tend to suppress any potential behavioral reaction. For example, an animal involved in mating or foraging may not react with the same degree of severity as an animal involved in less-critical behavior. Reinforcing stimuli reinforce the behavioral reaction caused by acoustic stimuli. For example, the awareness of a predator in the area coupled with the acoustic stimuli may elicit a stronger reaction than the acoustic stimuli themselves otherwise would have.

The visual stimulus of seeing human activities such as ships and aircraft maneuvering, coupled with the acoustic stimuli, may also increase the likelihood or severity of a behavioral response. It is difficult to separate the stimulus of the sound from the stimulus of the ship or platform creating the sound. The sound may act as a cue, or as one stimulus of many that the animal is considering when deciding how to react. An activity with several platforms (e.g., ships and aircraft) may elicit a different reaction than an activity with a single platform, both with similar acoustic footprints. The total number of vehicles and

platforms involved, the size of the activity area, and the distance between the animal and activity are important considerations when predicting behavioral responses.

An animal may reorient or become more vigilant if it detects a sound-producing activity (Box C7). Some animals may investigate the sound using other sensory systems (e.g., vision), and perhaps move closer to the sound source. Reorientation, vigilance, and investigation all require the animal to divert attention and resources and therefore slow or stop their presumably beneficial natural behavior. This can be a very brief diversion, after which the animal continues its natural behavior, or an animal may not resume its natural behaviors until after a longer period when the animal has habituated to the sound or the activity has concluded. An attentional change via an orienting response represents behaviors that would be considered mild disruption. More severe alterations of natural behavior would include aggression or panic.

An animal may choose to leave or avoid an area where a sound-producing activity is taking place (Box C8). Avoidance is the displacement of an individual from an area. A more severe form of this comes in the form of flight or evasion. A flight response is a dramatic change in normal movement to a directed and rapid movement away from the detected location of a sound source. Avoidance of an area can help the animal avoid further acoustic effects by avoiding or reducing further exposure.

An animal may choose not to respond to a sound-producing activity (Box C9). The physiological stress response may not rise to the level that would cause the animal to modify its behavior. The animal may have habituated to the sound or simply learned through past experience that the sound is not a threat. In this case a behavioral effect would not be predicted. An animal may choose not to respond to a sound-producing activity in spite of a physiological stress response. Some combination of competing stimuli may be present such as a robust food patch or a mating opportunity that overcomes the stress response and suppresses any potential behavioral responses. If the noise-producing activity persists over long periods or reoccurs frequently, the acute stress felt by animals could increase their overall chronic stress levels.

6.1.1.12 Costs to the Animal

The potential costs to a marine animal from an involuntary or behavioral response include no measurable cost, expended energy reserves, increased stress, reduced social contact, missed opportunities to secure resources or mates, displacement, and stranding or severe evasive behavior (which may potentially lead to secondary trauma or death). Animals suffer costs on a daily basis from a host of natural situations such as dealing with predator or competitor pressure. If the costs to the animal from an acoustic-related effect fall outside of its normal daily variations, then individuals must recover from significant costs to avoid long-term consequences.

6.1.1.13 Trauma

Trauma or injury to an animal may reduce its ability to secure food by reducing its mobility or the efficiency of its sensory systems, make the injured individual less attractive to potential mates, or increase an individual's chances of contracting diseases or falling prey to a predator (Box D2). A severe trauma can lead to the death of the individual (Box D1).

6.1.1.14 Auditory Fatigue and Auditory Masking

Auditory fatigue and masking can impair an animal's ability to hear biologically important sounds (Box D3), especially fainter and distant sounds. Sounds could belong to conspecifics such as other individuals

in a social group (i.e., pod, school, etc.), potential mates, potential competitors, or parents/offspring. Biologically important sounds could also be an animal's own biosonar echoes used to detect prey, predators, and the physical environment. Therefore, auditory masking or a hearing loss could reduce an animal's ability to contact social groups, offspring, or parents; and reduce opportunities to detect or attract more distant mates. Animals may also use sounds to gain information about their physical environment by detecting the reverberation of sounds in the underwater space or sensing the sound of crashing waves on a nearby shoreline. These cues could be used by some animals to migrate long distances or navigate their immediate environment. Therefore, an animal's ability to navigate may be impaired if the animal uses acoustic cues from the physical environment to help identify its location. Auditory masking and fatigue both effectively reduce the animal's acoustic space and the ocean volume in which detection and communication are effective.

An animal that modifies its vocalization in response to auditory masking could incur a cost (Box D4). Modifying vocalizations may cost the animal energy from its finite energy budget. Additionally, shifting the frequency of a call can make an animal appear to be less-fit to conspecifics. Animals that are larger are typically capable of producing lower-frequency sounds than smaller conspecifics. Therefore, lower-frequency sounds are usually an indicator of a larger and presumably more fit and experienced potential mate.

Auditory masking or auditory fatigue may also lead to no measurable costs for an animal. Masking could be of short duration or intermittent such that biologically important sounds that are continuous or repeated are received by the animal between masking noise. Auditory fatigue could also be inconsequential for an animal if the frequency range affected is not critical for that animal to hear within, or the auditory fatigue is of such short duration (e.g. a few minutes) that there are no costs to the individual.

6.1.1.15 Behavioral Reactions and Physiological Stress

An animal that alters its natural behavior in response to stress or an auditory cue may slow or cease its presumably beneficial natural behavior and instead expend energy reacting to the sound-producing activity (Box D5). Beneficial natural behaviors include feeding, breeding, sheltering, and migrating. The cost of feeding disruptions depends on the energetic requirements of individuals and the potential amount of food missed during the disruption. Alteration in breeding behavior can result in delaying reproduction. The costs of a brief interruption to migrating or sheltering are less clear. Most behavior alterations also require the animal to expend energy for a nonbeneficial behavior. The amount of energy expended depends on the severity of the behavioral response.

An animal that avoids a sound-producing activity may expend additional energy moving around the area, be displaced to poorer resources, miss potential mates, or have social interactions affected (Box D6). Avoidance reactions can cause an animal to expend energy. The amount of energy expended depends on the severity of the behavioral response. Missing potential mates can result in delaying reproduction. Social groups or pairs of animals, such as mates or parent/offspring pairs, could be separated during a severe behavioral response such as flight. Offspring that depend on their parents may die if they are permanently separated. Splitting up an animal group can result in a reduced group size, which can have secondary effects on individual foraging success and susceptibility to predators.

Some severe behavioral reactions can lead to stranding (Box D7) or secondary trauma (Box D8). Animals that take prolonged flight, a severe avoidance reaction, may injure themselves or strand in an environment for which they are not adapted. Some trauma is likely to occur to an animal that strands

(Box D8). Trauma can reduce the animal's ability to secure food and mates, and increase the animal's susceptibility to predation and disease (Box D2). An animal that strands and does not return to a hospitable environment quickly will likely die (Box D9).

Elevated stress levels may occur whether or not an animal exhibits a behavioral response (Box D10). Even while undergoing a stress response, competing stimuli (e.g., food or mating opportunities) may overcome an animal's initial stress response during the behavior decision. Regardless of whether the animal displays a behavioral reaction, this tolerated stress could incur a cost to the animal. Reactive oxygen species produced during normal physiological processes are generally counterbalanced by enzymes and antioxidants; however, excess stress can result in an excess production of reactive oxygen species, leading to damage of lipids, proteins, and nucleic acids at the cellular level (Berlett and Stadtman 1997{Sies, 1997 #108; Touyz 2004)

6.1.1.16 Recovery

The predicted recovery of the animal (Box E1) is based on the cost of any masking or behavioral response and the severity on any involuntary physiological reactions (e.g., direct trauma, hearing loss, or increased chronic stress). Many effects are fully recoverable upon cessation of the sound-producing activity, and the vast majority of effects are completely recoverable over time; whereas a few effects may not be fully recoverable. The availability of resources and the characteristics of the animal play a critical role in determining the speed and completeness of recovery.

Available resources fluctuate by season, location, and year and can play a major role in an animal's rate of recovery (Box E2). Plentiful food can aid in a quicker recovery, whereas recovery can take much longer if food resources are limited. If many potential mates are available, an animal may recover quickly from missing a single mating opportunity. Refuge or shelter is also an important resource that may give an animal an opportunity to recover or repair after an incurred cost or physiological response.

An animal's health, energy reserves, size, life history stage, and resource gathering strategy affect its speed and completeness of recovery (Box E3). Animals that are in good health and have abundant energy reserves before an effect will likely recover more quickly. Adult animals with stored energy reserves (e.g., fat reserves) may have an easier time recovering than juveniles that expend their energy growing and developing and have less in reserve. Large individuals and large species may recover more quickly, also due to having more potential for energy reserves. Animals that gather and store resources, perhaps fasting for months during breeding or offspring rearing seasons, may have a more difficult time recovering from being temporarily displaced from a feeding area than an animal that feeds year round.

Damaged tissues from mild to moderate trauma may heal over time. The predicted recovery of direct trauma is based on the severity of the trauma, availability of resources, and characteristics of the animal. After a sustained injury an animal's body attempts to repair tissues. The animal may also need to recover from any potential costs due to a decrease in resource gathering efficiency and any secondary effects from predators or disease (Box E1). Moderate to severe trauma that does not cause mortality may never fully heal.

Small to moderate amounts of hearing loss may recover over a period of minutes to days, depending on the nature of the exposure and the amount of initial threshold shift. Severe noise-induced hearing loss may not fully recover, resulting in some amount of permanent hearing loss.

Auditory masking only occurs when the sound source is operating; therefore, direct masking effects stop immediately upon cessation of the sound-producing activity (Box E1). Natural behaviors may resume shortly after or even during the acoustic stimulus after an initial assessment period by the animal. Any energetic expenditures and missed opportunities to find and secure resources incurred from masking or a behavior alteration may take some time to recover.

Animals displaced from their normal habitat due to an avoidance reaction may return over time and resume their natural behaviors, depending on the severity of the reaction and how often the activity is repeated in the area. In areas of repeated and frequent acoustic disturbance, some animals may habituate to the new baseline or fluctuations in noise level. More sensitive species, or animals that may have been sensitized to the stimulus over time due to past negative experiences, may not return to an area. Other animals may return but not resume use of the habitat in the same manner as before the acoustic-related effect. For example, an animal may return to an area to feed or navigate through it to get to another area, but that animal may no longer seek that area as refuge or shelter.

Frequent milder physiological responses to an individual may accumulate over time if the time between sound-producing activities is not adequate to give the animal an opportunity to fully recover. An increase in an animal's chronic stress level is also possible if stress caused by a sound-producing activity does not return to baseline between exposures. Each component of the stress response is variable in time, and stress hormones return to baseline levels at different rates. For example, adrenaline is released almost immediately and is used or cleared by the system quickly, whereas glucocorticoid and cortisol levels may take long periods (i.e., hours to days) to return to baseline.

6.1.1.17 Long-Term Consequences to the Individual and the Population

The magnitude and type of effect and the speed and completeness of recovery must be considered in predicting long-term consequences to the individual animal and its population (Box E4). Animals that recover quickly and completely from explosive or acoustic-related effects will likely not suffer reductions in their health or reproductive success, or experience changes in habitat utilization (Box F2). No population-level effects would be expected if individual animals do not suffer reductions in their lifetime reproductive success or change their habitat utilization (Box G2).

Animals that do not recover quickly and fully could suffer reductions in their health and lifetime reproductive success; they could be permanently displaced or change how they utilize the environment; or they could die (Box F1). Severe injuries can lead to reduced survivorship (longevity), elevated stress levels, and prolonged alterations in behavior that can reduce an animal's lifetime reproductive success. An animal with decreased energy stores or a lingering injury may be less successful at mating for one or more breeding seasons, thereby decreasing the number of offspring produced over its lifetime.

An animal whose hearing does not recover quickly and fully could suffer a reduction in lifetime reproductive success (Box F1). An animal with decreased energy stores or a PTS may be less successful at mating for one or more breeding seasons, thereby decreasing the number of offspring it can produce over its lifetime.

As mentioned above, the involuntary reaction of masking ends when the acoustic stimuli conclude. The direct effects of auditory masking could have long-term consequences for individuals if the activity was continuous or occurred frequently enough; however, most of the proposed training and testing activities are normally spread over vast areas and occur infrequently in a specific area.

Missed mating opportunities can have a direct effect on reproductive success. Reducing an animal's energy reserves over longer periods can directly reduce its health and reproductive success. Some species may not enter a breeding cycle without adequate energy stores, and animals that do breed may have a decreased probability of offspring survival. Animals displaced from their preferred habitat, or utilize it differently, may no longer have access to the best resources. Some animals that leave or flee an area during a noise-producing activity, especially an activity that is persistent or frequent, may not return quickly or at all. This can further reduce an individual's health and lifetime reproductive success.

Frequent disruptions to natural behavior patterns may not allow an animal to fully recover between exposures, which increases the probability of causing long-term consequences to individuals. Elevated chronic stress levels are usually a result of a prolonged or repeated disturbance. Excess stress produces reactive molecules in an animal's body that can result in cellular damage (Berlett and Stadtman 1997{Sies, 1997 #108; Touyz 2004). Chronic elevations in the stress levels (e.g., cortisol levels) may produce long-term health consequences that can reduce in lifetime reproductive success.

These long-term consequences to the individual can lead to consequences for the population (Box G1). Population dynamics and abundance play a role in determining how many individuals would need to suffer long-term consequences before there was an effect on the population (Box G1). Long-term abandonment or a change in the utilization of an area by enough individuals can change the distribution of the population. Death has an immediate effect in that no further contribution to the population is possible, which reduces the animal's lifetime reproductive success.

Carrying capacity describes the theoretical maximum number of animals of a particular species that the environment can support. When a population nears its carrying capacity, the lifetime reproductive success in individuals may decrease due to finite resources or predator-prey interactions. Population growth is naturally limited by available resources and predator pressure. If one, or a few animals, in a population are removed or gather fewer resources, then other animals in the population can take advantage of the freed resources and potentially increase their health and lifetime reproductive success. Abundant populations that are near their carrying capacity (theoretical maximum abundance) that suffer effects on a few individuals may not be affected overall.

Populations that are reduced well below their carrying capacity may suffer greater consequences from any lasting effects on even a few individuals. Population-level consequences can include a change in the population dynamics, a decrease in the growth rate, or a change in geographic distribution. Changing the dynamics of a population (the proportion of the population within each age/growth) or their geographic distribution can also have secondary effects on population growth rates.

6.1.2 Analysis Background and Framework

The acoustic stressors that are estimated to result in Level B harassment, Level A harassment, or mortality of marine mammals in the Study Area include the following:

- Sonar and other active sound sources (non-impulsive sources)- Level A and Level B
- Explosives (impulsive sources)- Mortality, Level A, and Level B
- Pile driving and removal (impulsive sources)- Level A and Level B

In this analysis, marine mammal species are grouped together based on similar biology (such as hearing) or behaviors (such as feeding or expected reaction to stressors) when most appropriate for the discussion. In addition, for some stressors, species are grouped based on their taxonomic relationship

and discussed as follows: mysticetes (baleen whales), odontocetes (toothed whales), and pinnipeds (seals).

Methods used to predict acoustic effects on marine mammals build on the Conceptual Framework for Assessing Effects from Sound Producing Activities (Section 6.1.2). Additional research specific to marine mammals is presented where available.

6.1.2.1 Direct Injury

The potential for direct injury to marine mammals is inferred from terrestrial mammal experiments and from post-mortem examination of marine mammals believed to have been exposed to underwater explosions (Ketten et al. 1993; Richmond et al. 1973b; Yelverton et al. 1973a). Additionally, non-injurious effects on marine mammals are extrapolated to injurious effects based on data from terrestrial mammals to estimate the potential for injury (Southall et al. 2007a). Actual effects on marine mammals may differ due to anatomical and physiological adaptations to the marine environment; e.g., some characteristics such as a reinforced trachea and flexible thoracic cavity (Ridgway and Dailey 1972) may or may not decrease the risk of lung injury.

Potential direct injury from non-impulsive sound sources, such as sonar, is unlikely due to lower peak pressures and slower rise times than potentially injurious sources such as explosives. Non-impulsive sources lack the strong shock wave associated with an explosion. Therefore, primary blast injury and barotrauma (i.e., injuries caused by large, rapid pressure changes) would not occur due to exposure to non-impulsive sources such as sonar. The theories of sonar-induced acoustic resonance and bubble formation are discussed below. Although these phenomena are feasible under extreme, controlled laboratory conditions, they are difficult to replicate in the natural environment and are, therefore, unlikely to occur.

6.1.2.2 Primary Blast Injury and Barotrauma

The greatest potential for direct, non-auditory tissue effects is primary blast injury and barotrauma after exposure to high amplitude impulsive sources, such as explosions. Primary blast injury refers to those injuries that result from the initial compression of a body exposed to a blast wave. Primary blast injury is usually limited to gas-containing structures (e.g., lung and gut) and the auditory system (Craig and Hearn 1998a; Craig Jr. 2001; Phillips and Richmond 1990). Barotrauma refers to injuries caused when large pressure changes occur across tissue interfaces, normally at the boundaries of air-filled tissues such as the lungs. Primary blast injury to the respiratory system, as measured in terrestrial mammals, may consist of lung contusions (lung bruises), pneumothorax (collapsed lung), pneumomediastinum (air in the chest between the lungs), traumatic lung cysts, or interstitial or subcutaneous emphysema (collection of air outside of the lungs) (Phillips and Richmond 1990). These injuries may be fatal, depending on the severity of the trauma. Rupture of the lung may introduce air into the vascular system, possibly producing air emboli that can cause a stroke or heart attack by restricting oxygen delivery to these organs. Though often secondary in life-threatening severity to pulmonary blast trauma, the gastrointestinal tract can also suffer contusions (bruises) and lacerations (cuts) from blast exposure, particularly in air-containing regions of the tract. Potential traumas include hematoma (collection of blood outside of a blood vessel), bowel perforation, mesenteric tears, and ruptures of the hollow abdominal viscera (organs). Although hemorrhage of solid organs (e.g., liver, spleen, and kidney) from blast exposure is possible, rupture of these organs is rarely encountered.

The only known occurrence of mortality or injury to a marine mammal due to a U.S. Navy training or testing event involving impulsive sources occurred in March 2011, when a group of long-beaked

common dolphins entered the 640-m mitigation zone surrounding an explosive with a net explosive weight of 8.75 lb (3.97 kg) set at a depth of 48 feet, approximately 0.5-0.75 nm from shore. One minute after detonation, three animals were observed at the surface, and a fourth animal stranded 42.3 miles (68 km) to the north of the detonation site three days later. Upon necropsy, all four animals were found to have sustained typical mammalian primary blast injuries (Danil and St. Ledger 2011).

6.1.2.3 Auditory Trauma

Relatively little is known about auditory system trauma in marine mammals resulting from a known sound exposure. A single study spatially and temporally correlated the occurrence of auditory system trauma in humpback whales with the detonation of a 5,000 kg (11,023 lb.) explosive (Ketten et al. 1993). The exact magnitude of the exposure in this study cannot be determined, but it is likely the trauma was caused by the shock wave produced by the explosion. There are no known occurrences of direct auditory trauma in marine mammals exposed to tactical sonars or other non-impulsive sound sources. The potential for auditory trauma in marine mammals exposed to impulsive sources (e.g., explosions) is inferred from tests of submerged terrestrial mammals exposed to underwater explosions (Ketten et al. 1993; Richmond et al. 1973b; Yelverton et al. 1973a).

6.1.2.4 Acoustic Resonance

In 2002, NMFS convened a panel of government and private scientists to address the issue of mid-frequency sonar-induced resonance of gas-containing structures (Evans 2002). It modeled and evaluated the likelihood that Navy mid-frequency sonar caused resonance effects in beaked whales that eventually led to their stranding (U.S. Department of Commerce and U.S. Department of the Navy 2001). The conclusions of that group were that resonance in air-filled structures was not likely to have caused a mass stranding event in the Bahamas in 2000 (Evans 2002). The frequencies at which resonance was predicted to occur were below the frequencies used by the mid-frequency sonar systems associated with the Bahamas event. Furthermore, air cavity vibrations were not considered to be of sufficient magnitude to cause tissue damage, even at the worst-case resonant frequencies that would lead to the greatest vibratory response. These same conclusions would apply to other training and testing activities involving acoustic sources. Therefore, the Navy concludes that acoustic resonance leading to tissue damage is not likely under realistic conditions during training and testing, and this type of impact is not considered further in this analysis.

6.1.2.5 Bubble Formation

A suggested indirect cause of injury to marine mammals is rectified diffusion (Crum and Mao 1996), the process of increasing the size of a bubble by exposing it to a sound field. The process depends on many factors, including the sound pressure level and duration. Under this hypothesis, microscopic bubbles assumed to exist in the tissues of marine mammals may experience one of three things: (1) bubbles grow to the extent that tissue hemorrhage (injury) occurs; (2) bubbles develop to the extent that an immune response is triggered or nervous system tissue is subjected to enough localized pressure that pain or dysfunction occurs (a stress response without injury); or (3) the bubbles are cleared by the lung without negative consequence to the animal. The probability of rectified diffusion, or any other indirect tissue effect, will necessarily be based on what is known about the specific process involved. Rectified diffusion is facilitated if the environment in which the ensonified bubbles exist is supersaturated with gas. Repetitive diving by marine mammals can cause the blood and some tissues to accumulate nitrogen gas to a greater degree than is supported by the surrounding environmental pressure (Ridgway and Howard 1979). The dive patterns of some marine mammals (for example, beaked whales) are theoretically predicted to induce greater nitrogen gas supersaturation (Houser et al. 2001). If rectified

diffusion were possible in marine mammals exposed to a high level of sound, conditions of tissue supersaturation could theoretically speed the rate and increase the size of bubble growth. Subsequent effects due to tissue trauma and emboli would presumably mirror those observed in humans suffering from decompression sickness (e.g., nausea, disorientation, localized pain, breathing problems, etc.).

It is unlikely that the short duration of sonar or explosion sounds would last long enough to drive bubble growth to any substantial size, if such a phenomenon occurs. However, an alternative but related hypothesis is also suggested: stable microbubbles could be destabilized by high-level sound exposures so bubble growth would occur through static diffusion of gas out of the tissues. In such a scenario, the marine mammal would need to be in a gas-supersaturated state for a long enough time for bubbles to become a problematic size. Recent research with ex vivo supersaturated bovine tissues suggests that for a 37 kHz signal, a sound exposure of approximately 215 dB re 1 µPa would be required before microbubbles became destabilized and grew (Crum et al. 2005). Assuming spherical spreading loss and a nominal sonar source level of 235 dB re 1 µPa, a whale would need to be within 33 ft. (10 m) of the sonar dome to be exposed to such sound levels. Furthermore, tissues in the study were supersaturated by exposing them to pressures of 400 to 700 kiloPascals (kPa) for periods of hours and then releasing them to ambient pressures. Assuming the equilibration of gases with the tissues occurred when the tissues were exposed to the high pressures, levels of supersaturation in the tissues could have been as high as 400 to 700 percent. These levels of tissue supersaturation are substantially higher than model predictions for marine mammals (Houser et al. 2001). It is improbable that this mechanism would be responsible for stranding events or traumas associated with beaked whale strandings. Both the degree of supersaturation and exposure levels observed to cause microbubble destabilization are unlikely to occur, either alone or in concert.

There is considerable disagreement among scientists as to the likelihood of bubble formation in diving marine mammals (Evans and Miller 2003; Piantadosi and Thalmann 2004). Although it has been argued that traumas from recent beaked whale strandings are consistent with gas emboli and bubble-induced tissue separations (Fernández et al. 2005; Jepson et al. 2003b), nitrogen bubble formation as the cause of the traumas has not been verified. The presence of bubbles postmortem, particularly after decompression, is not necessarily indicative of bubble pathology. Prior experimental work demonstrates that the postmortem presence of bubbles following decompression in laboratory animals can occur as a result of invasive investigative procedures (Stock et al. 1980). Also, variations in diving behavior or avoidance responses can possibly result in nitrogen tissue supersaturation and nitrogen off-gassing, possibly to the point of deleterious vascular bubble formation (Jepson et al. 2003b). The mechanism for bubble formation would be different from rectified diffusion, but the effects would be similar. Although hypothetical, the potential process is under debate in the scientific community. The hypothesis speculates that if exposure to a startling sound elicits a rapid ascent to the surface, tissue gas saturation sufficient for the evolution of nitrogen bubbles might result (Fernández et al. 2005; Jepson et al. 2003b). In this scenario, the rate of ascent would need to be sufficiently rapid to compromise behavioral or physiological protections against nitrogen bubble formation.

Recent modeling suggests that even unrealistically rapid rates of ascent from normal dive behaviors are unlikely to result in supersaturation to the extent that bubble formation would be expected in beaked whales (Zimmer and Tyack 2007). Tyack et al. (Tyack et al. 2006) suggested that emboli observed in animals exposed to mid-frequency active sonar (Fernández et al. 2005; Jepson et al. 2003b) could stem instead from a behavioral response that involves repeated dives, shallower than the depth of lung collapse. A bottlenose dolphin was trained to repetitively dive to specific depths to elevate nitrogen saturation to the point that asymptomatic nitrogen bubble formation was predicted to occur. However,

inspection of the vascular system of the dolphin via ultrasound did not demonstrate the formation of any nitrogen gas bubbles (Houser et al. 2009).

More recently, modeling has suggested that the long, deep dives performed regularly by beaked whales over a lifetime could result in the saturation of long-halftime tissues (e.g. fat, bone lipid) to the point that they are supersaturated when the animals are at the surface (Hooker et al. 2009). Proposed adaptations for prevention of bubble formation under conditions of persistent tissue saturation have been suggested (Fahlman et al. 2006; Hooker et al. 2009), while the condition of supersaturation required for bubble formation has been demonstrated in bycatch animals drowned at depth and brought to the surface (Moore et al. 2009). Since bubble formation is facilitated by compromised blood flow, it has been suggested that rapid stranding may lead to bubble formation in animals with supersaturated, long-halftime tissues because of the stress of stranding and the cardiovascular collapse that can accompany it (Houser et al. 2009).

A fat embolic syndrome was identified by Fernández et al. (2005) coincident with the identification of bubble emboli in stranded beaked whales. The fat embolic syndrome was the first pathology of this type identified in marine mammals, and was thought to possibly arise from the formation of bubbles in fat bodies, which subsequently resulted in the release of fat emboli into the blood stream. Recently, Dennison et al. (2011) reported on investigations of dolphins stranded in 2009-2010 and, using ultrasound, identified gas bubbles in kidneys of 21 of 22 live-stranded dolphins and in the liver of two of 22. The authors postulated that stranded animals are unable to recompress by diving, and thus may retain bubbles that are otherwise re-absorbed in animals that can continue to dive. The researchers concluded that the minor bubble formation observed can be tolerates since the majority of stranded dolphins released did not re-strand. As a result, no marine mammals addressed in this analysis are given differential treatment due to the possibility for acoustically mediated bubble growth.

6.1.2.6 Hearing Loss

The most familiar effect of exposure to high intensity sound is hearing loss, meaning an increase in the hearing threshold. This phenomenon is called a noise-induced threshold shift, or simply a threshold shift (Miller 1974). The distinction between permanent threshold shift (PTS) and temporary threshold shift (TTS) is based on whether there is complete recovery of a threshold shift following a sound exposure. If the threshold shift eventually returns to zero (the threshold returns to the pre-exposure value), the threshold shift is a TTS. The recovery to pre-exposure threshold from studies of marine mammals is usually on the order of minutes to hours for the small amounts of TTS induced (Finneran et al. 2005a; Nachtigall et al. 2004). The recovery time is related to the exposure duration, sound exposure level, and the magnitude of the threshold shift, with larger threshold shifts and longer exposure durations requiring longer recovery times (Finneran et al. 2005a; Mooney et al. 2009a). If the threshold shift does not return to zero but leaves some finite amount of threshold shift, then that remaining threshold shift is a PTS. Figure 6-2 shows one hypothetical threshold shift that completely recovers, a TTS, and one that does not completely recover, leaving some PTS. The actual amount of threshold shift depends on the amplitude, duration, frequency, temporal pattern of the sound exposure, and on the susceptibility of the individual animal.

Although both auditory trauma and fatigue may result in hearing loss, the mechanisms responsible for auditory fatigue differ from auditory trauma and would primarily consist of metabolic fatigue and exhaustion of the hair cells and cochlear tissues. The term “auditory fatigue” is often used to mean “TTS”; however, in this analysis the Navy uses a more general meaning to differentiate between fatigue

mechanisms (e.g., metabolic exhaustion and distortion of tissues) and trauma mechanisms (e.g., physical destruction of cochlear tissues occurring at the time of exposure).

Hearing loss due to auditory fatigue in marine mammals was studied by numerous investigators (Kastak et al. 2007; Mann et al. 2010; Popov et al. 2011; Southall et al. 2007b)(Finneran et al. 2010a, b; Finneran et al. 2005a; Finneran and Schlundt 2010; Finneran et al. 2007; Finneran et al. 2000; Finneran et al. 2002a; Lucke et al. 2009; Mooney et al. 2009a; Mooney et al. 2009b; Nachtigall et al. 2003; Nachtigall et al. 2004; Schlundt et al. 2000). The studies of marine mammal auditory fatigue were all designed to determine relationships between TTS and exposure parameters such as level, duration, and frequency. In these studies, hearing thresholds were measured in trained marine mammals before and after exposure to intense sounds. The difference between the pre-exposure and post-exposure thresholds indicates the amount of TTS. Species studied include the bottlenose dolphin (total of nine individuals), beluga (2), harbor porpoise (1), finless porpoise (2), California sea lion (3), harbor seal (1), and northern elephant seal (1). Some of the more important data obtained from these studies are onset-TTS levels– exposure levels sufficient to cause a just-measurable amount of TTS, often defined as 6 dB of TTS (for example Schlundt et al. 2000).

Primary findings of the marine mammal TTS studies discussed above (unless otherwise cited) are:

- The growth and recovery of TTS are analogous to those in terrestrial mammals. This means that, as in terrestrial mammals, threshold shifts primarily depend on the amplitude, duration, frequency content, and temporal pattern of the sound exposure.
- The amount of TTS increases with exposure sound pressure level and the exposure duration.
- For continuous sounds, exposures of equal energy lead to approximately equal effects (Ward 1997). For intermittent sounds, less hearing loss occurs than from a continuous exposure with the same energy (some recovery will occur during the quiet period between exposures) (Kryter et al. 1965; Ward 1997).
- The Sound Exposure Level is correlated with the amount of TTS and is a good predictor for onset-TTS from single, continuous exposures with similar durations. This agrees with human TTS data presented by Ward et al. (1958; 1959a). However, for longer duration sounds, beyond 16 – 32 seconds, the relationship between TTS and sound exposure levels breaks down and duration becomes a more important contributor to TTS (Finneran et al. 2010a).
- The maximum TTS after tonal exposures occurs one-half to one octave above the exposure frequency (Finneran et al. 2007; Schlundt et al. 2000). Thus, TTS from tonal exposures can extend over a large (greater than one octave) frequency range.
- For bottlenose dolphins, non-impulsive sounds with frequencies above 10 kHz are more hazardous than those at lower frequencies (i.e., lower sound exposure levels required to affect hearing) (Finneran and Schlundt 2010).
- The amount of observed TTS tends to decrease at differing rates following noise exposure; however, the relationship is not monotonic. The amount of time required for complete recovery of hearing depends on the magnitude of the initial shift; for relatively small shifts, recovery may be complete in a few minutes, while large shifts (e.g., 40 dB) require several days for recovery.
- TTS can accumulate across multiple exposures, but the resulting TTS will be less than the TTS from a single, continuous exposure with the same sound exposure level. This means that

predictions based on total, cumulative sound exposure level will overestimate the amount of TTS from intermittent exposures.

Although there have been no marine mammal studies designed to measure PTS, the potential for PTS in marine mammals can be estimated based on known similarities between the inner ears of marine and terrestrial mammals. Experiments with marine mammals have revealed similarities to terrestrial mammals for features such as TTS, age-related hearing loss, ototoxic drug-induced hearing loss, masking, and frequency selectivity. Therefore, in the absence of marine mammal PTS data, onset-PTS exposure levels may be estimated by assuming some upper limit of TTS that equates to the onset of PTS, then using TTS growth relationships from marine and terrestrial mammals to determine the exposure levels capable of producing this amount of TTS.

Hearing loss resulting from auditory fatigue could effectively reduce the distance over which animals can communicate, detect biologically relevant sounds such as predators, and echolocate (for odontocetes). The costs to marine mammals with TTS, or even some degree of PTS, have not been studied; however, it is likely that a relationship between the duration, magnitude, and frequency range of hearing loss could have consequences to biologically important activities (e.g., intraspecific communication, foraging, and predator detection) that affect survivability and reproduction.

6.1.2.7 Auditory Masking

As with hearing loss, auditory masking can effectively limit the distance over which a marine mammal can communicate, detect biologically relevant sounds, and echolocate (odontocetes). Unlike auditory fatigue, which always results in a localized stress response, behavioral changes resulting from auditory masking may not be coupled with a stress response. Another important distinction between masking and hearing loss is that masking only occurs in the presence of the sound stimulus, whereas hearing loss can persist after the stimulus is gone.

Critical ratios, the lowest ratio of signal-to-noise at which a signal can be detected, were determined for pinnipeds (Southall et al. 2000; Southall et al. 2003). Detections of signals under varying masking conditions were determined for active echolocation and passive listening tasks in odontocetes (Au and Pawloski 1989; Erbe 2000; Johnson 1971). These studies provide baseline information from which the probability of masking can be estimated. Clark et al. (Clark et al. 2009) developed a method for estimating masking effects on communication signals for low-frequency cetaceans, including calculating the cumulative impact of multiple noise sources. For example, their technique calculates that in Stellwagen Bank National Marine Sanctuary, when two commercial vessels pass through a right whale's optimal communication space (estimated as a sphere of water with a diameter of 10.8 nm [20 km]), that space is decreased by 84 percent. This method relies on empirical data on source levels of calls (which is unknown for many species) and requires many assumptions about ancient ambient noise conditions and simplifications of animal behavior, but it is an important step in determining the impact of anthropogenic noise on animal communication.

Vocal changes in response to anthropogenic noise can occur across the repertoire of sound production modes used by marine mammals, such as whistling, echolocation click production, calling, and singing. Vocalization changes may result from a need to compete with an increase in background noise. In cetaceans, vocalization changes were reported from exposure to anthropogenic noise sources such as sonar, vessel noise, and seismic surveying.

In the presence of low-frequency active sonar, humpback whales were observed to increase the length of their "songs" (Fristrup et al. 2003; Miller et al. 2000), possibly due to the overlap in frequencies between the whale song and the low-frequency active sonar. Right whales were observed to shift the frequency content of their calls upward while reducing the rate of calling in areas of increased anthropogenic noise (Parks et al. 2007) as well as increasing the amplitude (intensity) of their calls (Parks 2009). In contrast, both sperm and pilot whales potentially ceased sound production during the Heard Island feasibility test, with transmissions centered at 57 Hz at up to 220 dB re 1 µPa (Bowles et al. 1994), although it cannot be absolutely determined whether the inability to acoustically detect the animals was due to the cessation of sound production or the displacement of animals from the area.

Differential vocal responses in marine mammals were documented in the presence of seismic survey noise. An overall decrease in vocalization during active surveying was noted in large marine mammal groups (Potter et al. 2007), while blue whale feeding/social calls increased when seismic exploration was underway (Di lorio and Clark 2010), indicative of a compensatory response to the increased noise level. As noted previously, Melcon et al. (2012) recently documented blue whales decreased the proportion of time spent producing D calls when mid-frequency sonar was present. At present it is not known if these changes in vocal behavior corresponded to changes in foraging or any other behaviors

Evidence suggests that at least some marine mammals have the ability to acoustically identify potential predators. For example, harbor seals that reside in the coastal waters off British Columbia are frequently targeted by certain groups of killer whales, but not others. The seals discriminate between the calls of threatening and non-threatening killer whales (Deecke et al. 2002), a capability that should increase survivorship while reducing the energy required for attending to and responding to all killer whale calls.

The occurrence of masking or hearing impairment provides a means by which marine mammals may be prevented from responding to the acoustic cues produced by their predators. Whether this is a possibility depends on the duration of the masking/hearing impairment and the likelihood of encountering a predator during the time that predator cues are impeded.

6.1.2.8 Physiological Stress

Marine mammals naturally experience stressors within their environment and as part of their life histories. Changing weather and ocean conditions, exposure to diseases and naturally occurring toxins, lack of prey availability, social interactions with members of the same species, and interactions with predators all contribute to the stress a marine mammal experiences. In some cases, naturally occurring stressors can have profound impacts on marine mammals; for example, chronic stress, as observed in stranded animals with long-term debilitating conditions (e.g., disease), was demonstrated to result in an increased size of the adrenal glands and an increase in the number of epinephrine-producing cells (Clark et al. 2006). Anthropogenic activities have the potential to provide additional stressors beyond those that occur naturally. Although sample sizes are small, the data collected to date suggest that different types of sounds potentially cause variable degrees of stress in marine mammals. Belugas demonstrated no catecholamine (hormones released in situations of stress) response to the playback of oil drilling sounds (Thomas et al. 1990b) but showed an increase in catecholamines following exposure to impulsive sounds produced from a seismic water gun (Romano et al. 2004). A bottlenose dolphin exposed to the same seismic water gun signals did not demonstrate a catecholamine response, but did demonstrate an elevation in aldosterone, a hormone suggested as being a significant indicator of stress in odontocetes (St.Aubin and Dierauf 2001; St.Aubin and Geraci 1989). Increases in heart rate were observed in bottlenose dolphins to which conspecific calls were played, although no increase in heart rate was observed when tank noise was played back (Miksis et al. 2001). Collectively, these results suggest a

variable response that depends on the characteristics of the received signal and prior experience with the received signal.

Other types of stressors include the presence of vessels, fishery interactions, acts of pursuit and capture, the act of stranding, and pollution. In contrast to the limited amount of work performed on stress responses resulting from sound exposure, a considerably larger body of work exists on stress responses associated with pursuit, capture, handling and stranding. Many cetaceans exhibit an apparent vulnerability in the face of these particular situations when taken to the extreme. A recent study compared pathological changes in organs/tissues of odontocetes stranded on beaches or captured in nets over a 40-year period (Cowan and Curry 2008). The type of changes observed indicate harm to multiple systems caused in part by an overload of catecholamines into the system, as well as a restriction in blood supply capable of causing tissue damage or tissue death. This extreme response to a major stressor(s) is thought to be mediated by the overactivation of the animal's normal physiological adaptations to diving or escape. Pursuit, capture, and short-term holding of belugas resulted in a decrease in thyroid hormones (St.Aubin and Geraci 1988) and increases in epinephrine (St.Aubin and Dierauf 2001). In bottlenose dolphins, the trend is more complicated with the duration of the handling time potentially contributing to the magnitude of the stress response (Ortiz and Worthy 2000; St.Aubin 2002; St.Aubin et al. 1996). Male gray seals subjected to capture and short-term restraint showed an increase in cortisol levels accompanied by an increase in testosterone (Lidgard et al. 2008). This result may be indicative of a compensatory response that enables the seal to maintain reproduction capability in spite of stress. Elephant seals demonstrate an acute cortisol response to handling but do not demonstrate a chronic response; on the contrary, adult females demonstrate a reduction in the adrenocortical response following repetitive chemical immobilization (Engelhard et al. 2002). Similarly, no correlation between cortisol levels and heart or respiration rate changes were seen in harbor porpoises during handling for satellite tagging (Eskesen et al. 2009). Taken together, these studies illustrate the wide variations in the level of response that can occur when faced with these stressors.

Factors to consider when trying to predict a stress or cueing response include the mammal's life history stage and whether they are naïve or experienced with the sound. Prior experience with a stressor may be of particular importance as repeated experience with a stressor may dull the stress response via acclimation (St.Aubin and Dierauf 2001).

The sound characteristics that correlate with specific stress responses in marine mammals are poorly understood. Therefore, in practice, a stress response is assumed if a physiological reaction such as a hearing loss or trauma is predicted; or if a significant behavioral response is predicted.

6.1.2.9 Behavioral Reactions

The response of a marine mammal to an anthropogenic sound will depend on the frequency, duration, temporal pattern and amplitude of the sound as well as the animal's prior experience with the sound and the context in which the sound is encountered (i.e., what the animal is doing at the time of the exposure). The distance from the sound source and whether it is perceived as approaching or moving away can also affect the way an animal responds to a sound (Wartzok et al. 2003). For marine mammals, a review of responses to anthropogenic sound was first conducted by Richardson and others (Richardson et al. 1995b). More recent reviews (Nowacek et al. 2007; Southall et al. 2007b) address studies conducted since 1995 and focus on observations where the received sound level of the exposed marine mammal(s) was known or could be estimated.

Except for some vocalization changes in response to auditory masking, all behavioral reactions are assumed to occur due to a preceding stress or cueing response; however, stress responses cannot be predicted directly due to a lack of scientific data (see preceding section). Responses can overlap; for example, an increased respiration rate is likely to be coupled to a flight response. Differential responses between and within species are expected since hearing ranges vary across species and the behavioral ecologies of individual species are unlikely to completely overlap.

Southall et al. (Southall et al. 2007b) synthesized data from many past behavioral studies and observations to determine the likelihood of behavioral reactions at specific sound levels. While in general, the louder the sound source the more intense the behavioral response, it was clear that the proximity of a sound source and the animal's experience, motivation, and conditioning were also critical factors influencing the response (Southall et al. 2007b). After examining all of the available data, the authors felt that the derivation of thresholds for behavioral response based solely on exposure level was not supported because context of the animal at the time of sound exposure was an important factor in estimating response. Nonetheless, in some conditions, consistent avoidance reactions were noted at higher sound levels depending on the marine mammal species or group allowing conclusions to be drawn. Most low-frequency cetaceans (mysticetes) observed in studies usually avoided sound sources at levels of less than or equal to 160 dB re 1 µPa. Published studies of mid-frequency cetaceans analyzed include sperm whales, belugas, bottlenose dolphins, and river dolphins. These groups showed no clear tendency, but for non-impulsive sounds, captive animals tolerated levels in excess of 170 dB re 1 µPa before showing behavioral reactions, such as avoidance, erratic swimming, and attacking the test apparatus. High-frequency cetaceans (observed from studies with harbor porpoises) exhibited changes in respiration and avoidance behavior at levels between 90 and 140 dB re 1 µPa, with profound avoidance behavior noted for levels exceeding this. Phocid seals showed avoidance reactions at or below 190 dB re 1 µPa; thus, seals may actually receive levels adequate to produce TTS before avoiding the source. Recent studies with beaked whales have shown them to be particularly sensitive to noise, with animals during three playbacks of sound breaking off foraging dives at levels below 142 dB sound pressure level, although acoustic monitoring during actual sonar exercises revealed some beaked whales continuing to forage at levels up to 157 dB sound pressure level (Tyack et al. 2011).

6.1.2.10 Behavioral Reactions to Sonar and other Active Acoustic Sources

6.1.2.11 Mysticetes

Specific to U.S. Navy systems using low-frequency sound, studies were undertaken in 1997–98 pursuant to the Navy's Low-Frequency Sound Scientific Research Program. These studies found only short-term responses to low-frequency sound by mysticetes (fin, blue, and humpback whales), including changes in vocal activity and avoidance of the source vessel (Clark and Fristrup 2001; Croll et al. 2001; Fristrup et al. 2003; Miller et al. 2000; Nowacek et al. 2007). Baleen whales exposed to moderate low-frequency signals demonstrated no variation in foraging activity (Croll et al. 2001). However, five out of six North Atlantic right whales exposed to an acoustic alarm interrupted their foraging dives, although the alarm signal was long in duration, lasting several minutes, and purposely designed to elicit a reaction from the animals as a prospective means to protect them from ship strikes (Nowacek et al. 2004a). Although the animal's received sound pressure level was similar in the latter two studies (133–150 dB sound pressure level), the frequency, duration, and temporal pattern of signal presentation were different. Additionally, the right whales did not respond to playbacks of either right whale social sounds or vessel noise, highlighting the importance of the sound characteristics, species differences, and individual sensitivity in producing a behavioral reaction.

Low-frequency signals of the Acoustic Thermometry of Ocean Climate sound source were not found to affect dive times of humpback whales in Hawaiian waters (Frankel and Clark 2000) or to overtly affect elephant seal dives (Costa et al. 2003). However, they did produce subtle effects that varied in direction and degree among the individual seals, again illustrating the equivocal nature of behavioral effects and consequent difficulty in defining and predicting them.

Blue whales exposed to mid-frequency sonar in the Southern California Bight were less likely to produce low frequency calls usually associated with feeding behavior (Melcón et al. 2012). It is not known whether the lower rates of calling actually indicated a reduction in feeding behavior or social contact since the study used data from remotely deployed, passive acoustic monitoring buoys. In contrast, blue whales increased their likelihood of calling when ship noise was present, and decreased their likelihood of calling in the presence of explosive noise, although this result was not statistically significant (Melcón et al. 2012). Additionally, the likelihood of an animal calling decreased with the increased received level of mid-frequency sonar, beginning at a sound pressure level of approximately 110 to 120 dB re 1 µPa (Melcón et al. 2012). Preliminary results from the 2010–2011 field season of the ongoing behavioral response study in southern California waters indicated that in some cases and at low received levels, tagged blue whales responded to mid-frequency sonar but that those responses were mild and there was a quick return to their baseline activity (Southall et al. 2011). These preliminary findings from Melcón et al. (2012) and Southall et al. (2011) are consistent with the Navy's criteria and thresholds for predicting behavioral effects to mysticetes (including blue whales) from sonar and other active acoustic sources used in the quantitative acoustic effects analysis (see Section 6.1.6, Quantitative Analysis below). The behavioral risk function predicts a probability of a substantive behavioral reaction for individuals exposed to a received sound pressure level of 120 dB re 1µPa or greater, with an increasing probability of reaction with increased received level as demonstrated in Melcón et al. (2012).

6.1.2.12 Odontocetes

From 2007 to 2011, behavioral response studies were conducted through the collaboration of various research organizations in the Bahamas, Southern California, the Mediterranean, Cape Hatteras, and Norwegian waters. These studies attempted to define and measure responses of beaked whales and other cetaceans to controlled exposures of sonar and other sounds to better understand their potential impacts. Results from the 2007–2008 study conducted near the Bahamas showed a change in diving behavior of an adult Blainville's beaked whale to playback of mid-frequency source and predator sounds (Boyd et al. 2008; Tyack et al. 2011). Reaction to mid-frequency sounds included premature cessation of clicking and termination of a foraging dive, and a slower ascent rate to the surface. Preliminary results from a similar behavioral response study in southern California waters have been presented for the 2010–2011 field season (Southall et al. 2011). Cuvier's beaked whale responses suggested particular sensitivity to sound exposure as consistent with results for Blainville's beaked whale. Similarly, beaked whales exposed to sonar during British training exercises stopped foraging (DSTL 2007), and preliminary results of controlled playback of sonar may indicate feeding/foraging disruption of killer whales and sperm whales (Miller et al. 2011).

In the 2007–2008 Bahamas study, playback sounds of a potential predator–a killer whale–resulted in a similar but more pronounced reaction, which included longer inter-dive intervals and a sustained straight-line departure of more than 20 km from the area. The authors noted, however, that the magnified reaction to the predator sounds could represent a cumulative effect of exposure to the two sound types since killer whale playback began approximately 2 hours after mid-frequency source playback. Pilot whales and killer whales off Norway also exhibited horizontal avoidance of a transducer with outputs in the mid-frequency range (signals in the 1 kHz – 2 kHz and 6 kHz to 7 kHz ranges) (Miller

et al. 2011). Additionally, separation of a calf from its group during exposure to mid-frequency sonar playback was observed (Miller et al. 2011). In contrast, preliminary analyses suggest that none of the pilot whales or false killer whales in the Bahamas showed an avoidance response to controlled exposure playbacks (Southall et al. 2009).

Through analysis of the behavioral response studies, a preliminary overarching effect of greater sensitivity to all anthropogenic exposures was seen in beaked whales compared to the other odontocetes studied (Southall et al. 2009). Therefore, recent studies have focused specifically on beaked whale responses to active sonar transmissions or controlled exposure playback of simulated sonar on various military ranges (Claridge and Durban 2009; DSTL 2007; McCarthy et al. 2011; Moretti et al. 2009; Tyack et al. 2011). In the Bahamas, Blainville's beaked whales located on the range will move off-range during sonar use and return only after the sonar transmissions have stopped, sometimes taking several days to do so (Claridge and Durban 2009; McCarthy et al. 2011; Moretti et al. 2009; Tyack et al. 2011).

In May 2003, killer whales in Haro Strait, Washington exhibited what were believed by some observers to be aberrant behaviors, which were observed while the USS Shoup was in the vicinity and engaged in mid-frequency active sonar operations. Sound fields modeled for the USS Shoup transmissions (U.S. Department of the Navy 2004; Fromm 2009; NMFS (Office of Protected Resources) 2005) estimated a mean received sound pressure level of approximately 169.3 dB re 1μPa at the location of the killer whales at the closest point of approach between the animals and the vessel (estimated sound pressure levels ranged from 150 to 180 dB re 1μPa).

Research on sperm whales near the Grenadines (Caribbean) in 1983 coincided with the U.S. intervention in Grenada, where animals were observed scattering and leaving the area in the presence of military sonar, presumably from nearby submarines (Watkins et al. 1985b; Watkins and Schevill 1975). The authors did not report received levels from these exposures and reported similar reactions from noise generated by banging on their boat hull. It was unclear if the sperm whales were reacting to the sonar signal itself or to a potentially new unknown sound in general. Additionally, sperm whales In the Caribbean stopped vocalizing when presented with sounds from nearby acoustic pingers (Watkins and Schevill 1975).

Researchers at the Navy's Marine Mammal Program facility in San Diego, California have conducted a series of controlled experiments on bottlenose dolphins and beluga whales to study TTS (Finneran et al. 2003a; Finneran et al. 2001; Finneran et al. 2005a; Finneran and Schlundt 2004; Schlundt et al. 2000). Ancillary to the TTS studies, scientists evaluated whether the marine mammals performed their trained tasks when prompted, during and after exposure to mid-frequency tones. Altered behavior during experimental trials usually involved refusal of animals to return to the site of the sound stimulus. This refusal included what appeared to be deliberate attempts to avoid a sound exposure or to avoid the location of the exposure site during subsequent tests (Finneran et al. 2002a; Schlundt et al. 2000). Bottlenose dolphins exposed to 1-second intense tones exhibited short-term changes in behavior above received sound levels of 178 to 193 dB re 1 μPa root mean square, and beluga whales did so at received levels of 180 to 196 dB re 1 μPa and above. In some instances, animals exhibited aggressive behavior toward the test apparatus (Ridgway et al. 1997; Schlundt et al. 2000). While these studies were generally not designed to test avoidance behavior and animals were commonly reinforced with food, the controlled environment and ability to measure received levels provide insight on received levels at which animals will behaviorally responds to noise sources.

Studies with captive harbor porpoises showed increased respiration rates upon introduction of acoustic alarms, such as those used on fishing nets to help deter marine mammals from becoming caught or entangled (Kastelein et al. 2006; Kastelein et al. 2001) and emissions for underwater data transmission (Kastelein et al. 2005c). However, exposure of the same acoustic alarm to a striped dolphin under the same conditions did not elicit a response (Kastelein et al. 2006), again highlighting the importance in understanding species differences in the tolerance of underwater noise.

6.1.2.13 Pinnipeds

Different responses displayed by captive and wild phocid seals to sound judged to be "unpleasant" have been reported; where captive seals habituated (did not avoid the sound), and wild seals showed avoidance behavior (Götz and Janik 2010). Captive seals received food (reinforcement) during sound playback, while wild seals were exposed opportunistically. These results indicate that motivational state (e.g., reinforcement via food acquisition) can be a factor in whether or not an animal habituates to novel or unpleasant sounds. Another study found that captive hooded seals reacted to 1–7 kHz sonar signals, in part with displacement to the areas of least sound pressure level, at levels between 160 and 170 dB re 1 µPa (Kvadsheim et al. 2010).

Captive studies with other pinnipeds have shown a reduction in dive times when presented with qualitatively unpleasant sounds. These studies indicated that the subjective interpretation of the pleasantness of a sound, as opposed to the more commonly studied factor of received sound level, can affect diving behavior (Götz and Janik 2010).

6.1.2.14 Behavioral Reactions to Impulsive Sound Sources

6.1.2.15 Mysticetes

Baleen whales have shown a variety of responses to impulsive sound sources, including avoidance, reduced surface intervals, altered swimming behavior, and changes in vocalization rates (Gordon et al. 2003; Richardson et al. 1995b; Southall et al. 2007b). While most bowhead whales did not show active avoidance until within 8 km of seismic vessels (Richardson et al. 1995b), some whales avoided vessels by more than 20 km at received levels as low as 120 dB re 1 µPa rms. Additionally, Malme et al. (1988) observed clear changes in diving and respiration patterns in bowheads at ranges up to 73 km from seismic vessels, with received levels as low as 125 dB re 1 µPa.

Gray whales migrating along the U.S. west coast showed avoidance responses to seismic vessels by 10 percent of animals at 164 dB re 1 µPa, and by 90 percent of animals at 190 dB re 1 µPa, with similar results for whales in the Bering Sea (Malme et al. 1988; Malme et al. 1986). In contrast, noise from seismic surveys was not found to impact feeding behavior or exhalation rates while resting or diving in western gray whales off the coast of Russia (Gailey et al. 2007; Yazvenko et al. 2007).

Humpback whales showed avoidance behavior at ranges of 5–8 km from a seismic array during observational studies and controlled exposure experiments in western Australia (McCauley et al. 1998). Todd et al. (1996) found no clear short-term behavioral responses by foraging humpbacks to explosions associated with construction operations in Newfoundland but did see a trend of increased rates of net entanglement and a shift to a higher incidence of net entanglement closer to the noise source.

Seismic pulses at average received levels of 131 dB re 1 µPa2s caused blue whales to increase call production (Di Iorio and Clark 2010). In contrast, McDonald et al. (1995) tracked a blue whale with seafloor seismometers and reported that it stopped vocalizing and changed its travel direction at a

range of 10 km from the seismic vessel (estimated received level 143 dB re 1 µPa peak-to-peak). These studies demonstrate that even low levels of noise received far from the noise source can induce behavioral responses.

6.1.2.16 Odontocetes

Madsen et al. (2006) and Miller et al. (2009) tagged and monitored eight sperm whales in the Gulf of Mexico exposed to seismic airgun surveys. Sound sources were from approximately 2 to 7 nm away from the whales, and based on multipath propagation, received levels were as high as 162 dB sound pressure level re 1 µPa with energy content greatest between 0.3 to 3.0 kHz (Madsen et al. 2006). The whales showed no horizontal avoidance, although the whale that was approached most closely had an extended resting period and did not resume foraging until the airguns had ceased firing (MIller et al. 2009). The remaining whales continued to execute foraging dives throughout exposure, however swimming movements during foraging dives were 6 percent lower during exposure than control periods, suggesting subtle effects of noise on foraging behavior (MIller et al. 2009). Captive bottlenose dolphins sometimes vocalized after an exposure to impulsive sound from a seismic watergun (Finneran et al. 2002a).

6.1.2.17 Pinnipeds

A review of behavioral reactions by pinnipeds to impulsive noise can be found in (Richardson et al. 1995b; Southall et al. 2007b). Blackwell et al. (2004) observed that ringed seals exhibited little or no reaction to pipe-driving noise with mean underwater levels of 157 dB re 1 µPa and in air levels of 112 dB re 20 µPa, suggesting that the seals had habituated to the noise. In contrast, captive California sea lions avoided sounds from an impulsive source at levels of 165-170 dB re 1 µPa (Finneran et al. 2003c).

Experimentally, Götz and Janik (Götz and Janik 2011) tested, underwater, startle responses to a startling sound (sound with a rapid rise time and a 93 dB sensation level [the level above the animal's threshold at that frequency]) and a nonstartling sound (sound with the same level, but with a slower rise time) in wild-captured gray seals. The animals exposed to the startling treatment avoided a known food source, whereas animals exposed to the nonstartling treatment did not react or habituated during the exposure period. The results of this study highlight the importance of the characteristics of the acoustic signal in an animal’s response of habituation.

6.1.2.18 Repeated Exposures

Repeated exposures of an individual to multiple sound-producing activities over a season, year, or life stage could cause reactions with costs that can accumulate over time to cause long-term consequences for the individual. Conversely, some animals habituate to or become tolerant of repeated exposures over time, learning to ignore a stimulus that in the past has not accompanied any overt threat.

Repeated exposure to acoustic and other anthropogenic stimuli has been studied in several cases, especially as related to vessel traffic and whale watching. Common dolphins in New Zealand responded to dolphin-watching vessels by interrupting foraging and resting bouts, and took longer to resume behaviors in the presence of the vessel (Stockin et al. 2008). The authors speculated that repeated interruptions of the dolphins' foraging behaviors could lead to long-term implications for the population. Bejder et al. (Bejder et al. 2006a) studied responses of bottlenose dolphins to vessel approaches and found stronger and longer lasting reactions in populations of animals that were exposed to lower levels of vessel traffic overall. The authors indicated that lesser reactions in populations of dolphins regularly

subjected to high levels of vessel traffic could be a sign of habituation, or it could be that the more sensitive animals in this population previously abandoned the area of higher human activity.

Marine mammals exposed to high levels of human activities may leave the area, habituate to the activity, or simply tolerate the disturbance. Marine mammals that are more tolerant may stay in a disturbed area, whereas individuals that are more sensitive may leave for areas with less human disturbance. Terrestrial examples of this abound as human disturbance and development displace more sensitive species, and tolerant animals move in to exploit the freed resources and fringe habitat. Longer-term displacement can lead to changes in abundance or distribution patterns of the species in the affected region if they do not become acclimated to the presence of the sound (Bejder et al. 2006c; Blackwell et al. 2004; Teilmann et al. 2006). Gray whales in Baja California abandoned a historical breeding lagoon in the mid-1960s due to an increase in dredging and commercial shipping operations. Whales did repopulate the lagoon after shipping activities had ceased for several years (Bryant et al. 1984). Over a shorter time scale, studies on the Atlantic Undersea Test and Evaluation Center instrumented range in the Bahamas have shown that some Blainville's beaked whales may be resident during all or part of the year in the area, and that individuals may move off of the range for several days during and following a sonar event. However animals are thought to continue feeding at short distances (a few kilometers) from the range out of the louder sound fields (less than 157 dB re 1 µPa) (McCarthy et al. 2011; Tyack et al. 2011). Mysticetes in the northeast tended to adjust to vessel traffic over a number of years, trending towards more neutral responses to passing vessels (Watkins 1986), indicating that some animals may habituate or otherwise learn to cope with high levels of human activity. Nevertheless, the long-term consequences of these habitat utilization changes are unknown, and likely vary depending on the species, geographic areas, and the degree of acoustic or other human disturbance.

6.1.2.19 Stranding

When a live or dead marine mammal swims or floats onto shore and becomes beached or incapable of returning to sea, the event is termed a stranding (Geraci et al. 1999; Geraci and Lounsbury 2005; Perrin and Geraci 2002). Animals outside of their “normal” habitat are also sometimes considered stranded even though they may not have beached themselves. The legal definition for a stranding within the United States is that: (A) a marine mammal is dead and is (i) on a beach or shore of the United States; or (ii) in waters under the jurisdiction of the United States (including any navigable waters); or (B) a marine mammal is alive and is (i) on a beach or shore of the United States and is unable to return to the water; (ii) on a beach or shore of the United States and, although able to return to the water, is apparently in need of medical attention; or (iii) in the waters under the jurisdiction of the United States (including any navigable waters), but is unable to return to its natural habitat under its own power or without assistance” (16 USC § 1421(h)).

Marine mammals are subjected to a variety of natural and anthropogenic factors, acting alone or in combination, which may cause a marine mammal to strand (Geraci et al. 1999; Geraci and Lounsbury 2005). Even for the fractions of more thoroughly investigated strandings involving post-stranding data collection and necropsies, the cause (or causes) for the majority of strandings remain undetermined. Natural factors related to strandings include, for example, the availability of food, predation, disease, parasitism, climatic influences, and aging (Bradshaw et al. 2006; Culik 2002; Geraci et al. 1999; Geraci and Lounsbury 2005; Hoelzel 2003; National Research Council (NRC) 2006; Perrin and Geraci 2002; Walker et al. 2005). Anthropogenic factors include, for example, pollution (Hall et al. 2006; Jepson et al. 2005), vessel strike (Geraci and Lounsbury 2005; Laist et al. 2001b), fisheries interactions (Read et al. 2006), entanglement, and noise.

Along the coasts of the continental United States and Alaska between 2001-2009, there were on average approximately 1,400 cetacean strandings and 4,300 pinniped strandings (5,700 total) per year (National Marine Fisheries Service 2011). Several mass strandings (strandings that involve two or more individuals of the same species, excluding a single cow-calf pair) that have occurred over the past two decades have been associated with naval operations, seismic surveys, and other anthropogenic activities that introduced sound into the marine environment. An in-depth discussion of strandings is presented in the Navy's Marine Mammal Strandings Associated with U.S. Navy Sonar Activities Technical Report. Sonar use during exercises involving U.S. Navy (most often in association with other nations' defense forces) has been identified as a contributing cause or factor in five specific mass stranding events: Greece in 1996; the Bahamas in March 2000; Madeira Island, Portugal in 2000; the Canary Islands in 2002, and Spain in 2006 (Marine Mammal Commission 2006b). These five mass strandings have resulted in about 40 known, scientifically verifiable sonar-related deaths among cetaceans consisting mostly of beaked whales (International Council for the Exploration of the Sea (ICES) 2005).
In these circumstances, exposure to non-impulsive acoustic energy has been considered a potential indirect cause of the death of marine mammals (Cox et al. 2006). One hypothesis is that strandings may result from tissue damage caused by "gas and fat embolic syndrome" (Fernández et al. 2005; Jepson et al. 2003b; Jepson et al. 2005). Models of nitrogen saturation in diving marine mammals have been used to suggest that altered dive behavior might result in the accumulation of nitrogen gas such that the potential for nitrogen bubble formation is increased (Houser et al. 2001; Zimmer and Tyack 2007). If so, this mechanism might explain the findings of gas and bubble emboli in stranded beaked whales. It is also possible that stranding is a behavioral response to a sound under certain conditions and that the subsequently observed physiological effects (e.g., overheating, decomposition, or internal hemorrhaging from being on shore) were the result of the stranding versus exposure to sonar (Cox et al. 2006).

As the International Council for the Exploration of the Sea (International Council for the Exploration of the Sea (ICES) 2005) noted, taken in context of marine mammal populations in general, sonar is not a major threat or a significant portion of the overall ocean noise budget. This has also been demonstrated by monitoring in areas where the Navy operates (Bassett et al. 2010; Baumann-Pickering et al. 2010; McDonald et al. 2006; Tyack et al. 2011). Regardless of the direct cause, the Navy considers potential sonar related strandings important and continues to fund research and work with scientists to better understand circumstances that may result in strandings.

During a Navy training event on 4 March 2011 at the Silver Strand Training Complex in San Diego, California, three or possibly four dolphins were killed in an explosion. During an underwater detonation training event, a pod of 100–150 long-beaked common dolphins were observed moving towards the 700-yard exclusion zone around the explosive charge, monitored by personnel in a safety boat and participants in a dive boat. Approximately 5 minutes remained on a time-delay fuse connected to a single 8.76 lb. explosive charge (C-4 and detonation cord). Although the dive boat was placed between the pod and the explosive in an effort to guide the dolphins away from the area, that effort was unsuccessful and three long-beaked common dolphins near the explosion died. In addition to the three dolphins found dead on 4 March 2011 at the event site, the remains of a fourth dolphin were discovered on 7 March 2011 near Ocean Beach, California (3 days later and approximately 11.8 mi. [19 km] from Silver Strand where the training event occurred), which might also have been related to this event. Association of the fourth stranding with the training event is uncertain because dolphins strand on a regular basis in the San Diego area. Details such as the dolphins' depth and distance from the explosive at the time of the detonation could not be estimated from the 250 yard (228.6 m) standoff point of the observers in the dive boat or the safety boat.

These dolphin mortalities are the only known occurrence of a U.S. Navy training or testing event involving impulse energy (underwater detonation) that caused mortality or injury to a marine mammal. Despite this being a rare occurrence, Navy has reviewed training requirements, safety procedures, and possible mitigation measures and implemented changes to reduce the potential for this to occur in the future. Discussions of procedures associated with these and other training and testing events are presented in Chapter 11 (Means of Effecting the Least Practicable Adverse Impacts – Mitigation Measures), which details all mitigations.

In comparison to potential strandings or injury resulting from events associated with Navy activities, marine mammal strandings and injury from commercial vessel ship strike, impacts from urban pollution, and annual fishery-related bycatch have been estimated to be orders of magnitude greater (hundreds of thousands of animals versus tens of animals) (Culik 2002; International Council for the Exploration of the Sea (ICES) 2005; Read et al. 2006). This does not negate the potential influence of mortality or additional stressors to small, regionalized sub-populations that may be at greater risk from human related impacts (fishing, vessel strike, and sound) than populations with larger distributions.

Long-Term Consequences for the Individual and the Population

Long-term consequences to a population are determined by examining changes in the population growth rate. Individual effects that could lead to a reduction in the population growth rate include mortality or injury (that removes animals from the reproductive pool), hearing loss (which depending on severity could impact navigation, foraging, predator avoidance, or communication), chronic stress (which could make individuals more susceptible to disease), displacement of individuals (especially from preferred foraging or mating grounds), and disruption of social bonds (due to masking of conspecific signals or displacement) (Section 6.1.2.1, Flowchart). However, the long-term consequences of any of these effects are difficult to predict because individual experience and time can create complex contingencies, especially for intelligent, long-lived animals like marine mammals. While a lost reproductive opportunity could be a “measurable” cost to the individual, the outcome for the animal, and ultimately the population, can range from insignificant to significant. Any number of factors, such as maternal inexperience, years of poor food supply, or predator pressure, could produce a cost of a lost reproductive opportunity, but these events may be “made up” during the life of a normal healthy individual. The same holds true for exposure to human-generated sound sources. These biological realities must be taken into consideration when assessing risk, uncertainties about that risk, and the feasibility of preventing or recouping such risks. All too often, the long-term consequence of relatively trivial events like short-term masking of a conspecific’s social sounds, or a single lost feeding opportunity, is exaggerated beyond its actual importance by focus on the single event and not the important variable, which is the individual and its lifetime parameters of growth, reproduction and survival.

The linkage between a stressor such as sound and its immediate behavioral or physiological consequences for the individual, and then the subsequent effects on that individual’s vital rates (growth, survival and reproduction), and the consequences, in turn, for the population have been reviewed in National Research Council (2005). The Population Consequences of Acoustic Disturbance model (National Research Council (NRC) 2005) proposes a quantitative methodology for determining how changes in the vital rates of individuals (i.e., a biologically significant consequence to the individual) translates into biologically significant consequences to the population. Population models are well known from many fields in biology including fisheries and wildlife management. These models accept inputs for the population size and changes in vital rates of the population such as the mean values for

survival age, lifetime reproductive success, and recruitment of new individuals into the population. The time-scale of the inputs in a population model for long-lived animals such as marine mammals is on the order of seasons, years, or life stages (e.g., neonate, juvenile, reproductive adult), and are often concerned only with the success of individuals from one time period or stage to the next. Unfortunately, for acoustic and explosive impacts on marine mammal populations, many of the inputs required by population models are not known.

The best assessment of long-term consequences from training and testing activities will be to monitor the populations over time within the Study Area. A recent U.S. workshop on Marine Mammals and Sound (Fitch et al. 2011) indicated a critical need for baseline biological data on marine mammal abundance, distribution, habitat, and behavior over sufficient time and space to evaluate impacts from human-generated activities on long-term population survival. The Navy has developed monitoring plans for protected marine mammals occurring on Navy ranges with the goal of assessing the impacts of training and testing activities on marine species and the effectiveness of the Navy's current mitigation practices. Results from intensive monitoring beginning in 2009 until mid-2012 by independent scientists and Navy observers in Southern California Range Complex and Hawaii Range Complex have observed over 256,000 marine mammals with no evidence of distress or unusual behavior observed during Navy activities. Continued monitoring efforts over time will be necessary to begin to evaluate the long-term consequences of exposure to noise sources.

6.1.3 Summary of Observations During Previous Navy Activities

The Navy, non-Navy marine mammal scientists, and research institutions have, since 2006, conducted scientific monitoring and research in and around ocean areas in the Atlantic and Pacific where Navy has been and proposes to continue training and testing. Data collected from Navy monitoring, scientific research findings, and annual reports provided to NMFS (as available at www.nmfs.noaa.gov/pr/permits/incidental.htm#applications) may be informative to the analysis of impacts to marine mammals for a variety of reasons, including species distribution, habitat use, and evaluating potential responses to Navy activities. Monitoring is performed using a variety of methods, including visual surveys from surface vessels and aircraft, as well as passive acoustics. Navy monitoring can generally be divided into two types of efforts: (1) collecting long-term data on distribution, abundance, and habitat use patterns within Navy activity areas, and (2) collecting data during individual training or testing activities. Navy also contributes to funding of basic research (as described in Chapter 14), including behavioral response studies specifically designed to determine the effects to marine mammals from the Navy's main mid-frequency surface ship ASW active acoustic (sonar) system.

The majority of the training and testing activities Navy is proposing for the next five years, are similar if not identical to activities that have been occurring in the same locations for decades. For example, the mid-frequency sonar system on the cruisers, destroyers, and frigates has the same sonar system components in the water as was first deployed in the 1970s. While the signal analysis and computing processes onboard these ships have been upgraded with modern technology, the power and output of the sonar transducer, which puts signals into the water, have not changed. For this reason, the history of past marine mammal observations, research, and monitoring reports remain applicable to the analysis of effects from the proposed future training and testing activities. In addition, because there is a longer (six year) record of monitoring Navy activities in the Pacific and because there is more available science specific to the areas where Navy has historically trained and tested in the HSTT Study Area), the research and monitoring record from the HSTT Study Area is informative with regard to assessing the effects of Navy training and testing in general.

In the HRC portion of the HSTT Study Area between 2006 and 2012, there were 21 scientific marine mammal surveys conducted before, during, or after major exercises. In the SOCAL and HRC portions of HSTT from 2009 to 2012, Navy-funded marine mammal monitoring research has completed over 5,000 hours of visual survey effort covering over 65,000 nautical miles, sighted over 256,000 individual marine mammals, taken over 45,600 digital photos and 36 hours of digital video, attached 70 satellite tracking tags to individual marine mammals, and collected over 40,000 hours of passive acoustic recordings. Navy also co-funded additional visual surveys conducted by the NMFS' Pacific Island Fisheries Science Center and Southwest Fisheries Science Center. Finally, there were an additional 1,532 sightings of an estimated 16,224 marine mammals made and reported by Navy lookouts aboard Navy ships within the HSTT from 2009 to 2012.

Based on this research, monitoring before, during, and after training and testing events since 2006, and the reports that have been submitted to and reviewed by NMFS, the Navy's assessment is that it is unlikely there will be impacts to populations of marine mammals (such as whales, dolphins and porpoise, seals and sea lions) having any long term consequences as a result of the proposed continuation of training and testing in the ocean areas historically used by the Navy.

This assessment of likelihood is based on four indicators from areas in the Pacific where Navy training and testing has been ongoing for decades; (1) evidence suggesting or documenting increases in the numbers of marine mammals present; (2) examples of documented presence and site fidelity of species and long-term residence by individual animals of some species; (3) use of training and testing areas for breeding and nursing activities; and (4) six years of comprehensive monitoring data indicating a lack of any observable effects to marine mammal populations as a result of Navy training and testing activities[12]. Citations to evidence indicative of increases and/or viability of marine mammal populations are not meant to suggest that Navy training and testing events are beneficial to marine mammals. There is, however, no direct evidence from HRC or SOCAL suggesting Navy training and testing has had or may have any long term consequences to marine mammals and therefore baring any evidence to the contrary, what limited and preliminary evidence there is should be considered. This is especially the case given the widespread public misperception that Navy training and testing, especially involving use of mid-frequency sonar, will cause countless numbers of marine mammals to be injured or die. Examples to the contrary where the Navy has conducted training and testing activities for decades include the following.

Work by Moore and Barlow (2011) indicate that since 1991, there is strong evidence of increasing fin whale abundance in the California Current area, which includes the SOCAL Range Complex. They predict continued increases in fin whale numbers over the next decade, and that perhaps fin whale densities are reaching "current ecosystem limits". For humpback whales that winter in the Hawaiian Islands, research has confirmed that the overall humpback whale population in the North Pacific has continued to increase and is now greater than some prior estimates of prewhaling abundance (Barlow et al 2011). The Hawaiian Islands, the location of the Hawaii Range Complex for decades, continue to function as a critical breeding, calving, and nursing area for this endangered species. In a similar manner, the beaches and shallow water areas within the Pacific Missile Range Facility (PMRF) at Kauai (in the main Hawaiian Islands) continue to be an important haul-out and nursing area for endangered Hawaiian Monk Seal. While there has been a decline in the population of Hawaiian monk seals in the northwestern Hawaiian

12 Monitoring of Navy activities began in July 2006 as a requirement under issuance of an Incidental Harassment Authorization by NMFS for the Rim of the Pacific exercise and has continued to the present for Major Training Events in the HRC and SOCAL as well as other monitoring as part of the coordinated efforts under the Navy's Integrated Comprehensive Monitoring Plan developed in coordination with NMFS and others.

Islands, in the main Hawaiian Islands the numbers have continued to increase (Littnan 2010); the main Hawaiian Islands is where the Navy trains and tests.

As increases in population would seem to indicate, evidence for the presence and/or residence of marine mammal individuals and populations would also seem to suggest a lack of long term or detrimental effects from Navy training and testing historically occurring in the same locations. For example, photographic records spanning more than two decades demonstrated there had been re-sightings of individual beaked whales (from two species; Cuvier's and Blainville's beaked whales) suggesting long-term site fidelity to the area west of the Island of Hawaii (McSweeney et al. 2007). This is specifically an area in the Hawaiian Islands where the Navy has been using mid-frequency sonar during anti-submarine warfare training (including relatively intense swept channel events) over many years. Similar findings of high site fidelity have been reported for this same area involving pygmy killer whales (*Feresa attenuata*) (McSweeney et al. 2009). Similarly, the intensively used instrumented range at PMRF remains the foraging area for a resident pod of spinner dolphins that was the focus for part of the RIMPAC 2006 monitoring effort. More recently at PMRF, Martin and Kok (2011) reported on the presence of minke whales, humpback whales, beaked whales, pilot whales, and sperm whales on or near the range during a Submarine Commander Course involving three surface ships and a submarine using MFA sonar over the span of the multiple day event. The analysis showed it was possible to evaluate the behavioral response of minke whale and found there did not appear to be a significant reaction by the minke whale to the MFA transmissions and the training activity in general did not appear to affect the presence of other detected species on or near the range.

In SOCAL, based on a series of surveys from 2006 to 2008 and the high number encounter rate, Falcone et al. (2009) proposed that their observations suggested the ocean basin west of San Clemente Island may be an important region for Cuvier's beaked whales. For over three decades, the ocean area west of San Clemente has been the location of the Navy's instrumented training range and is one of the most intensively used training and testing areas in the Pacific, given the proximity to the Naval installations in San Diego.

To reiterate, while the evidence is limited to a few species and only suggestive of the general viability of those species, there is no direct evidence that routine Navy training and testing spanning decades has negatively impacted those species. Therefore, based on the best available science, Navy believes that long-term consequences for individuals or populations are unlikely to result from Navy training and testing activities.

6.2 Thresholds and Criteria for Predicting Non-Impulsive and Impulsive Acoustic Impacts on Marine Mammals

If proposed Navy activities introduce sound or explosive energy into the marine environment, a quantitative estimate of effects to marine mammals is conducted. To do this, information about the numerical sound and energy levels that are likely to elicit certain types of physiological and behavioral reactions is needed.

6.2.1 Mortality and Injury from Explosions

There is a considerable body of laboratory data on injuries from impulsive sound exposure, usually from explosive pulses, obtained from tests with a variety of lab animals (mice, rats, dogs, pigs, sheep and other species). Onset mortality, onset slight lung injury, and onset slight gastrointestinal tract injury represent a series of effects with decreasing likelihood of serious injury or lethality. Primary impulse

injuries from explosive blasts are the result of differential compression and rapid re-expansion of adjacent tissues of different acoustic properties (e.g., between gas-filled and fluid-filled tissues or between bone and soft tissues). These injuries usually manifest themselves in the gas-containing organs (lung and gut) and auditory structures (e.g., rupture of the eardrum across the gas-filled spaces of the outer and inner ear) (Craig and Hearn 1998b; Craig Jr. 2001). Criteria and thresholds for predicting mortality and injury to marine mammals from explosions were initially developed for the U.S. Navy shock trials of the SEAWOLF submarine (Craig and Hearn 1998) and WINSTON S. CHURCHILL surface ship (Craig Jr. 2001). NMFS adopted these criteria and thresholds in several Final Rules issued under the Marine Mammal Protection Act (MMPA) (63 Federal Register [FR] 230; 66 FR 87; 73 FR 121; 73 FR 199). Similar criteria and thresholds also were used for the shock trial of the U.S. Navy amphibious transport dock ship MESA VERDE (Department of Navy 2008) and were subsequently adopted by NMFS in their MMPA Final Rule authorizing the MESA VERDE shock trial (National Marine Fisheries Service2008). Upper and lower frequency limits of hearing are not applied for lethal and injurious exposures. These criteria and their origins are explained in greater detail in the Navy's HSTT DEIS Thresholds and Criteria Technical Report.

Mortality and Slight Lung Injury- In air or submerged, the most commonly reported internal bodily injury was hemorrhaging in the fine structure of the lungs. Biological damage is governed by the impulse of the underwater blast (pressure integrated over time), not peak pressure or energy (Richmond et al. 1973; Yelverton et al. 1973; Yelverton et al. 1975; Yelverton and Richmond 1981). Therefore, impulse was used as a metric upon which internal organ injury could be predicted. Impulse (explosives) thresholds for onset mortality and slight lung injury are indexed to 75 and 93 lb. (34 and 42 kg) for mammals, respectively (Richmond et al. 1973). The regression curves based on these experiments were plotted, such that a prediction of mortality to larger animals could be determined as a function of impulse and mass (Craig Jr. 2001). After correction for atmospheric and hydrostatic pressures and based on the cube root scaling of body mass, as used in the Goertner injury model (Goertner 1982), the minimum impulse for predicting onset of extensive lung injury for "1 Percent Mortality" (defined as where most survivors had moderate blast injuries and should survive on their own) and slight lung injury for "0 Percent Mortality" (defined as no mortality, slight blast injuries) (Yelverton and Richmond 1981) were derived for each species. The Navy uses the minimum impulse level predictive of extensive lung injury, the exposure level likely to result in one percent mortality of animals in a population (99 percent would be expected to recover from the injury) as the onset of mortality. The scaling of lung volume to depth is conducted for all species, since data is from experiments with terrestrial animals held near the water's surface and marine mammals' gaseous cavities compress with depth making them less vulnerable to impulse injury. The received impulse that is necessary for mortality or slight lung injury must be delivered over a time period that is the lesser of the positive pressure duration or 20% of the natural period of the assumed-spherical lung adjusted for the size and depth of the animal. Therefore, as depth increases or animal size decreases, the impulse delivery time to experience an effect decreases (Goertner 1982a).

Species-specific calf masses are used for determining impulse-based thresholds because they most closely represent effects to individual species. *The Criteria and Thresholds for Navy Acoustic Effects Analysis Technical Report* (Finneran and Jenkins 2012) provides a nominal conservative body mass for each species based on newborn weights. In some cases, body masses were extrapolated from similar species rather than the listed species. Because the thresholds for onset of mortality and onset of slight lung injury are proportional to the cube root of body mass, the use of newborn, or calf, weights rather than representative adult weights results in an over-estimate of effects. The range to onset mortality for a newborn compared to an adult animal of the same species can range from less than twice to over four

times as far from an explosion, depending on the differences in calf versus adult sizes for a given species and the size of the explosion. Considering that injurious high pressures due to explosions propagate away from detonations in a roughly spherical manner, the volumes of water in which the threshold for onset mortality may be exceeded are generally less than a fifth for an adult animal versus a calf.

The use of onset mortality and onset slight lung injury is a conservative method to estimate potential mortality and recoverable (non-mortal, non-PTS) injuries. When analyzing impulse-based effects, all animals within the range to these thresholds are assumed to experience the effect. The onset mortality and onset slight lung injury criteria identify the impulse at which these effects are predicted for one percent of animals, and the portion of animals affected would increase closer to the explosion. Therefore, these criteria conservatively over-estimate the number of animals that could be killed or injured.

Onset of Gastrointestinal Tract Injury- Evidence indicates that gas-containing internal organs, such as lungs and intestines, were the principal damage sites from shock waves in submerged terrestrial mammals (Clark and Ward 1943; Greaves et al. 1943; Richmond et al. 1973; Yelverton et al. 1973). Furthermore, slight injury to the gastrointestinal tract may be related to the peak pressure of the shock wave and would be independent of the animal's size and mass (Goertner 1982). Slight contusions to the gastrointestinal tract were reported during small charge tests (Richmond et al. 1973), when the peak pressure was 237 dB re 1 µPa.

The Navy has elected to include the criterion in this analysis because there are instances where injury to the gastrointestinal tract could occur at a greater distance from the source than slight lung injury, especially near the surface. Gastrointestinal tract injury from small test charges (described as "slight contusions") was observed at peak pressure levels as low as 104 pounds per square inch (psi), equivalent to a sound pressure level of 237 dB re 1 µPa (Richmond et al. 1973). This criterion was previously used by Navy and NMFS for ship shock trials (U.S. Department of the Navy 1998, 2001, 2008) (National Marine Fisheries Service 63 FR 230; 66 FR 87; 73 FR 143).

Frequency Weighting- Frequency-weighting functions, called "M-weighting" functions, were proposed by Southall et al. (2007) to account for the frequency bandwidth of hearing in marine mammals. Frequency-weighting functions are used to adjust the received sound level based on the sensitivity of the animal to the frequency of the sound. The weighting functions de-emphasize sound exposures at frequencies to which marine mammals are not particularly sensitive. This effectively makes the acoustic thresholds frequency-dependent, which means they are applicable over a wide range of frequencies and therefore applicable for a wide range of sound sources. The Southall et al. (2007) M-weighting functions (hereafter called Type I functions) are nearly flat between the lower and upper cutoff frequencies, and thus were believed to represent a precautionary approach to assessing the effects of noise (Figure 6-3). These Type I functions are applied to the received sound level from sonar and other active sources before comparing the level to the Behavioral Response Function.

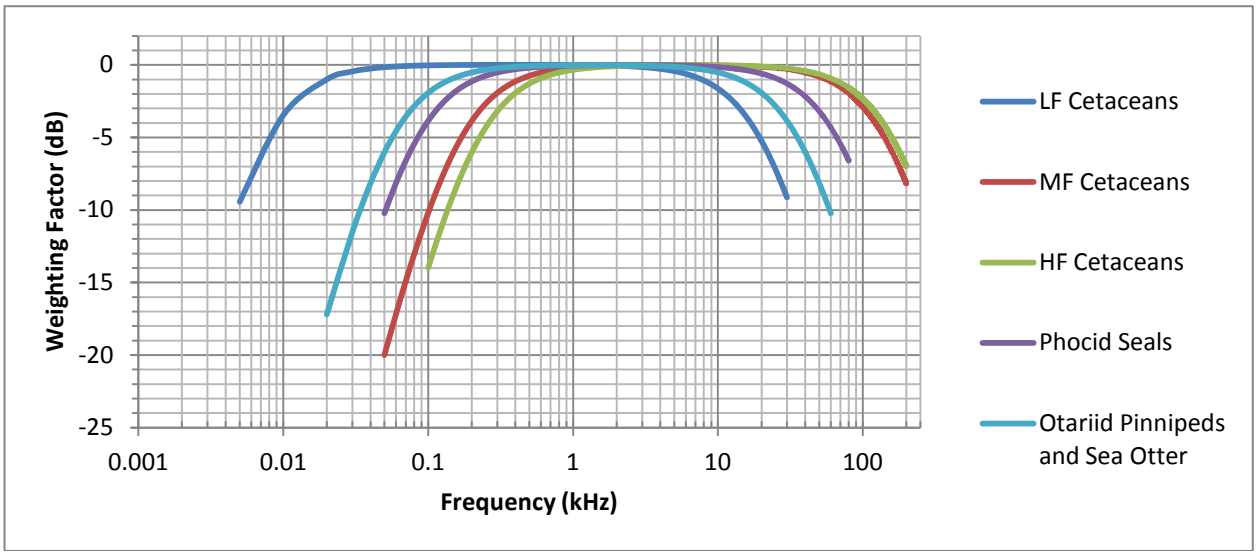

Figure 6-3: Marine Mammal Flat Auditory Weighting Functions Modified from Southall et al. (2007)

Two experiments conducted since 2007 suggest that modification of the mid-frequency cetacean non-impulsive Type I weighting function is necessary. The first experiment measured TTS in a bottlenose dolphin after exposure to pure tones with frequencies from 3–28 kHz (Finneran 2010). These data were used to derive onset-TTS values as a function of exposure frequency, and demonstrate that the use of a single numeric threshold for onset-TTS, regardless of frequency, is not correct. The second experiment examined how subjects perceived the loudness of sounds at different frequencies to derive equal loudness contours (Finneran and Schlundt 2011). These data are important because human auditory weighting functions are based on equal loudness contours. The dolphin equal loudness contours provide a means to generate auditory weighting functions in a manner directly analogous to the approach used to develop safe exposure guidelines for people working in noisy environments (National Institute for Occupational Safety and Health 1998). Taken together, the recent higher-frequency TTS data and equal loudness contours provide the underlying data necessary to develop new weighting functions (Type II) to improve accuracy and avoid underestimating the impacts on animals at higher frequencies (Figure 6-3). In order to generate the new weighting functions, Finneran and Schlundt (2011) substituted new lower and upper frequency values which differ from the values used by Southall et al. (2007). The new Type II weighting curve predicts appreciably higher (almost 20 dB) susceptibility for frequencies above 3 kHz for bottlenose dolphins, a mid-frequency cetacean. Since data below 3 kHz are not available, the original Type I weighting functions from Southall et al. (2007) were substituted below this frequency. Low- and high-frequency cetacean weighting functions were extrapolated from the dolphin data as well, because of the suspected similarities of greatest susceptibility at best frequencies of hearing.

The Type II auditory weighting functions (Figure 6-4) are applied to the received sound level before comparing it to the appropriate sound exposure level thresholds for TTS or PTS, or the explosive behavioral response threshold. For some criteria, received levels are not weighted before being compared to the thresholds to predict effects. These include the peak pressure criteria for predicting TTS and PTS from underwater explosions; the acoustic impulse metrics used to predict onset-mortality and slight lung injury from underwater explosions; and the thresholds used to predict behavioral responses from harbor porpoises and beaked whales from sonar and other active acoustic sources. As mentioned above, the Type I auditory weighting functions (Figure 6-3) are applied to the received sound

level from sonar and other active acoustic sources before comparing the adjusted sound level to the behavioral response function.

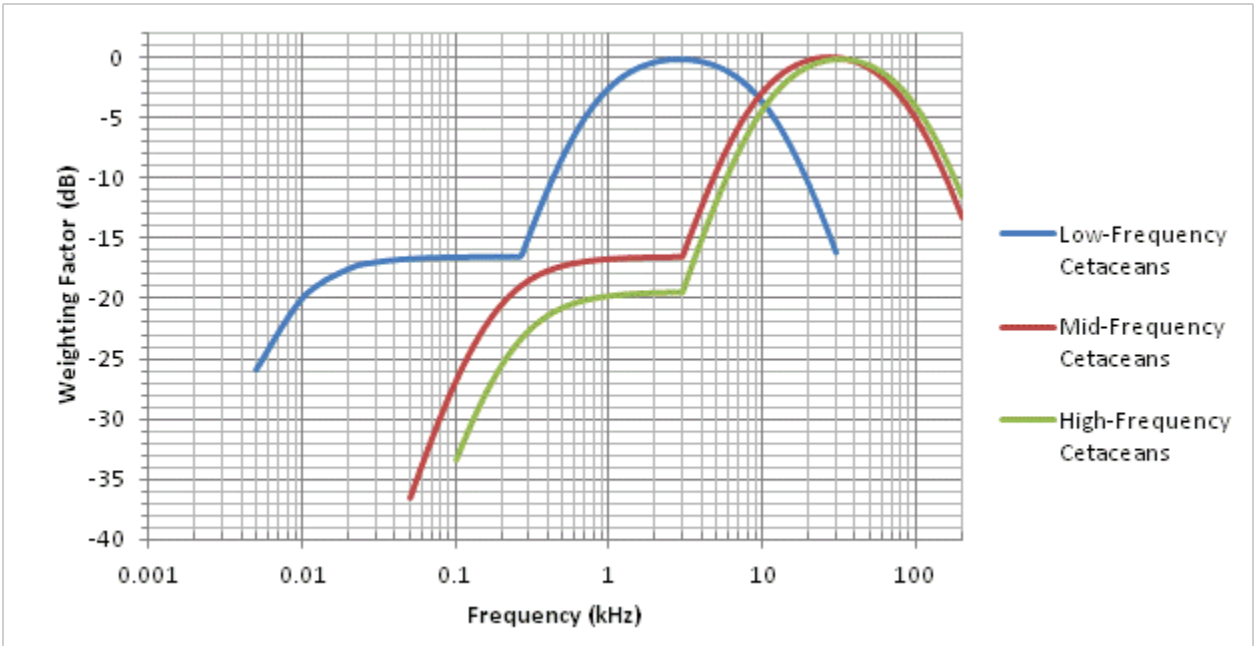

Figure 6-4: New Type II Weighting Functions for Low-, Mid-, and High-Frequency Marine Mammals

Summation of Energy from Multiple Sources- In most cases an animal's received level will be the result of exposure to a single sound source. In some scenarios, however, multiple sources will be operating simultaneously, or nearly so, creating the potential for accumulation of energy from multiple sources. In such scenarios, energy will be summed for all exposures within a cumulative exposure band, with the cumulative exposure bands defined in four bands: below 1.0 kHz (low-frequency sources); 1.0-10.0 kHz (mid-frequency sources); 10.1-100.0 kHz (high-frequency sources); and above 100.0 kHz (very high frequency sources). Sources operated at frequencies above 200 kHz are considered to be inaudible to all groups of marine mammals and are not analyzed in the quantitative modeling of exposure levels.

Hearing Loss - Temporary and Permanent Threshold Shift- Criteria for physiological effects from non-impulsive sources are based on TTS and PTS with thresholds based on cumulative sound exposure levels (Table 6-1). The onset of TTS or PTS from exposure to impulsive sources is predicted using a sound exposure level-based threshold in conjunction with a peak pressure threshold. The horizontal ranges are then compared, with the threshold producing the greatest being the one used to predict effects. For multiple exposures within any 24-hour period, the received sound exposure level (SEL) for individual events are accumulated for each marine mammal.. Since no studies have been designed to intentionally induce PTS in marine mammals, onset-PTS levels for these animals must be estimated using TTS data and relationships between TTS and PTS established in terrestrial mammals. TTS and PTS thresholds are based on TTS onset values for impulsive and non-impulsive sounds obtained from representative species of mid- and high-frequency cetaceans and pinnipeds. These data are then extended to the other marine mammals for which data are not available. The HSTT DEIS Criteria and Thresholds Technical Report provides a detailed explanation of the selection of criteria and derivation of thresholds for temporary and permanent hearing loss for marine mammals. Tables 6-1 and 6-2 provide a summary of non-impulsive thresholds for TTS and PTS for marine mammals.

Table 6-1: Onset TTS and PTS Thresholds for Non-Impulsive Sound

Group	Species	Onset TTS	Onset PTS
Low-Frequency Cetaceans	All mysticetes	178 dB re 1µPa2-sec(LF_{II})	198 dB re 1µPa2-sec(LF_{II})
Mid-Frequency Cetaceans	Most delphinids, beaked whales, medium and large toothed whales	178 dB re 1µPa2-sec(MF_{II})	198 dB re 1µPa2-sec(MF_{II})
High-Frequency Cetaceans	Porpoises, *Kogia* spp.	152 dB re 1µPa2-sec(HF_{II})	172 dB re 1µPa2-secSEL (HF_{II})
Phocidae In-water	Harbor, Hawaiian Monk, Elephant seals	183 dB re 1µPa2-sec(P_{WI})	197 dB re 1µPa2-sec(P_{WI})
Otariidae & Obodenidae In-water	Sea lions and Fur seals	206 dB re 1µPa2-sec(O_{WI})	220 dB re 1µPa2-sec(O_{WI})
Mustelidae In-water	Sea Otters		

LF_{II}, MF_{II}, HF_{II}: New compound Type II weighting functions; P_{WI}, O_{WI}: Original Type I (Southall et al. 2007) for pinniped and mustelid in water.

Table 6-2: Impulsive Sound and Explosive Criteria and Thresholds for Predicting Physiological Effects on Marine Mammals

Group	Species	Behavior		Slight Injury			Mortality
		Behavioral (for ≥2 pulses/24 hrs)	TTS	PTS	GI Tract	Lung	
Low Frequency Cetaceans	All mysticetes	167 dB SEL (LF_{II})	172 dB SEL (LF_{II}) or 224 dB Peak SPL	187 dB SEL (LF_{II}) or 230 dB Peak SPL	237 dB SPL or 104 psi	Equation 1	Equation 2
Mid-Frequency Cetaceans	Most delphinids, medium and large toothed whales	167 dB SEL (MF_{II})	172 dB SEL (MF_{II}) or 224 dB Peak SPL	187 dB SEL (MF_{II}) or 230 dB Peak SPL			
High Frequency Cetaceans	Porpoises and *Kogia* spp.	141 dB SEL (HF_{II})	146 dB SEL (HF_{II}) or 195 dB Peak SPL	161 dB SEL (HF_{II}) or 201dB Peak SPL			
Phocidae	Hawaiian monk, elephant, and harbor seal	172 dB SEL (P_{WI})	177 dB SEL (P_{WI}) or 212 dB Peak SPL	192 dB SEL (P_{WI}) or 218 dB Peak SPL			
Otariidae	Sea lions and Fur seals	195 dB SEL (O_{WI})	200 dB SEL (O_{WI}) or 212 dB Peak SPL	215 dB SEL (O_{WI}) or 218 dB Peak SPL			
Mustelidae	Sea Otters						

(1) $$= 39.1M^{1/3}\left(1+\frac{D_{Rm}}{10.081}\right)^{1/2} Pa-\text{sec}$$

(2) $$= 91.4M^{1/3}\left(1+\frac{D_{Rm}}{10.081}\right)^{1/2} Pa-\text{sec}$$

M = mass of the animals in kg

Drm = depth of the receiver (animal) in meters

SEL = re 1µPa2-sec); SPL = re 1µPa

6.2.2 BEHAVIORAL RESPONSES

The behavioral response criteria are used to estimate the number of animals that may exhibit a behavioral response. In this analysis, animals may be behaviorally harassed in each modeled scenario (using the Navy Acoustic Effects Model) or within each 24-hour period, whichever is shorter. Therefore, the same animal could have a behavioral reaction multiple times over the course of a year.

Non-Impulsive Sound- Potential behavioral effects to marine mammals from in-water sound from sonar and other non-impulse sources were predicted using the behavioral risk function for most animals. The received sound level is weighted with the flat Type I weighting functions before the behavioral risk function is applied. Beaked whales were the exception. They have unique criteria based on specific research that shows these animals to be especially sensitive to sound. Beaked whale behavioral criteria are unweighted.

Behavioral Response Functions- The Navy worked with NMFS to define a mathematical function used to predict potential behavioral effects to odontocetes (Figure 6-5) and mysticetes (Figure 6-6) from mid-frequency sonar (National Marine Fisheries Service 2008a).

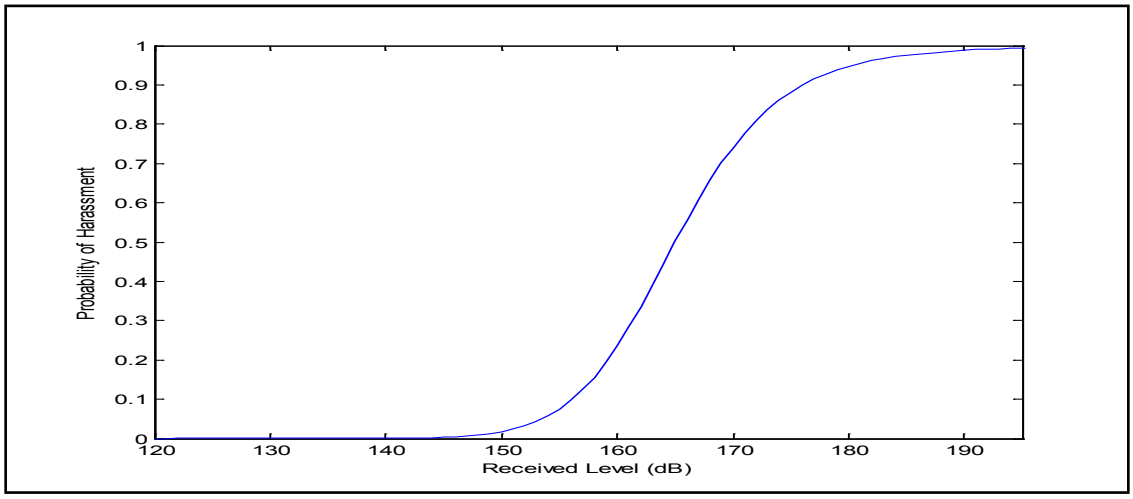

Figure 6-5: Behavioral Response Function Applied to Odontocetes and Pinnipeds

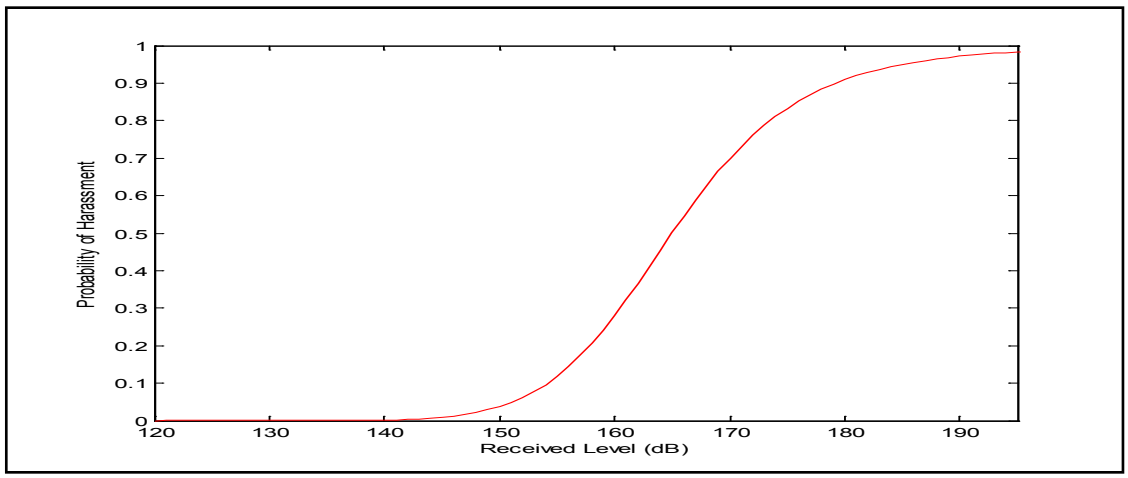

Figure 6-6: Behavioral Response Function Applied to Mysticetes

This effects analysis assumes that the potential consequences of exposure to non-impulsive sound on individual animals would be a function of the received sound pressure level (dB re 1 µPa). The behavioral response function applied to mysticetes differs from that used for odontocetes and pinnipeds in having a shallower slope, which results in the inclusion of more behavioral events at lower amplitudes, consistent with observational data from North Atlantic right whales (Nowacek et al. 2007). These analyses assume that sound poses a negligible risk to marine mammals if they are exposed to sound pressure levels below a certain basement value. The values used in this analysis are based on three sources of data: behavioral observations during TTS experiments conducted at the Navy Marine Mammal Program and documented in Finneran et al. (2001, 2003, and 2005; Finneran and Schlundt 2004); reconstruction of sound fields produced by the USS Shoup associated with the behavioral responses of killer whales observed in Haro Strait (Fromm 2004a, b; National Marine Fisheries Service 2005c; U.S. Department of the Navy 2004e) and observations of the behavioral response of North Atlantic right whales exposed to alert stimuli containing mid-frequency components documented in Nowacek et al. (2004). The behavioral risk function is used to estimate the percentage of an exposed population that is likely to exhibit behaviors that would qualify as harassment (as that term is defined by the MMPA applicable to military readiness activities, such as the Navy's testing and training and testing with mid-frequency active sonar) at a given received level of sound. For example, at 165 dB sound pressure level (dB re 1µPa root mean square), the risk (or probability) of harassment is defined according to this function as 50 percent. This means that 50 percent of the individuals exposed at that received level would be predicted to exhibit a significant behavioral response. The risk function is not applied to individual animals, only to exposed populations.

In some circumstances, some individuals will continue normal behavioral activities in the presence of high levels of human-made noise. In other circumstances, the same individual or other individuals may avoid an acoustic source at much lower received levels (Richardson et al. 1995; Southall et al. 2007; Wartzok et al. 2003). These differences within and between individuals appear to result from a complex interaction of experience, motivation, and learning that are difficult to quantify and predict. Therefore, the behavioral risk functions represent a relationship that is deemed to be generally true, but may not be true in specific circumstances. Specifically, the behavioral risk function treats the received level as the only variable that is relevant to a marine mammal's behavioral response. However, we know that many other variables, such as the marine mammal's gender, age, and prior experience; the activity it is engaged in during a sound exposure; its distance from a sound source; the number of sound sources;

and whether the sound sources are approaching or moving away from the animal can be critically important in determining whether and how a marine mammal will respond to a sound source (Southall et al. 2007). Currently available data do not allow for incorporation of these other variables in the current behavioral response functions; however, the risk function represents the best use of the data that are available. Furthermore, the behavioral response functions do not differentiate between different types of behavioral reactions (i.e. area avoidance, diving avoidance, or alteration of natural behavior) or provide information regarding the predicted biological significance of the reaction.

Beaked Whales- The inclusion of a special behavioral response criterion for beaked whales of the family Ziphiidae is new to these Phase II criteria. It has been speculated for some time that beaked whales might have unusual sensitivities to sonar sound due to their likelihood of stranding in conjunction with mid-frequency sonar use, even in areas where other species were more abundant (D'Amico et al. 2009), but there were not sufficient data to support a separate treatment for beaked whales until recently. With the recent publication of results from Blainville's beaked whale monitoring and experimental exposure studies on the instrumented Atlantic Undersea Test and Evaluation Center range in the Bahamas (McCarthy et al. 2011; Tyack et al. 2011), there are now statistically strong data suggesting that beaked whales tend to avoid both actual naval mid-frequency sonar in real anti-submarine training scenarios as well as sonar-like signals and other signals used during controlled sound exposure studies in the same area. The Navy has therefore adopted an unweighted 140 dB re 1 µPa sound pressure level threshold for significant behavioral effects for all beaked whales (family: Ziphiidae).

Impulsive Sound- If more than one impulsive event occurs within any given 24-hour period within a training or testing event, criteria are applied to predict the number of animals that may have a significant behavioral reaction. For multiple impulsive events (with the exception of pile driving) the behavioral threshold used in this analysis is 5 dB less than the TTS onset threshold (in sound exposure level). This value is derived from observed onsets of behavioral response by test subjects (bottlenose dolphins) during non-impulse TTS testing (Schlundt et al. 2000). Some multiple impulsive events, such as certain naval gunnery exercises, may be treated as a single impulsive event because a few explosions occur closely spaced within a very short period of time (a few seconds). For single impulses at received sound levels below hearing loss thresholds, the most likely behavioral response is a brief alerting or orienting response. Since no further sounds follow the initial brief impulses, significant behavioral reactions would not be expected to occur. This reasoning was applied to previous shock trials (63 FR 230; 66 FR 87; 73 FR 143) and is extended to these Phase II criteria. Since impulse events can be quite short, it may be possible to accumulate multiple received impulses at sound pressure levels considerably above the energy-based criterion and still not be considered a behavioral take. The Navy treats all individual received impulses as if they were one second long for the purposes of calculating cumulative sound exposure level for multiple impulse events. For example, five air gun impulses, each 0.1 second long, received at 178 dB sound pressure level would equal a 175 dB sound exposure level, and would not be predicted as leading to a significant behavioral response. However, if the five 0.1 second pulses are treated as a 5 second exposure, it would yield an adjusted value of approximately 180 dB, exceeding the threshold. For impulses associated with explosions that have durations of a few microseconds, this assumption greatly overestimates effects based on sound exposure level metrics such as TTS and PTS and behavioral responses. Appropriate weighting values will be applied to the received impulse in one-third octave bands and the energy summed to produce a total weighted sound exposure level value. For impulsive behavioral criteria, the new weighting functions (Figure 6-3) are applied to the received sound level before being compared to the threshold.

Table 6-3 summarizes behavioral thresholds by marine mammal hearing group.

Table 6-3: Behavioral Thresholds for Impulsive Sound

Hearing Group	Impulsive Behavioral Threshold for >2 pulses/24 hrs	Onset TTS
Low-Frequency Cetaceans	167 dB SEL (LF_{II})	172 dB SEL (MF_{II}) or 224 dB Peak SPL
Mid-Frequency Cetaceans	167 dB SEL (MF_{II})	
High-Frequency Cetaceans	141 dB SEL (HF_{II})	146 dB SEL (HF_{II}) or 195 dB Peak SPL
Phocid Seals (in water)	172 dB SEL (P_{WI})	177 dB SEL (P_{WI}) or 212 dB Peak SPL
Otariidae & Mustelidae (in water)	195 dB SEL (O_{WI})	200 dB SEL (O_{WI}) or 212 dB Peak SPL

$LF_{II,}$ $MF_{II,}$ HF_{II}: New compound Type II weighting functions; $P_{WI,}$ O_{WI}: Original Type I (Southall et al. 2007) for pinniped and mustelid in water. SEL = re 1µPa2-sec); SPL = re 1µPa

6.2.3 PILE DRIVING

Existing NMFS risk criteria are applied to the unique sounds generated by pile driving (Table 6-4).

Table 6-4: Pile Driving and AirgunThresholds Used in this Analysis to Predict Effects on Marine Mammals

Species Groups	Underwater Vibratory Pile Driving Criteria (sound pressure level, dB re 1 µPa)		Underwater Impact Pile Driving and Airgun Criteria (sound pressure level, dB re 1 µPa)	
	Level B Disturbance Threshold	Level A Injury Threshold	Level B Disturbance Threshold	Level A Injury Threshold
Cetaceans (whales, dolphins, porpoises)	120 dB rms	180 dB rms	160 dB rms	180 dB rms
Pinnipeds (seals, sea lions)	120 dB rms	190 dB rms	160 dB rms	190 dB rms

rms = Root Mean Square (also RMS) and refers to 90% of the energy under the envelope.

6.3 QUANTITATIVE MODELING FOR IMPULSIVE AND NON-IMPULSIVE SOURCES

The Navy performed a quantitative analysis to estimate the number of marine mammals that could be harassed by acoustic sources or explosives used during Navy training and testing activities. Inputs to the quantitative analysis included marine mammal density estimates; marine mammal depth occurrence distributions; oceanographic and environmental data; marine mammal hearing data; and criteria and thresholds for levels of potential effects. The quantitative analysis consists of computer modeled estimates and a post-model analysis to determine the number of potential mortalities and harassments. The model calculates sound energy propagation from sonars, other active acoustic sources, and explosives during naval activities; the sound or impulse received by animat dosimeters representing marine mammals distributed in the area around the modeled activity; and whether the sound or impulse received by a marine mammal exceeds the thresholds for effects. The model estimates are then further analyzed to consider animal avoidance and implementation of mitigation measures, resulting in final estimates of effects due to Navy training and testing.

A number of computer models and mathematical equations can be used to predict how energy spreads from a sound source (e.g. sonar or underwater detonation) to a receiver (e.g. dolphin or sea turtle). Basic underwater sound models calculate the overlap of energy and marine life using assumptions that account for the many, variable, and often unknown factors that can greatly influence the result. Assumptions in previous Navy models have intentionally erred on the side of overestimation when there are unknowns or when the addition of other variables was not likely to substantively change the final analysis. For example, because the ocean environment is extremely dynamic and information is often limited to a synthesis of data gathered over wide areas and requiring many years of research, known information tends to be an average of a seasonal or annual variation. The Equatorial Pacific El Nino disruption of the ocean-atmosphere system is an example of dynamic change where unusually warm ocean temperatures are likely to redistribute marine life and alter the propagation of underwater sound energy. Previous Navy modeling therefore made some assumptions indicative of a maximum theoretical propagation for sound energy (such as a perfectly reflective ocean surface and a flat seafloor). More complex computer models build upon basic modeling by factoring in additional variables in an effort to be more accurate by accounting for such things as bathymetry and an animal's likely presence at various depths.

The Navy has developed a set of data and new software tools for quantification of estimated marine mammal impacts from Navy activities. This new approach is the resulting evolution of the basic model previously used by Navy and reflects a more complex modeling approach as described below. Although this more complex computer modeling approach accounts for various environmental factors affecting acoustic propagation, the current software tools do not consider the likelihood that a marine mammal would attempt to avoid repeated exposures to a sound or avoid an area of intense activity where a training or testing event may be focused. Additionally, the software tools do not consider the implementation of mitigation (e.g., stopping sonar transmissions when a marine mammal is within a certain distance of a ship or range clearance prior to detonations). In both of these situations, naval activities are modeled as though an activity would occur regardless of proximity to marine mammals and without any horizontal movement by the animal away from the sound source or human activities (e.g., without accounting for likely animal avoidance). Therefore, the final step of the quantitative analysis of acoustic effects is to consider the implementation of mitigation and the possibility that marine mammals would avoid continued or repeated sound exposures.

The quantified results of the marine mammal acoustic effects analysis presented in this Request for Letters of Authorization differ from the quantified results presented in the Draft Environmental Impact Statement/Overseas Environmental Impact Statement (DEIS/OEIS) for Hawaii and Southern California Training and Testing (HSTT) (DoN 2012). Presentation of the results in this new manner for MMPA, ESA, and other regulatory analyses is well within the framework of the previous NEPA analyses presented in the DEIS. These differences are due to three main factors: (1) refinement to the modeling inputs for training and testing; (2) use of a more accurate seasonal density for the species (short-beaked common dolphins) having the highest abundance of any marine mammal in the HSTT study area; and (3) additional post-model quantification to further refine the numerical analysis of acoustic effects so as to include animal avoidance of sound sources, avoidance of areas of activity before use of a sound source or explosive, and implementation of mitigation. This additional quantification was in direct response to public comments received on HSTT DEIS/OEIS with regard to a somewhat universal misunderstanding of the numbers presented as modeling results. These comments indicated that many readers believed the modeling effects numbers presented in the tables were the entire acoustic impact analysis. Furthermore, it was clear that these same readers had missed the critical subsequent qualitative analysis required to accurately interpret those numbers since the model does not account for animal

avoidance of repeated explosive exposures nor movement and does not account for standard Navy mitigations. In response to these comments, the numbers presented in this Request for Letters of Authorization and as will be reflected in the HSTT Final EIS/OEIS, have been adjusted to more fully quantify the expected effects by having now quantified factors of animal avoidance or movement and standard Navy mitigations. The following sections describe the steps of the quantitative analysis of acoustic effects.

Marine Species Density Data- A quantitative analysis of impacts on a species requires data on the abundance and distribution of the species population in the potentially impacted area. The most appropriate unit of metric for this type of analysis is density, which is the number of animals present per unit area. Marine species density estimation requires a significant amount of effort to collect and analyze data to produce a usable estimate. The updated marine mammal density estimates used in the acoustic effects analysis are from the Navy Marine Species Density Database (U.S. Department of the Navy 2011). The Navy Marine Species Density Database includes a compilation of the best available density data from several primary sources and published works including survey data from NMFS within the U.S. Economic Exclusion Zone. NMFS publishes annual Stock Assessment Reports (SARs) for various regions of U.S. waters, which cover all stocks of marine mammals within those waters. The majority of species that occur in the HSTT Study Area are covered by the Pacific Region SAR (Carretta et al. 2011), with a few species (e.g., gray whale) covered by the Alaska Region SAR (Allen and Angliss 2011). Other independent researchers often publish density data or research covering a particular marine mammal species, which is integrated into the NMFS SARs. For most cetacean species, abundance is estimated using line-transect methods that employ a standard equation to derive densities based on sighting data collected from systematic ship or aerial surveys. More recently, habitat-based density models have been used effectively to model cetacean density as a function of environmental variables (e.g., Barlow et al. 2009). Habitat-based density models allow predictions of cetacean densities on a finer spatial scale than traditional line-transect analyses because cetacean densities are estimated as a continuous function of habitat variables (e.g., sea surface temperature, water depth, etc.). Within most of the world's oceans, however, there have not been enough systematic surveys to allow for line-transect density estimation or the development of habitat models. To get an approximation of the species distribution and abundance for unsurveyed areas, in some cases it is appropriate to extrapolate data from areas with similar oceanic conditions where extensive survey data exist. Habitat Suitability Index (HSI) or Relative Environmental Suitability (RES) have also been used in data-limited areas to estimate occurrence based on existing observations about a given species' presence and relationships between basic environmental conditions (Kaschner et al. 2006). There is no single source of density data for every area, species, and season because of the fiscal costs, resources, and effort involved in providing enough survey coverage to sufficiently estimate density. Therefore, to characterize the marine species density for large areas such as the HSTT Study Area, the Navy needed to compile data from multiple sources.

To develop a database of marine species density estimates, the Navy, in consultation with NMFS experts at the two science centers overlapping the Study Area (Southwest Fisheries Science Center and Pacific Islands Fisheries Science Center), adopted a protocol to select the best available data sources based on species, area, and season. The resulting Geographic Information System (GIS) database includes one single spatial and seasonal density value for every marine mammal species present within the HSTT Study Area. The updated marine mammal density estimates used in the acoustic effects analysis are from the Navy Marine Species Density Database (U.S. Department of the Navy 2011). In this analysis, marine mammal density data were used as an input in the Navy Acoustic Effects Model in their original temporal and spatial resolution. Seasons are defined as warm (June through November) and cold (December through May).The density grid cell spatial resolution varied, depending on the original data

source utilized, from 10 square kilometers (km^2) to 0.5 $degrees^2$. Where data sources overlap, there might be sudden increase or decrease in density due to different derivation methods or survey data utilized. This is an artifact of attempting to use the best available data for each geographic region. The density data was used as-is in order to preserve the original values. Any attempt to smooth the datasets would either increase or decrease adjacent values, and would inflate the error of those values by an unknown amount. The Navy modeled acoustic effects within representative locations where training and testing is expected to occur. Within the HSTT Study Area, the distribution extent for some species did not overlap with any of the affected areas from the sound source locations modeled.

Upper and Lower Frequency Limits-The Navy has adopted a single frequency cutoff at each end of a functional hearing group's frequency range, based on the most liberal interpretations of their composite hearing abilities. These are not the same as the values used to calculate weighting curves, but exceed the demonstrated or anatomy-based hypothetical upper and lower limits of hearing within each group. Table 6-1 provides the lower and upper frequency limits for each species group. Sounds with frequencies below the lower frequency limit, or above the upper frequency limit, are not analyzed with respect to auditory effects for a particular group.

Table 6-5: Lower and Upper Cutoff Frequencies for Marine Mammal Functional Hearing Groups Used in this Acoustic Analysis

Functional Hearing Group	Limit (Hz)	
	Lower	Upper
Low-Frequency Cetaceans	5	30,000
Mid-Frequency Cetaceans	50	200,000
High-Frequency Cetaceans	100	200,000
Otariidae Odobenidae & Mustelidae (in water)	20	60,000
Phocidae Pinnipeds (in water)	50	80,000

Navy Acoustic Effects Model - The Navy developed a set of software tools and compiled data for estimating acoustic effects on marine mammals without consideration of behavioral avoidance or Navy's standard mitigations. These databases and tools collectively form the Navy Acoustic Effects Model (NAEMO). The Navy Acoustic Effects Model improves upon previous modeling efforts in several ways. First, unlike earlier methods that modeled sources individually, the Navy Acoustic Effects Model has the capability to run all sources within a scenario simultaneously, providing a more realistic depiction of the potential effects of an activity. Second, previous models calculated sound received levels within set volumes of water and spread animals uniformly across the volumes; in the Navy Acoustic Effects Model, animats (virtual animals) are distributed nonuniformly based on higher resolution species-specific density, depth distribution, and group size information, and animats serve as dosimeters, recording energy received at their location in the water column. Third, a fully three-dimensional environment is used for calculating sound propagation and animat exposure in the Navy Acoustic Effects Model, rather than a two-dimensional environment where the worse case sound pressure level across the water column is always encountered. Finally, current efforts incorporate site-specific bathymetry, sound speed profiles, wind speed, and bottom properties into the propagation modeling process rather than the flat-bottomed provinces used during earlier modeling (NUWC 2012). The following paragraphs provide an overview of the Navy Acoustic Effects Model process and its more critical data inputs.

Using the best available information on the predicted density of marine mammals in the area being modeled, the Navy Acoustic Effects Model derives an abundance (total number of individuals) and distributes the resulting number of animats into an area bounded by the maximum distance that energy propagates out to a criterion threshold value (energy footprint). For example, for non-impulsive sources, all animats that are predicted to occur within a range that could receive sound pressure levels greater than or equal to 120 dB sound pressure level are distributed. These animats are distributed based on density differences across the area, the group (pod) size, and known depth distributions (dive profiles) (the (Marine Species Modeling Team 2012b)] discusses animal dive profiles in detail). Animats change depths every 4 minutes but do not otherwise mimic actual animal behaviors, such as avoidance or attraction to a stimulus (horizontal movement), or foraging, social, or traveling behaviors.

Schecklman et al. (2011) argue that static distributions underestimate acoustic exposure compared to a model with fully three-dimensionally moving animals. However, their static method is different from the Navy Acoustic Effects Model in several ways. First, they distribute the entire population at depth with respect to the species-typical depth distribution histogram, and those animats remain static at that position throughout the entire simulation. In the Navy Acoustic Effects Model, animats are placed horizontally dependent on nonuniform density information, and then move up and down over time within the water column by integrating species-typical depth distribution information. Second, for the static method they calculate acoustic received level for designated volumes of the ocean and then sum the animats that occur within that volume, rather than using the animats themselves as dosimeters, as in the Navy Acoustic Effects Model. Third, Schecklman et al. (2011) ran 50 iterations of the moving distribution to arrive at an average number of exposures, but because they rely on uniform horizontal density (and static depth density), only a single iteration of the static distribution is realized. In addition to moving the animats vertically, the Navy Acoustic Effects Model overpopulates the animats over a nonuniform density and then resamples the population a number of times to arrive at an average number of exposures as well. Tests comparing fully moving distributions and static distributions with vertical position changes at varying rates were compared during development of the Navy Acoustic Effects Model. For position updates occurring more frequently than every 5 minutes, the number of estimated exposures were similar between the Navy Acoustic Effects Model and the fully moving distribution; however, computational time was much longer for the fully moving distribution.

The Navy Acoustic Effects Model calculates the likely propagation for various levels of energy (sound or pressure) resulting from each non-impulse or impulse source used during a training or testing event. This is done by taking into account the actual bathymetric relief and bottom types (e.g., reflective), and estimated sound speeds and sea surface roughness at an event's location. Platforms (such as a ship using one or more sound sources) are modeled as moving across an area whose size is representative of what would normally occur during a training or testing scenario. The model uses typical platform speeds and event durations. Moving source platforms either travel along a predefined track or move along straight-line tracks from a random initial course, reflecting at the edges of a predefined boundary. Static sound sources are stationary in a fixed location for the duration of a scenario. Modeling locations were chosen based on historical data where activities have been ongoing and in an effort to include as much environmental variation within the Study Area as is reasonably available and can be incorporated into the model.

The Navy Acoustic Effects Model then records the energy received by each animat within the energy footprint of the event and calculates the number of animats having received levels of energy exposures that fall within defined impact thresholds. Predicted effects on the animats within a scenario are then tallied and the highest order effect (based on severity of criteria; e.g., PTS over TTS) predicted for a given

animat is assumed. Each scenario or each 24-hour period for scenarios lasting greater than 24 hours is independent of all others, and therefore, the same individual marine animal could be impacted during each independent scenario or 24-hour period. In few instances, although the activities themselves all occur within the Study Area, sound may propagate beyond the boundary of the Study Area. Any exposures occurring outside the boundary of the Study Area are counted as if they occurred within the Study Area boundary. The Navy Acoustic Effects Model provides the initial estimated impacts on marine species with a static horizontal distribution. These model-estimated results are then further analyzed to account for pre-activity avoidance by sensitive species, mitigation (considering sound source and platform), and avoidance of repeated sound exposures by marine mammals, producing the final predictions of effects used in this request for LOAs.

Model Assumptions- There are limitations to the data used in the acoustic effects model (NAEMO), and the results must be interpreted within these context. While the most accurate data and input assumptions have been used in the modeling, when there is a lack of definitive data to support an aspect of the modeling, modeling assumptions believed to overestimate the number of exposures have been chosen:

- Animats are modeled as being underwater, stationary, and facing the source and therefore always predicted to receive the maximum sound level (i.e., no porpoising or pinnipeds' heads above water). Some odontocetes have been shown to have directional hearing, with best hearing sensitivity facing a sound source and higher hearing thresholds for sounds propagating towards the rear or side of an animal (Mooney et al. 2008; Popov and Supin 2009; Kastelein et al. 2005).
- Animats do not move horizontally (but change their position vertically within the water column), which may overestimate physiological effects such as hearing loss, especially for slow moving or stationary sound sources in the model.
- Animats are stationary horizontally and therefore do not avoid the sound source, unlike in the wild where animals would most often avoid exposures at higher sound levels, especially those exposures that may result in PTS.
- Animats are assumed to receive the full impulse of the initial positive pressure wave due to an explosion, although the impulse-based thresholds (onset mortality and onset slight lung injury) assume an impulse delivery time adjusted for animal size and depth. Therefore, these impacts are overestimated at farther distances and increased depths.
- Multiple exposures within any 24-hour period are considered one continuous exposure for the purposes of calculating the temporary or permanent hearing loss, because there are not sufficient data to estimate a hearing recovery function for the time between exposures.
- Mitigation measures that are implemented during many training and testing activities were not considered in the model (see Chapter 11, Means of Effecting the Least Practicable Adverse Impacts – Mitigation Measures). In reality, sound-producing activities would be reduced, stopped, or delayed if marine mammals are detected within the mitigation zones around sound sources.

Because of these inherent model limitations and simplifications, model-estimated results must be further analyzed, considering such factors as the range to specific effects, avoidance, and the likelihood of successfully implementing mitigation measures. This analysis uses a number of factors in addition to the acoustic model results to predict acoustic effects on marine mammals.

6.3.1.1 Marine Mammal Avoidance of Sound Exposures

Marine mammals may avoid sound exposures by either avoiding areas with high levels of anthropogenic activity or moving away from a sound source. Because the Navy Acoustic Effects Model does not consider horizontal movement of animats, including avoidance of human activity or sounds, it over-estimates the number of marine mammals that would be exposed to sound sources that could cause injury. Therefore, the potential for avoidance is considered in the post-model analysis. The consideration of avoidance during use of sonar and other active acoustic sources and during use of explosives is described below and discussed in more detail in Section 6.3 (Analysis Background and Framework).

Avoidance of Human Activity

Cues preceding the commencement of an event (e.g., multiple vessel presence and movement, aircraft overflight) may result in some animals departing the immediate area, even before active sound sources begin transmitting. Harbor porpoises and beaked whales have been observed to be especially sensitive to human activity, which is accounted for by using a low threshold for behavioral disturbance due to exposure to sonars and other active acoustic sources (see Section 6.3 – Analysis Background and Framework). Both finless porpoises (Li et al. 2008) and harbor porpoises (Barlow 1988; Polachek and Thorpe 1990; Evans et al. 1994; Palka and Hammond 2001) routinely avoid and swim away from large motorized vessels. The vaquita, which is closely related to the harbor porpoise, appears to avoid large vessels at about 2,995 ft. (913 m) (Jaramillo-Legorreta et al. 1999). The assumption is that the harbor porpoise would respond similarly to large Navy vessels. Beaked whales have also been documented to exhibit avoidance of human activity (Pirotta et al. 2012).

Therefore, for certain naval activities preceded by high levels of vessel activity (multiple vessels) or hovering aircraft, harbor porpoises and beaked whales are assumed to avoid the activity area prior to the start of a sound-producing activity. Model-estimated effects during these types of activities are adjusted so that high level sound impacts to harbor porpoises and beaked whales (those causing PTS during use of sonar and other active acoustic sources and those causing mortality due to explosives) are considered to be TTS and injury, respectively, due to animals moving away from the activity and into a lower effect range.

Avoidance of Repeated Exposures

Marine mammals would likely avoid repeated high level exposures to a sound source that could result in injuries (i.e., PTS). Therefore, the model-estimated effects are adjusted to account for marine mammals swimming away from a sonar or other active source and away from multiple explosions to avoid repeated high level sound exposures. Avoidance of repeated sonar exposures is discussed further in Section 6.5.2.2 (Range to Non-Impulsive Effects) and avoidance of repeated explosive exposures is discussed further in Section 6.5.2.4 (Range to Impulsive Effects).

6.3.1.2 Implementing Mitigation to Reduce Sound Exposures

The Navy implements mitigation measures (described in Chapter 11) during sound-producing activities, including halting or delaying use of a sound source or explosives when marine mammals are observed in the mitigation zone. Sound-producing activities would not begin or resume until the mitigation zone is observed to be free of marine mammals. The Navy Acoustic Effects Model estimates acoustic effects without any shutdown or delay of the activity in the presence of marine mammals; therefore, the model over-estimates impacts to marine mammals within mitigation zones. The post-model analysis considers

the potential for highly effective mitigation to prevent Level A harassments due to exposure to sonar and other active acoustic sources and Level A harassments and mortalities due to explosives.

The effectiveness of mitigation depends on two factors: (1) the extent to which the type of mitigation proposed for a type of activity allows for observation of the mitigation zone prior to and during the sound-producing activity (probability of detection) and (2) the sightability of each species that may be present in the mitigation zone (availability bias). The mitigation zones proposed in Chapter 11 encompass the estimated ranges to injury (including the range to mortality for explosives) for a given source.

Mitigation is considered in the acoustic effects analysis when the mitigation zone can be fully or mostly observed up to and during a sound-producing activity. Mitigation for each activity is considered in its entirety, taking into account the different scenarios that may take place as part of that activity (some scenarios involve different mitigation zones, platforms, or number of lookouts). The ability to observe the range to mortality (for explosive activities only) and the range to potential injury (for all sound-producing activities) for each activity was estimated for each activity. Mitigation was considered in the acoustic analysis as follows:

- If the entire mitigation zone can be continuously visually observed based on the surveillance platform(s), number of lookouts, and size of the range to effects zone, the mitigation is considered fully effective (Effectiveness = 1).
- If over half of the mitigation zone can be continuously visually observed or if there is one or more of the scenarios within the activity for which the mitigation zone cannot be continuously visually observed (but the majority of the scenarios can continuously visually observe the range to effects zone), the mitigation is considered mostly effective (Effectiveness = 0.5).
- If less than half of the mitigation zone can be continuously visually observed or if the mitigation zone cannot be continuously visually observed during most of the scenarios within the activity due to the type of surveillance platform(s), number of lookouts, and size of the mitigation zone, the mitigation is not considered in the acoustic effects analysis.

The mitigation effectiveness scores are multiplied by the estimated sightability of each species to estimate the percent of each species model-estimated to experience mortality (explosives only) or injury (all sound-producing activities) that would, in reality, be observed by lookouts prior to or during a sound-producing activity. Observation of marine mammals prior to or during a sound-producing event would stop or. For purposes of this delay the sound-producing activity, which would reduce actual marine mammal sound exposures analysis, the sightability is based on availability bias g(0) for vessel and aerial platforms based on recent peer-reviewed literature. While g(0) is based on trained marine mammal observers' ability to identify specific species along a single line transect of a limited width and the animals being available for detection at the surface along that trackline, lookouts aboard Navy platforms would observe the full mitigation zone prior to and during a sound-producing activity and sound-producing activities would be halted when any marine mammal is observed, regardless of species. Because lookouts would report any marine mammal observation within the mitigation zone over a period of time preceding and during an activity, g(0) is considered to be a reasonable representation of the sightability of a marine mammal for this analysis.

The g(0) value used in the mitigation analysis is based on the platform(s) with lookouts utilized in the activity. In the case of multiple platforms, the higher g(0) value for either the aerial or vessel platform is selected. For species for which there is only a single published value for each platform, that individual value is used. For species for which there is a range of published g(0) values, an average of the values,

calculated separately for each platform, is used. A g(0) of zero is assigned to species for which there is no data available, unless a g(0) estimate can be extrapolated from similar species/guilds based on the published g(0) values. The g(0) values used in this analysis are provided in Table 6-5.

Table 6-6: Sightability based on g(0) Values for Marine Mammal Species in HSTT Study Area

Species/Stocks	Family	Vessel Sightability	Aircraft Sightability
Baird's Beaked Whale	Ziphidae	0.96	0.74
Blainville's Beaked Whale	Ziphidae	0.395	0.074
Blue Whale, Fin Whale	Balaenopteridae	0.921	0.407
Bottlenose Dolphin Coastal	Delphinidae	0.856	0.96
Bottlenose Dolphin, Fraser's Dolphin	Delphinidae	0.808	0.96
Bryde's Whale	Balaenopteridae	0.91	0.407
California Sea Lion, Guadalupe Fur Seal, Northern Fur Seal	Otariidae, Phocidae	0.299	0.299
Cuvier's Beaked Whale	Ziphidae	0.23	0.074
Dall's Porpoise	Phocoenidae	0.822	0.221
Dwarf Sperm Whale, Pygmy Sperm Whale, Kogia spp.	Kogiidae	0.35	0.074
False Killer Whale, Melon-headed Whale	Delphinidae	0.76	0.96
Gray Whale	Eschichtiidae	0.921	0.482
Hawaiian Monk Seal, Harbor Seal	Phocidae	0.281	0.281
Humpback Whale	Balaenopteridae	0.921	0.495
Killer Whale	Delphinidae	0.91	0.96
Long-beaked/Short-beaked Common Dolphin	Delphinidae	0.97	0.994
Longman's Beaked Whale, Pygmy Killer Whale	Ziphidae, Delphinidae	0.76	0.074
Minke Whale	Balaenopteridae	0.856	0.386
Northern Elephant Seal	Phocidae	0.105	0.105
Northern Right Whale Dolphin	Delphinidae	0.856	0.96
Pacific White-Sided Dolphin	Delphinidae	0.856	0.96
Pantropical Spotted/Risso's/Rough/Spinner/Striped Toothed Dolphin	Delphinidae	0.76	0.96
Sei Whale	Balaenopteridae	0.921	0.407
Short-finned Pilot Whale	Delphinidae	0.76	0.96
Small Beaked Whale Guild	Ziphidae	0.34	0.074
Sperm Whale	Physeteridae	0.87	0.495

References: Barlow 2010; Barlow and Forney 2007; Carretta et al 2000.

Note: For species having no data, the g(0) for Cuvier's aircraft value (where g(0)=0.074) was used; or in cases where there was no value for vessels, the g(0) for aircraft was used as an underestimate following the assumption that the availability bias from a slower moving vessel should result in a higher g(0); California Sea Lion data was used as a surrogate for other pinniped species lacking any other data.

The post-model acoustic effects analysis process is summarized in Table 6-7. The consideration of mitigation during use of sonar and other active acoustic sources and during use of explosives was previously discussed. The final quantified results of the acoustic effects analysis are presented in Tables 5-2 and 5-4.

Table 6-7: Post-model Acoustic Impact Analysis Process

Sonar or other active acoustic source	Explosives
S-1. Is the activity preceded by multiple vessel activity or hovering helicopter?	***E-1. Is the activity preceded by multiple vessel activity or hovering helicopter?***
Species sensitive to human activity (i.e., beaked whales) are assumed to avoid the activity area, putting them out of the range to Level A harassment. Model-estimated PTS to these species during these activities are unlikely to actually occur and, therefore, are considered to be behavioral disturbances (animal is assumed to move into the range of potential behavioral disturbance). The activities that are preceded by multiple vessel movements or hovering helicopters are listed in Table 6-11.	Species sensitive to human activity (i.e., beaked whales) are assumed to avoid the activity area, putting them out of the range to mortality. Model-estimated mortalities to these species during these activities are unlikely to actually occur and, therefore, are considered to be injuries (animal is assumed to move into the range of potential injury). The activities that are preceded by multiple vessel movements or hovering helicopters are listed in Table 6-14.
S-2. Is the range to effects for PTS very small?	
Marine mammals in the mid-frequency hearing group would have to be close to the most powerful moving source (less than 10 m) to experience PTS. These model-estimated PTS of mid-frequency cetaceans are unlikely to actually occur and, therefore, are considered to be TTS (animal is assumed to move into the range of TTS).	
S-3. Can lookouts observe the activity-specific mitigation zone (see Chapter 11) up to and during the sound-producing activity?	***E-2. Can lookouts observe the activity-specific mitigation zone (see Chapter 11) up to and during the sound-producing activity?***
If lookouts are able to observe the mitigation zone up to and during a sound-producing activity, the sound-producing activity would be halted or delayed if a marine mammal is observed and would not resume until the animal is thought to be out of the mitigation zone. Therefore, model-estimated PTS are reduced by the portion of animals that are likely to be seen [Mitigation Effectiveness (1, 0.5, or 0) x Sightability, g(0)]. Any animals removed from the model-estimated PTS are instead assumed to be TTS (animal is assumed to move into the range of TTS). The g(0) value is associated with the platform (vessel or aircraft) with the dedicated lookout(s). For activities with lookouts on both platforms, the higher g(0) is used for analysis. The g(0) values are provided in Table 6-6. The Mitigation Effectiveness values are provided in Table 6-12.	If lookouts are able to observe the mitigation zone up to and during an explosion, the explosive activity would be halted or delayed if a marine mammal is observed and would not resume until the animal is thought to be out of the mitigation zone. Therefore, model-estimated mortalities and injuries are reduced by the portion of animals that are likely to be seen [Mitigation Effectiveness (1, 0.5, or 0) x Sightability, g(0)]. Any animals removed from the model-estimated mortalities or injuries are instead assumed to be injuries or behavioral disturbances, respectively (animals are assumed to move into the range of a lower effect). The g(0) value is associated with the platform (vessel or aircraft) with the dedicated lookout(s). For activities with lookouts on both platforms, the higher g(0) is used for analysis. The g(0) values are provided in Table 6-6. The Mitigation Effectiveness values for explosive activities are provided in Table 6-15.
S-4. Does the activity cause repeated sound exposures which an animal would likely avoid?	***E-3. Does the activity cause repeated sound exposures which an animal would likely avoid?***
The Navy Acoustic Effects Model assumes that animals do not move away from a sound source and receive a maximum sound exposure level. In reality, an animal would likely avoid repeated sound exposures that would cause PTS by moving away from the sound source. Therefore, only the initial exposures resulting in model-estimated PTS to high-frequency cetaceans, low frequency cetaceans, and phocids are expected to actually occur (after accounting for mitigation in step S-3). Model estimates of PTS beyond the initial pings are considered to actually be behavioral disturbances, as the animal is assumed to move out of the range to PTS and into the range of TTS.	The Navy Acoustic Effects Model assumes that animals do not move away from multiple explosions and receive a maximum sound exposure level. In reality, an animal would likely avoid repeated sound exposures that would cause PTS by moving away from the site of multiple explosions. Therefore, only the initial exposures resulting in model-estimated PTS are expected to actually occur (after accounting for mitigation in step E-2). Model estimates of PTS are reduced to account for animals moving away from an area with multiple explosions, out of the range to PTS, and into the range of TTS. Activities with multiple explosions are listed in Table 6-16.

6.3.2 IMPACTS ON MARINE MAMMALS

6.3.2.1 Non-Impulsive (Sonar and Other Active Acoustic Sources)

Sonar and other active acoustic sources proposed for use are transient in most locations as active sonar activities pass through the Study Area. Sonar and other active acoustic sound sources emit sound waves into the water to detect objects, safely navigate, and communicate. General categories of sonar systems are described in Chapter 1. Exposure of marine mammals to non-impulsive sources such as active sonar is not likely to result in primary blast injuries or barotraumas. Sonar induced acoustic resonance and bubble formation phenomena are also unlikely to occur under realistic conditions in the ocean environment, as discussed in Section 6.3. Within this acoustic analysis, the number of animals that may receive some form of hearing loss is predicted using the Navy Acoustic Effects Model. Thresholds for determining hearing were developed using the best available data. The most intense underwater sounds in the Study Area associated with the proposed action are those produced by anti-submarine warfare sonar and explosives. These sounds are likely within the audible range of most cetaceans, but are normally very limited in the temporal, frequency, and spatial domains. The duration of individual sounds is short; sonar pulses can last up to a few seconds each. The duty cycle is low with most tactical anti-submarine warfare sonar only transmitting a few times per minute. Furthermore, events are geographically and temporally dispersed and most events are limited to a few hours. Tactical sonar has a narrow frequency band (typically less than one-third octave). These factors reduce the likelihood or severity of these sources causing significant auditory masking in marine mammals. Some object-detecting sonar (i.e. mine warfare sonar) has a high duty cycle producing up to a few pings per second. These sonar typically employ high frequencies (above 10 kHz) that attenuate rapidly in the water, thus producing only a small area of potential auditory masking. Higher-frequency mine warfare sonar systems are typically outside of the hearing and vocalization ranges of mysticetes (see Section 3.4.2.3 of the EIS/OEIS), therefore, mysticetes are unlikely to be able to detect the higher frequency mine warfare sonar, and these systems would not interfere with their communication or detection of biologically relevant sounds. Odontocetes may experience some limited masking at closer ranges as the frequency band of many mine warfare sonar overlaps the hearing and vocalization abilities of some odontocetes; however, the frequency band of these sonar is narrow, limiting the likelihood of auditory masking. With any of these activities, the limited duration and dispersion of the activities in space and time reduce the potential for auditory masking effects from proposed activities on marine mammals. For marine mammals, the predicted number of behavioral responses is determined using the Navy Acoustic Effects Model. Behavioral responses can range from a mild orienting response, or a shifting of attention, to flight and panic. Predicted effects are based on specific behavioral criteria meant to predict when an animal is likely to experience a significant behavioral reaction (see Section 6.3). Another concern is the number of times an individual marine mammal is exposed and potentially reacts to a sonar or other active acoustic source over the course of a year or within a specific geographic area. Animals that are resident during all or part of the year near Navy ports or on fixed Navy ranges are the most likely to experience multiple exposures. Repeated and chronic noise exposures to marine mammals and their observed reactions are discussed herein.

6.3.2.2 Range to Non-Impulsive Effects

The following section provides range to effects for sonar and other active acoustic sources to specific criteria determined using the Navy Acoustic Effects Model. Marine mammals within these ranges would be predicted to receive the associated effect. Range to effects is important information in not only predicting acoustic impacts, but also in verifying the accuracy of model results against real-world situations and determining adequate mitigation ranges to avoid higher level effects, especially

physiological effects to marine mammals. Although the Navy uses a number of sonar and active acoustic sources, the three sonar bins provided in Table 6-7 (i.e., MF1, MF4, and MF5) represent three of the most powerful sources. Section 6.1.6 (Classification of Acoustic and Explosive Sources) discusses sonar and other active acoustic source bins included in this analysis. These three sonar bins are often the dominant source in the activity in which they are included, especially for smaller unit level training exercises and many testing activities. Therefore, these ranges provide realistic maximum distances over which the specific effects would be possible.

PTS: The ranges to the PTS threshold are shown in Table 6-7 relative to the marine mammal's functional hearing group (Navy's high frequency sources have a lower source level and more energy loss over distance than these mid-frequency examples and therefore have a shorter range to effects). For a SQS-53C sonar transmitting for one second at 3 kHz and a source level of 235 dB re 1 µPa2-s at 1 m, the range to PTS for the most sensitive species (the high-frequency cetaceans) extends from the source to a range of 100 m. Since any hull mounted sonar, such as the SQS-53, engaged in anti-submarine warfare training and testing would be moving at between 10–15 knots (5.1– 7.7 m/second) and nominally pinging every 50 seconds, the vessel will have traveled a minimum distance of approximately 281 yd (257 m) during the time between those pings (note: 10 knots is the speed used in the Navy Acoustic Effects Model). As a result, there is little overlap of PTS footprints from successive pings, indicating that in most cases, an animal predicted to receive PTS would do so from a single exposure (i.e., ping). It is unlikely that any animal would receive overlapping PTS level exposures from a second ship, as Navy sonar exercises do not involve ships within such close proximity to each other while using their active sonar. For all other functional hearing groups (low-frequency cetaceans, mid-frequency cetaceans, pinniped (phocid seals and otariid sea lions), and sea otters) single-ping PTS zones are within 86 yd (79 m) of the sound source. A scenario could occur where an animal does not leave the vicinity of a ship or travels a course parallel to the ship, however, as indicated in Table 6-7, the distances required make a second PTS exposure unlikely. For a Navy vessel moving at a nominal 10 knots, it is unlikely a marine mammal could maintain the speed to parallel the ship and receive adequate energy over successive pings to suffer PTS. For all sources except hull-mounted sonar (e.g., SQS-53 and BQQ-10) ranges to PTS are well within 22 m, even for multiple pings (up to ten pings examined) and the most sensitive functional hearing group (high-frequency cetaceans).

Table 6-8: Non-Impulsive Approximate Range to Permanent Threshold Shift for Three Representative Sonar Systems for a Single Ping

Functional Hearing Group	Approximate PTS Maximum Ranges (meters)[1]		
	Sonar Bin MF1 (e.g., SQS-53; ASW Hull Mounted Sonar)	Sonar Bin MF4 (e.g., AQS-22; ASW Dipping Sonar)	Sonar Bin MF5 (e.g., SSQ-62; ASW Sonobuoy)
Low-Frequency Cetaceans	67	8	1
Mid-Frequency Cetaceans	10	2	1
High-Frequency Cetaceans	100	22	7
Phocid Pinniped	79	10	2
Otariid Pinniped	6	0	0

ASW: anti-submarine warfare; MIW: mine warfare; PTS: permanent threshold shift.
[1] PTS ranges extend from the sonar or other active acoustic sound source to the indicated distance.

TTS: Table 6-8 illustrates the range to TTS for one, five, and ten pings from four representative sonar systems. Due to the lower acoustic thresholds for TTS versus PTS, ranges to TTS are longer. Therefore,

successive pings can be expected to add together, further increasing the range to onset-TTS. For hull mounted sonar (e.g., the SQS-53), mid-frequency cetaceans have TTS ranges of up to 183 m for one ping; up to 419 m for five pings; and up to 590 m for ten pings. For all other sonar and other active acoustic sources, the range to TTS for up to ten pings is within 50 m for mid-frequency cetaceans, making any hearing loss in these species from these sources very unlikely. Phocid seals have TTS ranges approximately 2,275 m for ten pings from an anti-submarine warfare hull mounted sonar, but less than 153 m and often less than 50 m for all other sonar and active acoustic systems. Low-frequency cetaceans (mysticetes) have TTS ranges for ten pings from anti-submarine warfare hull mounted sonar (e.g., SQS-53) of approximately 4,323 m. Ten pings from an anti-submarine warfare dipping sonar (e.g., AQS-22) would produce a TTS zone of approximately328 m, with all other active systems producing ranges to TTS of less than 50 m for mysticetes. Ranges to TTS for high-frequency cetaceans are extensive based on a low acoustic effects threshold for these apparently sensitive species. For a hull mounted sonar (e.g., SQS-53), ranges to TTS for high-frequency cetaceans are1,076 m for one ping, 3,025 m for five pings, and 4,323 m for ten pings. Ranges to TTS for high-frequency cetaceans are much shorter for all other systems: anti-submarine warfare dipping sonar are approximately 90 m for one ping and up to 328 m for ten pings; sonobuoys and mine warfare mine hunting sonar are less than 50 m for one to ten pings.

Table 6-9: Non-Impulsive Range to Temporary Threshold Shift for Three Representative Sonar Systems

Functional Hearing Group	Approximate TTS Ranges (meters)[1]								
	Sonar Bin MF1 (e.g., SQS-53; ASW Hull Mounted Sonar)			Sonar Bin MF4 (e.g., AQS-22; ASW Dipping Sonar)			Sonar Bin MF5 (e.g., SSQ-62; ASW Sonobuoy)		
	One Ping	Five Pings	Ten Pings	One Ping	Five Pings	Ten Pings	One Ping	Five Pings	Ten Pings
Low-Frequency Cetaceans	665	1,487	2,103	80	180	255	11	25	35
Mid-Frequency Cetaceans	100	224	316	20	46	65	6	13	18
High-Frequency Cetaceans	1,000	2,235	3,161	215	482	681	67	150	213
Phoicd Pinnipeds	397	888	1,256	50	112	158	8	18	25
Otariid Pinnipeds	28	63	89	4	8	11	1	1	2

ASW: anti-submarine warfare; TTS: temporary threshold shift.
[1] Ranges to TTS represent the sound energy loss due to spherical spreading to reach the furthest distance to the effect criteria.

Behavioral: The range to 6-dB from four representative sonar sources and the percentage of animals that may exhibit a significant behavioral response under the mysticete and odontocete behavioral response function are shown in Table 6-9, respectively. See Section 6.4.3 for details on the derivation and use of the behavioral response function as well as the step function thresholds for beaked whales of 120 dB re 1 µPa and 140 dB re 1 µPa, respectively. Range to 120 dB re 1 µPa varies by system, but can exceed 107 mi. (173 km) for the most powerful hull mounted sonar; however, only a very small percentage of animals would be predicted to react at received levels between 120 and 130 dB re 1 µPa. Beaked whales would be predicted to have behavioral reactions at distances out to approximately 68 mi. (109 km).

Table 6-10: Non-Impulsive Range in 6-dB Bins and Percentage of Behavioral Harassments in Each Bin under Behavioral Risk Functions for Four Representative Sonar Systems

Received Level	Sonar Bin MF1 (e.g., SQS-53; ASW Hull Mounted Sonar)		Sonar Bin MF4 (e.g., AQS-22; ASW Dipping Sonar)		Sonar Bin MF5 (e.g., SSQ-62; ASW Sonobuoy)		Sonar Bin HF4 (e.g., SQQ-32; MIW Sonar)	
	Distance at Which Levels Occur Within Radius of Source (m)	Percentage of Behavioral Harassments Occurring at Given Levels	Distance at Which Levels Occur Within Radius of Source (m)	Percentage of Behavioral Harassments Occurring at Given Levels	Distance at Which Levels Occur Within Radius of Source (m)	Percentage of Behavioral Harassments Occurring at Given Levels	Distance at Which Levels Occur Within Radius of Source (m)	Percentage of Behavioral Harassments Occurring at Given Levels
Low Frequency Cetaceans								
120 ≤SPL <126	172,558 – 162,925	0.00%	40,000 – 40,000	0.00%	23,880 – 17,330	0.00%	3,100 – 2,683	0.00%
126 ≤SPL <132	162,925 – 117,783	0.00%	40,000 – 40,000	0.00%	17,330 – 12,255	0.10%	2,683 – 2,150	0.01%
132 ≤SPL <138	117,783 – 108,733	0.04%	40,000 – 12,975	3.03%	12,255 – 7,072	4.12%	2,150 – 1,600	0.48%
138 ≤SPL <144	108,733 – 77,850	1.57%	12,975 – 12,800	0.14%	7,072 – 3,297	23.69%	1,600 – 1,150	4.20%
144 ≤SPL <150	77,850 – 58,400	5.32%	12,800 – 6,525	27.86%	3,297 – 1,113	42.90%	1,150 - 575	24.79%
150 ≤SPL <156	58,400 – 53,942	4.70%	6,525 – 2,875	36.83%	1,113 - 255	24.45%	575 - 300	28.10%
156 ≤SPL <162	53,942 – 8,733	83.14%	2,875 – 1,088	23.78%	255 - 105	3.52%	300 - 150	24.66%
162 ≤SPL <168	8,733 – 4,308	3.51%	1,088 - 205	7.94%	105 - 55	1.08%	150 - 100	9.46%
168 ≤SPL <174	4,308 – 1,950	1.31%	205 - 105	0.32%	55 - 55	0.00%	100 - <50	8.30%
174 ≤SPL <180	1,950 - 850	0.33%	105 - 55	0.10%	55 - 55	0.00%	<50	0.00%
180 ≤SPL <186	850 - 400	0.06%	55 - <50	0.01%	55 - <50	0.13%	<50	0.00%
186 ≤SPL <192	400 - 200	0.01%	<50	0.00%	<50	0.00%	<50	0.00%
192 ≤ SPL <198	200 - 100	0.00%	<50	0.00%	<50	0.00%	<50	0.00%
Mid-Frequency Cetaceans								
120 ≤ SPL <126	172,592 – 162,933	0.00%	40,000 – 40,000	0.00%	24,205 – 18,872	0.00%	4,133 – 3,600	0.00%
126 ≤ SPL <132	162,933 – 124,867	0.00%	40,000 – 40,000	0.00%	18,872 – 12,697	0.10%	3,600 – 3,075	0.00%
132 ≤ SPL <138	124,867 – 108,742	0.07%	40,000 – 12,975	2.88%	12,697 – 7,605	3.03%	3,075 – 2,525	0.01%
138 ≤ SPL <144	108,742 – 78,433	1.54%	12,975 – 12,950	0.02%	7,605 – 4,080	17.79%	2,525 – 1,988	0.33%
144 ≤ SPL <150	78,433 – 58,650	5.41%	12,950 – 6,725	26.73%	4,080 – 1,383	46.83%	1,988 – 1,500	2.83%
150 ≤ SPL <156	58,650 – 53,950	4.94%	6,725 – 3,038	36.71%	1,383 - 300	27.08%	1,500 – 1,000	14.92%
156 ≤ SPL <162	53,950 – 8,925	82.62%	3,038 – 1,088	25.65%	300 - 155	3.06%	1,000 - 500	40.11%
162 ≤ SPL <168	8,925 – 4,375	3.66%	1,088 - 255	7.39%	155 - 55	2.02%	500 - 300	22.18%
168 ≤ SPL <174	4,375 – 1,992	1.34%	255 - 105	0.52%	55 - 55	0.00%	300 - 150	14.55%
174 ≤ SPL <180	1,992 - 858	0.34%	105 - 55	0.09%	55 - 55	0.00%	150 - <50	5.07%
180 ≤ SPL <186	858 - 408	0.06%	55 - <50	0.01%	55 - <50	0.09%	<50	0.00%
186 ≤ SPL <192	408 - 200	0.01%	<50	0.00%	<50	0.00%	<50	0.00%
192 ≤ SPL <198	200 - 100	0.00%	<50	0.00%	<50	0.00%	<50	0.00%

ASW: anti-submarine warfare; MIW: mine warfare; m: meter; SPL: sound pressure level

Avoidance Behavior and Mitigation Measures as Applied to Sonar and Active Acoustic Sources - As discussed above, within the Navy Acoustic Effects Model, animats do not move horizontally or react in any way to avoid sound at any level. Furthermore, mitigation measures that are implemented during training and testing activities that reduce the likelihood of physiological impacts are not considered. Therefore, the model overestimates acoustic impacts, especially physiological impacts near the sound source. Various researchers have demonstrated that cetaceans can perceive the movement of a sound source (e.g., vessel, seismic source, etc.) relative to their own location and react with responsive movement, often at distances of a kilometer or more (Au and Perryman 1982; Jansen et al. 2010; Palk and Hammond 2001; Richardson et al. 1995; Tyack et al. 2010; Watkins 1986; Wursig et al. 1998; Tyack 2009b). See Section 6.4.3, Behavioral Responses, for a review of research and observations of marine mammals' reactions to vessels and active sound sources. The behavioral criteria used as a part of this analysis acknowledges that a behavioral reaction is likely to occur at levels below those required to cause hearing loss (TTS or PTS) or higher order physiological impacts. At close ranges and high sound levels approaching those that could cause PTS, avoidance of the area immediately around the sound source is the assumed behavioral response for most cases. Additionally, the Navy Acoustic Effects Model does not account for the implementation of mitigation, which would prevent many of the model-estimated PTS effects. Therefore, the model-estimated PTS effects due to sonar and other active acoustic sources are further analyzed considering avoidance and implementation of mitigation measures.

If sound-producing activities are preceded by multiple vessel traffic or hovering aircraft, beaked whales are assumed to move beyond the range to PTS before sound transmission begins, as discussed above in Avoidance of Human Activity. Table 6-7 shows the ranges to PTS for several sonar systems, including the most powerful system, the SQS-53 in bin MF1. The range to PTS for all systems is generally much less than 100 m, with the exception of high-frequency cetaceans exposed to bin MF1 with a PTS range of approximately 100 m. Because the Navy Acoustic Effects Model does not include avoidance behavior, the model-estimated effects are based on unlikely behavior for these species- that they would tolerate staying in an area of high human activity. Beaked whales that were model-estimated to experience PTS due to sonar and other active acoustic sources are assumed to actually move into the range of TTS prior to the start of the sound-producing activity for the activities listed in Tables 6-10 and 6.11.

Table 6-11: Activities Using Sonar and Other Active Acoustic Sources Preceded by Multiple Vessel Movements or Hovering Helicopters

Training
Airborne Mine Countermeasure - Mine Detection
Maritime Homeland Defense/Security Mine Countermeasures
Composite Training Unit Exercise
Group Sail
Integrated Anti-Submarine Warfare Course
Joint Task Force Exercise/Sustainment Exercise
Kilo Dip
Mine Countermeasures Exercise-MCM Sonar - Ship Sonar
Tracking Exercise/ Torpedo Exercise-Helicopter

Table 6-10: Activities Using Sonar and Other Active Acoustic Sources Preceded by Multiple Vessel Movements or Hovering Helicopters (continued)

Testing
Airborne Towed Minehunting Sonar System Test
Anti-Submarine Warfare Mission Package Testing
Anti-Submarine Warfare Tracking Test - Helicopter
Mine Countermeasure Mission Package Testing
Mine Countermeasure/Neutralization Testing
Mine Detection and Classification Testing
Sonobuoy Lot Acceptance Test
Torpedo (Explosive) Testing
Torpedo (Non-Explosive) Testing

The Navy Acoustic Effects Model does not consider mitigation, discussed in detail in Chapter 11 (Means of Effecting the Least Practicable Adverse Impacts – Mitigation Measures). As explained in Section 6.3.1.2, to account for the implementation of mitigation measures, the acoustic effects analysis assumes a model-estimated PTS would not occur if an animal at the water surface would likely be observed during those activities with dedicated Lookouts up to and during use of the sound source, considering the mitigation effectiveness (see Table 6-12) and sightability of a species based on g(0) (see Table 6-6). The model-estimated PTS are reduced by the portion of animals that are likely to be seen (Mitigation Effectiveness x Sightability); these animals are instead assumed to be present within the range to TTS.

Animal avoidance of the area immediately around the sonar or other active acoustic system, coupled with mitigation measure designed to avoid exposing animals to high energy levels, would make the majority of model-estimated PTS to mid-frequency cetaceans unlikely. The maximum ranges to onset PTS for mid-frequency cetaceans and pinnipeds (Table 6-7) do not exceed 79 m in any environment modeled for the most powerful non-impulsive acoustic sources, hull-mounted sonar (e.g., Bin MF1; SQS-53C). In fact, the single ping range to PTS for mid-frequency cetaceans due to the SQS-53 is 10 m, and the PTS range for five pings is about 20 m. Ranges to PTS for low-frequency cetaceans and high-frequency cetaceans (Table 6-7) do not exceed 67 m and 100 m, respectively. Considering vessel speed during anti-submarine warfare activities normally exceeds 10 knots, and sonar pings occur about every 50 seconds, even for the MF1 an animal would have to maintain a position within a 20 m radius in front of or alongside the moving the ship for over 3 minutes (given the time between five pings) to experience PTS. Additionally, odontocetes have been demonstrated to have directional hearing, with best hearing sensitivity facing a sound source (Mooney et al. 2008; Popov and Supin 2009; Kastelein et al. 2005). An odontocete avoiding a source would receive sounds along a less sensitive hearing axis, potentially reducing impacts. All model-estimated PTS to mid-frequency cetaceans, therefore, are considered to actually be TTS due to the likelihood that an animal would be observed if it is present within the very short range to PTS effects.

Table 6-12: Consideration of Mitigation in Acoustic Effects Analysis for Sonar and Other Active Acoustic Sources

Activity[1]	Mitigation Effectiveness Factor for Acoustic Analysis	Mitigation Platform
Training		
Airborne Mine Countermeasure - Mine Detection	1	Aircraft
Maritime Homeland Defense/Security Mine Countermeasures	1	Vessel
COMPTUEX	1	Vessel
IAC	1	Vessel
JTFEX/SUSTAINEX	1	Vessel
Group Sail	1	Vessel
Kilo Dip	1	Aircraft
Mine Countermeasures Exercise (MCM) - Ship Sonar	1	Vessel
Mine Neutralization - ROV	1	Vessel
Submarine Sonar Maintenance	0.5	Vessel
Surface Ship Sonar Maintenance	1	Vessel
TRACKEX/TORPEX - MPA Sonobuoy	0.5	Aircraft
TRACKEX/TORPEX - Surface	0.5	Vessel
TRACKEX/TORPEX - Helo	0.5	Aircraft
Testing		
Airborne Mine Hunting Test	1	Aircraft
ASW Tracking Test – Helo	1	Aircraft
ASW Mission Package Testing	0.5	Aircraft
At-Sea Sonar Testing	0.5	Vessel
Combat System Ship Qualification Trials: In-Port	1	Vessel
Combat System Ship Qualification Trials: USW	0.5	Vessel
Countermeasure Testing	0.5	Vessel
Mine Countermeasure/Neutralization Testing	1	Vessel
Mine Detection/Classification Testing	1	Vessel
Pierside Integrated Swimmer Defense	1	Vessel
Pierside Sonar Testing	1	Vessel
Sonobuoy Lot Acceptance Testing	1	Vessel
Submarine Sonar Testing/Maintenance	0.5	Vessel
Surface Combatant Sea Trials: ASW Testing	1	Vessel
Surface Combatant Sea Trials: Pierside Sonar Testing	1	Vessel
Surface Ship Sonar Testing/Maintenance	1	Vessel
Torpedo (Non-Explosive) Testing	0.5	Vessel

[1] If less than half of the mitigation zone can be continuously visually observed or if the mitigation zone cannot be continuously visually observed during most of the scenarios within the activity due to the type of surveillance platform(s), number of lookouts, and size of the mitigation zone, Mitigation is not considered in the acoustic effects analysis of that activity and the activity is not listed in this table.

Marine mammals in other functional hearing groups, if present but not observed by lookouts, are assumed to leave the area near the sound source after the first 3 – 4 pings, thereby reducing sound exposure levels and the potential for PTS. The range to the onset of PTS for low-frequency cetaceans does not exceed 67 m; for phocid seals does not exceed and 79 m; and for high-frequency cetaceans does not exceed 100 m in any environment for the most powerful active acoustic sources, hull-mounted sonars (e.g., source class MF1: AN/SQS-53C). As stated above, odontocetes, including high-frequency cetaceans, may also minimize sound exposure during avoidance due to directional hearing. During the first few pings of an event, or after a pause in sonar operations, if animals are caught unaware and mitigation measures are not yet implemented (e.g., animals are at depth and not visible at the surface) it is possible that they could receive enough acoustic energy to suffer PTS. Only these initial exposures resulting in model-estimated PTS are expected to actually occur. The remaining model-estimated PTS are considered to be TTS due to avoidance.

6.3.2.3 Impulsive (In-Water Explosives)

Explosions associated with Navy proposed training and testing activities could occur throughout the Study Area. These activities include amphibious warfare, strike warfare, anti-surface warfare, anti-submarine warfare, and mine warfare. Activities that involve explosions are described in Chapter 2. Predicted impacts on marine mammals from at-sea explosions are based on a modeling approach that considers many factors. The equations for the models consider the net explosive weight, the properties of detonations underwater, and environmental factors such as depth of the explosion, overall water depth, water temperature, and bottom type. The net explosive weight accounts for the mass and type of explosive material. Section 6.3 presents a review of observations and experiments involving marine mammals and reactions to impulsive sounds and underwater detonations. Energy from explosions is capable of causing mortality, injury to the lungs or gastrointestinal tract, permanent or TTS, or a behavioral response depending on the level of exposure. The death of an animal will, of course, eliminate future reproductive potential and cause a long-term consequence for the individual that must then be considered for potential long-term consequences for the population.

Exposures that result in long-term injuries such as PTS may limit an animal's ability to find food, communicate with other animals, or interpret the environment around them. Impairment of these abilities can decrease an individual's chance of survival or impact its ability to successfully reproduce. TTS can also impair animal's abilities, but the individual may recover quickly with little significant effect. Behavioral responses can include shorter surfacings, shorter dives, fewer blows (breaths) per surfacing, longer intervals between blows, ceasing or increasing vocalizations, shortening or lengthening vocalizations, and changing frequency or intensity of vocalizations (National Research Council of the National Academies 2005). However, it is not clear how these responses relate to long-term consequences for the individual or population (National Research Council of the National Academies 2005). Explosions in the ocean or near the water surface can introduce loud, impulsive, broadband sounds into the marine environment. These sounds are likely within the audible range of most cetaceans, but the duration of individual sounds is very short. The direct sound from explosions used during Navy training and testing activities last less than a second, and most events involve the use of only one or a few explosions. Furthermore, events are dispersed in time and throughout the Study Area. These factors reduce the likelihood of these sources causing substantial auditory masking in marine mammals.

6.3.2.4 Range to Impulsive Effects

Table 6-12 shows the minimum and maximum ranges to the potential effect based on the thresholds described in Section 6.4. Ranges for onset slight lung injury and onset mortality are based on the smallest and largest calf weight in each category and represent conservative estimates (i.e., longer ranges) based on assuming all impulses are one second in duration. In fact, most impulses are much less than one second and therefore contain less energy than what is being used to produce the estimated ranges below.

Avoidance Behavior and Mitigation Measures as Applied to Explosions - As discussed above, within the Navy Acoustic Effects Model, animats (virtual animals) do not move horizontally or react in any way to avoid sound at any level. In reality, various researchers have demonstrated that cetaceans can perceive the location and movement of a sound source (e.g., vessel, seismic source, etc.) relative to their own location and react with responsive movement away from the source, often at distances of a kilometer or more (Au and Perryman 1982; Jansen et al. 2010; Richardson et al. 1995b)(Tyack et al. 2011; Watkins 1986; Wursig et al. 1998). Section 6.3 (Analysis Background and Framework) reviews research and

observations of marine mammals' reactions to sound sources including seismic surveys and explosives. The Navy Acoustic Effects Model also does not account for the implementation of mitigation, which would prevent many of the model-predicted injurious and mortal exposures to explosives. Therefore, the model-estimated mortality and Level A effects are further analyzed considering avoidance and implementation of mitigation measures (Section 6.5).

Table 6-13: Average Approximate Range to Effects from a Single Explosion for Marine Mammals across Representative Acoustic Environments within the Study Area

Hearing Group Criteria / Predicted Impact	Average Approximate Range (meters) to Effects for Sample Explosive Bins					
	Bin E3 (0.6-2.6 lb NEW)	Bin E5 (6-10 lb. NEW)	Bin E7 (21-60 lb. NEW)	Bin E9 (101-250 lb. NEW)	Bin E10 (251-500 lb. NEW)	Bin E12 (>650-1,000 lb. NEW)
Low-frequency Cetaceans (calf weight 200 kg)						
Onset Mortality	10	20	80	65	80	95
Onset Slight Lung Injury	20	40	165	110	135	165
Onset Slight GI Tract Injury	40	80	150	145	180	250
PTS	85	170	370	255	305	485
TTS	215	445	860	515	690	1,760
Behavioral Response	320	525	1,290	710	905	2,655
Mid-frequency Cetaceans (calf weight 5 kg)						
Onset Mortality	25	45	205	135	165	200
Onset Slight Lung Injury	50	85	390	235	285	345
Onset Slight GI Tract Injury	40	80	150	145	180	250
PTS	35	70	160	170	205	265
TTS	100	215	480	355	435	720
Behavioral Response	135	285	640	455	555	970
High-Frequency Cetaceans (calf weight 4 kg)						
Onset Mortality	30	50	225	145	175	215
Onset Slight Lung Injury	55	90	425	250	305	370
Onset Slight GI Tract Injury	40	80	150	145	180	250
PTS	140	375	710	470	570	855
TTS	500	705	4,125	810	945	2,415
Behavioral Response	570	930	5,030	2,010	4,965	5,705
Otariidae (pup weight 4 kg)						
Onset Mortality	35	65	285	175	215	260
Onset Slight Lung Injury	70	115	530	307	370	450
Onset Slight GI Tract Injury	40	8	150	145	180	250
PTS	30	50	30	50	85	150
TTS	40	85	210	220	260	400
Behavioral Response	60	145	305	300	350	530
Phocinea (pup weight 4 kg						
Onset Mortality	30	50	240	150	185	225
Onset Slight Lung Injury	60	100	445	265	320	385
Onset Slight GI Tract Injury	40	80	150	145	180	250
PTS	95	180	410	340	445	680
TTS	235	500	1,215	665	815	1,350
Behavioral Response	345	600	1,575	815	950	1,685

If explosive activities are preceded by multiple vessel traffic or hovering aircraft, harbor porpoises and beaked whales are assumed to move beyond the range to onset mortality before detonations occur. Table 6-13 shows the ranges to onset mortality for mid-frequency and high frequency cetaceans for a representative range of charge sizes. The range to onset mortality for all net explosive weights is less than 260 m, which is conservatively based on range to onset mortality for a calf. Because the Navy Acoustic Effects Model does not include avoidance behavior, the model-estimated mortalities are based on unlikely behavior for these species- that they would tolerate staying in an area of high human activity. Therefore, harbor porpoises and beaked whales that were model-estimated to experience mortality are assumed to move into the range of potential injury prior to the start of the explosive activity for the activities listed in Table 6-14.

Table 6-14: Activities Using Explosives Preceded by Multiple Vessel Movements or Hovering Helicopters

Training
Missile Exercise (Air-to-Surface)
Missile Exercise (Air-to-Surface) – Rocket
Mine Countermeasure (MCM) – Mine Neutralization
Maritime Homeland Defense/Security Mine Countermeasures
Gunnery Exercise (Surface-to-Surface) Ship/Boat – Medium-caliber
Composite Training Unit Exercise
Fire Support Exercise – at Sea
Group Sail
Joint Task Force Exercise/Sustainment Exercise
Mine Neutralization – Explosive Ordnance Disposal
Mine Neutralization - Remotely Operated Vehicle
Sinking Exercise
Underwater Demolition
Testing
Airborne Towed Minesweeping System Test
Anti-Submarine Warfare Tracking Test - Helicopter
Mine Countermeasure Mission Package Testing
Mine Countermeasure/Neutralization Testing
Rocket Test
Sonobuoy Lot Acceptance Testing
Torpedo (explosive) Testing

The Navy Acoustic Effects Model does not consider mitigation, discussed in detail in Chapter 11 (Means of Effecting the Least Practicable Adverse Impacts – Mitigation Measures). As explained in Section 6.3.1.2, to account for the implementation of mitigation measures, the acoustic analysis assumes a model-predicted mortality or injury would not occur if an animal at the water surface would likely be observed during those activities with dedicated Lookouts up to and during the use of explosives, considering the mitigation effectiveness (see Table 6-14) and sightability of a species based on g(0) (see Table 6-5). The mitigation effectiveness is considered over two regions of an activity's mitigation zone: (1) the range to onset mortality closer to the explosion and (2) range to onset PTS. The model-estimated mortalities and injuries are reduced by the portion of animals that are likely to be seen [Mitigation Effectiveness x Sightability, g(0)]; these animals are instead assumed to be present within the range to injury and range to TTS, respectively.

Table 6-15: Consideration of Mitigation in Acoustic Effects Analysis for Explosives

Activity[1]	Mitigation Effectiveness Factor for Acoustic Analysis		Mitigation Platform
	Injury Zone[2]	Mortality Zone	
Training			
[A-S] GUNEX (HF/Pinniped)	0.5	0.5	Aircraft
[A-S] GUNEX (MF/LF)	1	1	Aircraft
Airborne Mine Neutralization Systems (HF/Pinniped)	0	1	Both[3]
Airborne Mine Neutralization Systems (MF/LF)	1	1	Both[3]
Airborne Projectile-Based Mine Clearance System (HF/Pinniped)	0	1	Both[3]
Airborne Projectile-Based Mine Clearance System (MF/LF)	1	1	Both[3]
BOMBEX [A-S] (HF/Pinniped/LF)	0	1	Aircraft
BOMBEX [A-S] (MF)	0.5	1	Aircraft
Maritime Homeland Defense/Security Mine Countermeasures	1	1	Vessel
COMPTUEX (IEER/ MINEX)	0.5	0.5	Both[3]
FIREX At Sea	0	0	Vessel
Group Sail (IEER)	0.5	0.5	Aircraft
GUNEX [A-S] - Medium Caliber	1	1	Aircraft
GUNEX [S-S] - Boat - Medium Caliber (HF/Pinniped)	0.5	0.5	Vessel
GUNEX [S-S] - Boat - Medium Caliber (MF/LF)	1	1	Vessel
GUNEX [S-S] - Ship - Medium Caliber (HF/Pinniped)	0.5	0.5	Vessel
GUNEX [S-S] - Ship - Medium Caliber (MF/LF)	1	1	Vessel
GUNEX [S-S] - Ship - Large Caliber	0	0	Vessel
GUNEX [A-S] - Rocket	0	0	Aircraft
JTFEX-SUSTAINEX/SUSTAINEX (IEER)	0.5	0.5	Aircraft
Mine Neutralization - EOD	0.5	1	Vessel
Mine Neutralization - ROV	1	1	Vessel
MISSILEX [A-S]	0	0	Aircraft
SINKEX (HF/LF/Pinniped)	0.5	1	Aircraft
SINKEX (MF)	0.5	1	Aircraft
TRACKEX/TORPEX - MPA Sonobuoy	0.5	0.5	Aircraft
UNDET	1	1	Vessel
Testing			
Airborne Towed Mine Sweeping Test (HF/Pinniped)	0	1	Both[3]
Airborne Towed Mine Sweeping Test (MF/LF)	1	1	Both[3]
ASW Tracking Test - Helo	0.5	0.5	Aircraft
ASW Tracking Test - MPA	0	0	Aircraft
MCM Mission Package Testing	1	1	Vessel
Mine Countermeasure/Neutralization Testing	1	1	Vessel
Pierside Integrated Swimmer Defense	0	0	Vessel
Rocket Test	0	0	Aircraft
Sonobuoy Lot Acceptance Testing	1	1	Vessel
SUW Mission Package Testing	0	0	Vessel
Torpedo (Explosive) Testing	0.5	1	Aircraft

[1] Ranges to effect differ for functional hearing groups based on weighted threshold values. HF: high frequency cetaceans; MF: mid-frequency cetaceans; LF: low frequency cetaceans

[2] No value provided if mitigation across the injury zone was not considered in the acoustic effects analysis.

[3] Activity employs both vessel and aircraft based lookouts. The larger g(0) value (aerial or vessel) is used.

During an activity with a series of explosions (not concurrent multiple explosions), an animal is expected to exhibit an initial startle reaction to the first detonation followed by a behavioral response after multiple detonations. At close ranges and high sound levels approaching those that could cause PTS, avoidance of the area around the explosions is the assumed behavioral response for most cases. The ranges to PTS for each functional hearing group for a range of explosive sizes (single detonation) are shown in Table 6-12. Animals not observed by lookouts within the ranges to PTS at the time of the initial couple of explosions are assumed to experience PTS; however, animals that exhibit avoidance reactions beyond the initial range to PTS are assumed to move away from the expanding range to PTS effects with each additional explosion. Additionally, odontocetes have been demonstrated to have directional hearing, with best hearing sensitivity facing a sound source (Mooney et al. 2008; Popov and Supin 2009; Kastelein et al. 2005). An odontocete avoiding a source would receive sounds along a less sensitive hearing axis, potentially reducing impacts. Because the Navy Acoustic Effects Model does not account for avoidance behavior, the model-estimated effects are based on unlikely behavior that animals would remain in the vicinity of potentially injurious sound sources. Therefore, only the initial exposures resulting in model-estimated PTS are expected to actually occur. The remaining model-estimated PTS are considered to be TTS due to avoidance.

Table 6-16: Activities with Multiple Non-concurrent Explosions

Training
Airborne Mine Neutralization Systems
Airborne Projectile-Based Mine Clearance System
BOMBEX [A-S]
Civilian Port Defense
FIREX
GUNEX [S-S] - Ship - Large Caliber
Mine Neutralization - EOD
Mine Neutralization - ROV
SINKEX
Testing
MCM Mission Package Testing
Mine Countermeasure/Neutralization Testing
Sonobuoy Lot Acceptance Testing

This acoustic effects analysis uses the Navy Acoustic Effects Model followed by post-model consideration of avoidance and implementation of mitigation to predict effects using the explosive criteria and thresholds.

The Navy Acoustic Effects Model does not account for several factors that must be considered in the overall explosive analysis. When there is uncertainty in model input values, a conservative approach is often chosen to assure that potential effects are not under-estimated. As a result, the Navy Acoustic Effects Model provides estimates that are conservative (over-estimates the likely impacts). The following is a list of several such factors that cause the model to overestimate potential effects:

- The onset mortality criterion is based on one percent of the animals receiving an injury that would not be recoverable and lead to mortality. Therefore, many animals that are estimated to suffer mortality in this analysis may actually recover from their injuries.
- The onset slight lung injury criteria is based on one percent of the animals exposed at the threshold receiving a slight lung injury in which full recovery would be expected. Therefore, many animals that are estimated to suffer slight lung injury in this analysis may actually not incur injuries.

- The metrics used for the threshold for slight lung injury and mortality (i.e., acoustic impulse) are based on the animal's mass. The smaller an animal, the more susceptible that individual is to these effects. In this analysis, all individuals of a given species are assigned the weight of that species newborn calf or pup weight. Since many individuals in a population are obviously larger than a newborn calf or pup of that species, this assumption causes the acoustic model to overestimate the number of animals that may suffer slight lung injury or mortality. As discussed in the explanation of onset mortality and onset slight lung injury criteria, the volumes of water in which the threshold for onset mortality may be exceeded are generally less than a fifth for an adult animal versus a calf.
- Many explosions from ordnances such as bombs and missiles actually occur upon impact with above-water targets. However, for this analysis, sources such as these were modeled as exploding at 1 m depth. This overestimates the amount of explosive and acoustic energy entering the water and therefore overestimates effects on marine mammals.

6.3.3 Estimated Take of Marine Mammals by Elevated Causeway System Pile Driving and Removal

Underwater noise associated with Elevated Causeway System (ELCAS) training includes impulsive sounds resulting from driving and removing piles into the soft sandy substrate of the Silver Strand Training Complex (SSTC) and Camp Pendleton oceanside waters to temporarily support a causeway of linked pontoons. Two hammer-based methods will be used to install/remove ELCAS piles: impact pile driving for installation and vibratory driving for removal. The impact hammer is a large metal ram attached to a crane. A vertical support holds the pile in place and the ram is dropped or forced downward. The energy is then transferred to the pile which is driven into the seabed. The ram is typically lifted by a diesel power source.

ELCAS events would occur up to four times a year at either a dedicated training lane within San Diego Bay (Bravo Beach), in the oceanside training lanes at SSTC, or the oceanside landing beaches at Camp Pendleton. Pile installation occurs over a period of approximately 10 days and pile removal over approximately three days. Approximately 101 piles are driven in a typical ELCAS training event, with around 250 to 300 impacts per pile, and each pile taking on average 10 minutes to install. The ELCAS is then used for a period of time, usually less than two weeks to transfer cargo back and forth from sea to shore.

At the end of the all ELCAS training, a vibratory hammer attached to the pile head will be used to remove piles by applying a rapidly alternating force to the pile by rotating eccentric weights about shafts, resulting in an upward vibratory force on the pile. The vertical vibration in the pile disturbs or "liquefies" the sediment next to the pile causing the sediment particles to lose their frictional grip on the pile. This also allows sediment to fill back into the hole that is left after the pile is removed.

The available scientific literature suggest that introduction of pile driving into the marine environment could result in short term behavioral and/or physiological marine mammal impacts such as: altered headings; increased swimming rates; changes in dive, surfacing, respiration, feeding, and vocalization patterns; masking, and hormonal stress production (Southall et al. 2007); however some field studies also suggest marine mammals may or may not observably respond to construction type sounds such as drilling and pile driving (e.g., California Department of Transportation 2001; Moulton et al. 2005; Richardson et al. 1990, 1991). Individual animal responses are likely to be highly variable depending on situational state, and prior experience or habituation. Southall et al. 2007 point out that careful

distinction must be made of brief minor, biologically unimportant reactions as compared to profound, sustained or biologically meaningful responses related to growth, survival, and reproduction.

6.3.3.1 Predictive Modeling for ELCAS Events (Pile Driving and Removal)

The methodology for quantifying sound effects from ELCAS events is similar to that of other impulsive sources such as underwater explosives. The ELCAS modeling includes two steps used to calculate potential effects:

1. Estimate the area of influence for Level A injurious and Level B behavioral exposures for both impact pile driving and vibratory pile removal using the practical spreading loss equation (California Department of Transportation 2009).
2. Estimate the number of species exposed using species density estimates and estimated areas of influence.

The practical spreading loss equation is typically used to estimate the attenuation of underwater sound over distance (Urick 1982; Urick 1983). NOAA and USFWS have accepted the use of the practical spreading loss equation to estimate transmission loss of sound through water for past pile driving calculations (California Department of Transportation 2009).

The formula for this propagation loss can be expressed as:

$$TL = F * \log (D1/D2)$$

Where: TL = transmission loss (the sound pressure level at D1 minus the sound pressure level at D2, in RMS, dB re 1µPa)
F = attenuation constant
D1 = distance at which the targeted transmission loss occurs
D2 = distance from which the transmission loss is calculated

The attenuation constant (F) is a site-specific factor based on several conditions, including water depth, pile type, pile length, substrate type, and other factors. Measurements conducted by the California Department of Transportation and other consultants (Greeneridge Science) indicate that the attenuation constant (F) can vary from 5 to 30. For pile driving sounds, large piles produce lower frequency sounds that can propagate further than smaller piles which produce higher frequency sound. Small-diameter steel H-type piles have been found to have high F values in the range of 20 to 30 near the pile (i.e., between 30-60 feet) (California Department of Transportation 2009). In the absence of empirically measured values at SSTC or Camp Pendleton, the Navy set F value as F=15 to conservatively over-predict sound propagation and the resulting areas of influence.

6.3.3.2 Areas of Influence for ELCAS Events

Actual underwater noise levels of ELCAS pile driving depend on the type of hammer used, the size and material of the pile, and the substrate the piles are being driven into. Using known equipment, installation procedures, and applying certain constants derived from other west coast measured pile driving, predicted underwater sound levels from ELCAS pile driving can be calculated. The ELCAS uses 24-inch diameter hollow steel piles, installed using a diesel impact hammer to drive the piles into the sandy on-shore and near-shore substrate at SSTC or Camp Pendleton. For a dock repair project in Rodeo, California in San Francisco Bay, Root Mean Square (RMS) underwater sound level for a 24-inch steel pipe pile driven with a diesel impact hammer in less than 15 ft. (4.6 m) of water depth was measured at 189

dB re 1uPa from approximately 11 yds (10 m) away. RMS sound level for the same type and size pile also driven with a diesel impact hammer, but in greater than 36 ft. (11 m) of water depth, was measured to be 190 to 194 dB RMS during the Amoco Wharf repair project in Carquinez Straits, Martinez, California (California Department of Transportation 2009). The areas where these projects were conducted have a silty sand bottom with an underlying hard clay layer, which because of the extra effort required to drive into clay, would make these measured pile driving sound levels louder (more conservative) than they would if driving into sandy substrate more typical of California sandy beaches near the SSTC and Camp Pendleton. Given the local bathymetry and smooth sloping sandy bottom at these locations, ELCAS piles will generally be driven in water depths of 36 ft. (11 m) or less.

Therefore, for the purposes of the Navy's ELCAS analysis, both the Rodeo repair project (189 RMS) and the low end of the measured values of the Amoco Wharf repair projects (190 RMS) are considered to be reasonably representative of sound levels that would be expected during ELCAS pile driving at SSTC and Camp Pendleton. For hollow steel piles of similar size as those proposed for the ELCAS (<24-inch diameter) used in Washington State and California pile driving projects, the broadband frequency range of underwater sound was measured between 50 Hz to 10.5 kHz with highest energy at frequencies <1 kHz to 3 kHz (California Department of Transportation 2009). Although frequencies over 10.5 kHz are likely present during these pile driving projects, they are generally not typically measured since field data has shown a decrease in rms to less than 120 dB at frequencies greater than 10.5 kHz (Laughlin 2005, 2007). It is reasonable to assume that ELCAS pile driving would generate similar sound spectra to that measured by California Department of Transportation. The use of previously derived non-region data to generate attenuation constants ("F" values) for the SSTC and Camp Pendleton will be reviewed and compared to empirically measure ELCAS pile driving at the next oceanside ELCAS training event within the region as agreed in previously consultation with NMFS regarding conducting ELCAS events.

ELCAS Pile Driving- For ELCAS training events, using an estimated RMS measurement of 190 dB re 1uPa at 11 yds (10 m) as describe above, the area of influence (AOI) for a 24-inch steel diesel-driven ELCAS pile can be estimated via the practical spreading loss equation to have a radius of:

- 11 yds. (10 m) for Level A injurious harassment for pinnipeds (190 dB RMS);
- 46 yds. (42 m) for Level A injurious harassment for cetaceans (180 dB RMS), and
- 1,094 yds. (1,000 m) for the Level B behavioral harassment (160 dB RMS).

ELCAS pile removal- Underwater noise levels derived from piles removed via vibratory extractor are different than those driven with an impact hammer. Steel pilings and a vibratory driver were used for pile driving at the Port of Oakland (California Department of Transportation 2009). Underwater sound levels during this project for a 24-inch steel pile in 36 ft. (11 m) of water depth was field measured to be 160 dB RMS. The area where this project was conducted (Oakland) has a harder substrate, which because of the extra effort required to drive and remove the pile, would make these measured pile driving sound levels louder than should occur when driving into and removing from SSTC's and Camp Pendleton's sandy bottom substrate. Use of the measured data from Oakland will therefore provide an overestimate erring on the side of being conservative. Using this RMS measurement, the AOI for a 24-inch steel pile removed via a vibratory extractor out to the 120 dB RMS Level B behavioral harassment threshold can be estimated via the practical spreading loss equation to be:

- < 1 yard (< 1 m) yds. for Level A injurious harassment for pinnipeds (190 dB RMS);
- One (1) yard (1 m) for Level A injurious harassment for cetaceans (180 dB RMS), and
- 5,076 yds. (4,642 m) for the Level B behavioral harassment (120 dB RMS).

Table 6-16 tabulates maximum estimated areas of influence for HSTT ELCAS pile driving and removal.

Table 6-17: Maximum Area of Influence for Elevated Causeway System Pile Driving and Removal

	Level B (Continuous noise)	Level B (Impulsive)	Level A (Cetaceans)	Level A (Pinnipeds)
	120 dB RMS	160 dB RMS	180 dB RMS	190 dB RMS
Installation (Pile Driving)	N/A	1,094 yards (1,000 m)	46 yards (42 m)	11 yards (10 m)
Removal (Vibratory)	5,076 yards (4,642 m)	N/A	1 yard (1 m)	< 1 yard (< 1 m)

6.3.3.3 Estimated Marine Mammal Effects From ELCAS Pile Driving And Removal

Using the marine mammal densities derived for the HSTT EIS/OEIS, the number of animals exposed to annual Level B harassment from ELCAS pile driving can be estimated. For this assessment, the Navy predicted that bottlenose dolphin, gray whale, long-beaked common dolphin, Pacific white-sided dolphin, Risso's dolphin, California sea lion, and harbor seal would be the species most likely impacted by ELCAS pile installation and removal.

Assumptions used in this determination are:

1. Pile driving is estimated to occur 10 days per ELCAS training event, with up to four training exercises being conducted per year (40 days per year). Given likely variable training schedules, an assumption was made that approximately 20 of these 40 days would occur during the warm water season, and 20 of the 40 days would occur during the cold water season.
2. Pile removal is estimated to occur an average of 3 days per training exercise, with up to four training exercises being conducted per year (12 days per year). Given likely variable training schedules, an assumption was made that approximately 6 of these 12 days would occur during the warm water season, and 6 of the 12 days would occur during the cold water season.
3. There can be no "fractional" exposures of marine mammals. In other words, there is no exposure to 0.3, 0.5, 0.6, etc. of an animal, but that each instance of exposure gets rounded up to the nearest whole number.

Pile Driving- The Navy used the expression below to estimate potential ELCAS pile driving exposures: [(Area of Influence (π x AOI^2)/2) x warm season marine mammal density x warm season pile driving days] + [Area of Influence (π x AOI^2)/2 x cold season marine mammal density x cold season pile driving days] = annual exposures

With area of influence defined as: π x AOI^2= (3.14 x 1,000 m^2)/2 = 1.57 km^2

Based on the assessments conducted, using the methodology discussed previously, the limitations described in this section, and without consideration of current mitigation measures, the Navy's estimate is that ELCAS pile driving could result in:

Pile Removal- The Navy used the expression below to estimate potential ELCAS pile removal exposures: ([Area of Influence (π x AOI^2) x warm season marine mammal density x warm season pile driving days] + [Area of Influence (π x AOI^2) x cold season marine mammal density x cold season pile driving days] = annual exposures

With area of influence defined as: $\pi x\ AOI^2 = (3.14 \times 4{,}642\ m^2)/2 = 33.8\ km^2$

Table 6-17 summarizes species specific effects from both ELCAS pile driving and pile removal. These effects have been included in the overall summation of effects presented in Tables 5-1 and 5-2.

Table 6-18: Level B Effects from Elevated Causeway System Pile Driving and Pile Removal

Species		Annual Estimated Effect	
		Level B (Continuous) INSTALLATION	Level B (Impulsive) REMOVAL
		160 dB RMS	120 dB RMS
Cetaceans	Gray whale	4	24
	Bottlenose dolphin (coastal stock)	23	147
	Long-beaked common dolphin	4	23
	Risso's dolphin	8	51
	Pacific white-sided dolphin	3	14
Pinnipeds	Harbor seal	1	6
	California sea lion	17	104
Total Exposures by installation and removal		60	369

Grand Total ALL Level B exposures	
SPECIES	**Total Level B Exposures (installation and removal)**
Gray whale	28
Bottlenose dolphin	170
Long-beaked common dolphin	27
Risso's dolphin	59
Pacific white-side dolphin	17
Harbor seal	7
California sea lion	121

6.3.3.4 Limitations and Conservative Nature of the Elevated Causeway System Effects Assessment

The effects predicted from ELCAS assessment rely on many factors but are influenced greatly by assumptions, methods, and criteria used. The following list of assumptions, caveats, and limitations is not exhaustive but reveals several features of the technical approach that influence exposure prediction:

- Scientific uncertainties are implied and carried forward in any analysis using marine mammal density data as a predictor for animal occurrence within a given geographic area.
- The assessment conservatively assumed (i.e., over predicts) that all ELCAS training would occur along the oceanside of SSTC or Camp Pendleton. In actuality, some ELCAS training may be

conducted in the Bravo Beach training area on the south San Diego Bay side of SSTC. Marine mammals are rarely encountered within this southern portion of San Diego Bay, and given this lack of occurrence, exposures to marine mammals during ELCAS training in the Bay is not expected. By assuming that all ELCAS training would occur on the oceanside, exposure estimates may over represent actual potential exposures. For example, the estimates may be double of what they might actually be if half of the ELCAS training was to occur within San Diego Bay.

- Marine mammals are assumed to be uniformly distributed within the ocean waters adjacent SSTC and Camp Pendleton, when as discussed previously; marine mammal distribution is patchy and occasional at the small scales represented by SSTC and Camp Pendleton.
- The tempo of training events was divided evenly throughout the year with two oceanographic seasons, defined as warm and cold at this location, each having one-half of total events for simulated purposes.
- There are data limitations. Some of the data supporting the analysis was derived from other projects with different environmental and project conditions (pile driving source levels, and transmission loss parameters). As a function of previous Navy permitting for SSTC, the Navy obligated to conduct a one-time in-water sound propagation measurement to verify transmission loss parameters particular to California sandy oceanside beaches.

The ELCAS exposure assessment methodology is an estimate of the numbers of individuals potentially exposed to the effects of ELCAS pile driving and removals that exceed NMFS established thresholds. Of significant note in these exposure estimates, mitigation methods were not quantified within the assessment and successful implementation of mitigation is not reflected in exposure estimates. While the numbers generated from the ELCAS exposure calculations provide conservative overestimates of marine mammal exposures for consultation with NMFS, the short duration and limited geographic extent of ELCAS training would further limit actual exposures.

6.3.4 Estimated Take of Large Whales by Vessel Strike

Worldwide, many cetacean species have been documented to have been hit by transiting surface vessels (Carillo and Ritter 2010; Douglas et al. 2008; Félix and Van Waerebeek 2005; Glass et al. 2009; Jensen and Silber 2003; Laist et al. 2001; Lammers et al. 2003; Pace 2011; Richardson et al. 1995; Ritter 2009; Van Waerebeek et al. 2007), and vessel strikes are known to affect large whales within the HSTT Study Area (Abramson et al. 2009; Berman-Kowalewski et al. 2010; Laggner 2009; Lammers et al. 2003). The ability of a ship to detect a marine mammal and avoid a collision depends on a variety of factors, including environmental conditions, ship design, size, speed, and manning, as well as the behavior of the animal. Key points in discussion of Navy vessels in relationship to potential ship strike include:

- Many Navy ships have their bridges positioned closer to the bow, offering good visibility ahead of the ship;
- There are often aircraft associated with the training or testing activity, which can detect marine mammals in the vicinity or ahead of a vessel's present course.
- Navy ships are generally much more maneuverable than commercial merchant vessels if marine mammals are spotted and the need to change direction necessary. Navy ships operate at the slowest speed possible consistent with either transit needs, or training or testing need (see Table 1-14). While minimum speed is intended as a fuel conservation measure particular to a certain ship class, secondary benefits include better ability to spot and avoid objects in the water including marine mammals. In addition, a standard operating procedure also added as a mitigation measure in previous MMPA permits is for Navy vessels to maneuver to keep at least

500 yds. away from any observed whale in the vessel's path and avoid approaching whales head-on, so long as safety of navigation is not imperiled.

- In many cases, Navy ships will likely move randomly or with a specific pattern within a sub-area of the HSTT for a period of time from one day to two weeks as compared to straight line point-to-point commercial shipping.
- Navy overall crew size is much larger than merchant ships allowing for more potential observers on the bridge. At all times when vessels are underway, trained lookouts and bridge navigation teams are used to detect objects on the surface of the water ahead of the ship, including marine mammals. Additional lookouts, beyond already stationed bridge watch and navigation teams, are stationed during some training events.
- Navy lookouts receive extensive training including Marine Species Awareness Training designed to provide marine species detection cues and information necessary to detect marine mammals.

To determine the appropriate number of MMPA incidental takes for potential Navy vessel strike, the Navy assessed the probability of Navy vessels hitting individuals of different species of large whales that occur in the HSTT Study Area incidental to specified training and testing activities. To do this, the Navy considered unpublished ship strike data compiled and provided by NMFS' Southwest Regional Office (SWRO) and Pacific Island Regional Office (PIRO), unpublished Navy vessel strike information collected by the Navy and reported to NMFS, and information in this application regarding trends in the amount of vessel traffic related to their training and testing activities in the HSTT Study Area. Navy policy (OPNAVINST 3100.6 H) is to report all whale strikes by Navy vessels. That information is collected by the Office of the Chief of Naval Operations Environmental Readiness (OPNAV N45) and, by informal agreement, is provided to NOAA on an annual basis. In addition, as part of previous NMFS MMPA permits for the Hawaii Range Complex (HRC) and SOCAL, the Navy and NMFS also have standardized regional reporting protocols for communicating to regional NMFS stranding coordinators information on any Navy vessel strikes as soon as possible. These communication procedures will remain in place for the HSTT as part of this LOA application. Only the Navy and the U.S. Coast Guard report vessel strike in this manner so all statistics are skewed by a lack of comprehensive reporting by all vessels that may experience vessel strike.

6.3.4.1 HSTT Historic Navy Vessel Strikes

Southern California Range Complex

The following information can be used to examine a likely Navy vessel strike take estimate for which the Navy would seek MMPA authorization from NMFS :

- The Navy reports 100% of all vessel strikes to the NMFS. Only the Navy and the U.S. Coast Guard report vessel strike in this manner. Therefore the statistics in vessel strikes maintained by NMFS are skewed by a lack of comprehensive reporting from all vessels that may experience vessel strike (commercial ships, whale watching boats, research vessels, fishing boats, work vessels, etc.). For the 20-year period from 1991-2010, there were 86 whale strikes from all vessel categories in California (National Marine Fisheries Service2011c).
- During the period from 1991 to 2010, there were 16 Navy vessel strikes in Southern California reported to NMFS. Of these 16 strikes, 15 occurred between 1993 and 2009 within the SOCAL Range Complex, with one strike outside of the range complex offshore off Long Beach, California in 1995.

In the SOCAL portion of the HSTT Study Area (Table 6-18), the Navy has struck a total of 16 marine mammals in the 20-year period from 1991 through 2010 for an average of one per year (although statistically speaking 0.8 per year [16 strikes/20 years]). Table 6-19 shows the number of Navy vessel strikes by 5-year increments in the SOCAL range portion of the HSTT. In 16 of the last 20 years, there were zero to one whale strikes. In 2001 and 2002, there were three whale strikes each year (all unknown species); in 1998, there were two whale strikes (both gray whales); and in 2009 there were two whale strikes (both fin whales). Thus, the average number of whale strikes in the SOCAL portion of the HSTT is one per year.

Table 6-19: Number of Navy Vessel Strikes by Range Complex in the HSTT Study Area by Linear 5-Year Intervals

5-year interval	SOCAL Range Complex		HRC	
	Total # of Navy Vessel Strikes	Average Vessel Strike Per Year	Total # of Navy Vessel Strikes	Average Vessel Strike Per Year
1991-1995	2	0.4	0	0
1996-2000	3	0.6	1	0.2
2001-2005	8	1.6	2	0.4
2006-2010	3	0.6	2	0.4

If the time period of 1991-2010 is considered by looking at the 16 consecutive 5-year periods within it (i.e., 1991-1995, 1992-1996, 1993-1997, etc.), the average number of whales struck in a 5-year period is 4.5. Up to eight whales were struck within three of the 16 consecutive 5-year periods, although this was before the 2006 reporting period, and has not been repeated since (Table 6-19).

Table 6-20: Number of Navy Vessel Strikes by Range Complex in HSTT by Consecutive 5-Year Intervals

Count	Consecutive 5-year Intervals	# of SOCAL Range Complex Navy Vessel Strikes	# of Hawaii Range Complex Navy Vessel Strikes
1	1991-1995	2	0
2	1992-1996	2	0
3	1993-1997	3	0
4	1994-1998	4	1
5	1995-1999	4	1
6	1996-2000	3	1
7	1997-2001	6	1
8	1998-2002	8	1
9	1999-2003	7	2
10	2000-2004	8	2
11	2001-2005	8	2
12	2002-2006	6	2
13	2003-2007	3	3
14	2004-2008	2	2
15	2005-2009	3	2
16	2006-2010	3	2

Based on NMFS' Southwest Regional Office (SWRO) strike data for Southern California only, gray whales have the highest number of recorded strikes (and in all of California as well) followed by fin and humpback whales, and then blue whales.

Of the 16 Navy vessel strikes over the 20-year period in SOCAL, there were seven mortalities and nine injuries reported. Breakdown by species was: unknown species (two mortalities and eight injuries), gray whales (three mortalities in 1993, 1998, 1998), fin whales (one mortality and one injury, both in 2009), and blue whale (one mortality in 2004). In two of the SOCAL strikes no animal was seen following the event (the Navy is still including these records in this analysis). The majority of the Navy vessel strikes are of historic nature occurring from 1991 to 2005. There were 13 Navy vessel strikes prior to 2006. Since 2006, there have been three (one unknown species in 2006, and two fin whales in 2009). There were no Navy vessel strikes in 2010.

Hawaii Range Complex

In the HRC portion of the HSTT Study Area, the Navy struck a total of five marine mammals in the 20-year period from 1991 through 2010 for an average of zero to one per year (although statistically speaking 0.25 per year [five strikes/20 years]). Table 6-19 shows the number of Navy vessel strikes by 5-year increments in the HRC portion of the HSTT Study Area.

In 16 of the last 20 years, there were no (zero) whale strikes. In 2003 there were two whales struck (one unknown species and one humpback whale). In 1998 a humpback whale was struck, in 2007 a sperm whale was struck, and 2008 an unknown species was struck. No more than two whales were struck by Navy vessels in any given year in the HRC portion of the HSTT within the last 20 years (and the average was zero to one per year). It should be noted that two of the five HRC Navy vessel strikes were from workboats <40 feet (12 m) (the Navy is still including these records in this analysis).

If the time period of 1991-2010 is considered by looking at the 16 consecutive 5-year periods within it (i.e., 1991-1995, 1992-1996, 1993-1997, etc.), the average number of whales struck in a 5-year period was 1.4. Up to three whales were struck within one of the 16 consecutive 5-year periods although this was before 2006 (Table 6-19). Based on NMFS' Pacific Island Regional Office strike data for Hawaii, most whale strikes are to humpback whales (National Marine Fisheries Service, unpublished data).

Of the five Navy vessel strikes over the 20-year period in the HRC, there were five injuries reported. Breakdown by species was: unknown species (two injuries), humpback whales (two injuries), and sperm whale (one injury). In one of the HRC strikes no animal was seen and in one only a fin was seen following the event, so there is no confirmation of a whale injury although the Navy is still including these records in this analysis.

There was only one 12-month period in 20 years in the HRC when two whales were struck in a single year, and these were prior to 2006. Since 2006, there have been two strikes from 2006 to 2010. There were no Navy vessel strikes in 2010 and one vessel strike in 2011.

6.3.4.2 Probability of Navy Vessel Strike of Large Whale Species

The data set of Navy vessel strikes for 1991-2010 can be used to determine a statistical probability of Navy vessel strike as a rate parameter of a Poisson distribution to estimate the probability of 0,1,2,3,…n vessel strikes involving Navy vessels over an annual basis. To calculate the probability of a Navy vessel striking a whale in SOCAL portion of the HSTT area, the Navy used the probability of a strike estimated from Navy vessel strike data from the period from 1991-2010. There were 16 reported whale strikes during this 20-year period; thus the probability of a collision between a Navy vessel and a whale = 0.8000 (16/20). The above numbers were then used as the rate parameter to calculate a series of Poisson probabilities (a Poisson distribution is often used to describe random occurrences when the

probability of an occurrence is small, e.g., count data such as cetacean sighting data, or in this case strike data, are often described as a Poisson or over-dispersed Poisson distribution). To estimate the Poisson probabilities of 0, 1, 2, etc. occurrences, a simple computation can be generated: $P(X) = P(X-1)\mu/X$

P(X) is the probability of occurrence in a unit of time (or space) and μ is the population mean number of occurrences in a unit of time (or space). For the 20-year period from 1991-2010, μ is assumed to be μ = 0.8000. To estimate zero occurrences (in this case, no whales being struck), the following formula would apply: $P(0)=e^{-\mu}$

Plugging 0.8000 into the above equation yields a value of P(0)= 0.4493, hence the statement "there is slightly less than a 45 percent probability of a large whale of any species not being struck in any given 1-year period by a Navy vessel in the SOCAL portion of the HSTT." Thus, continuing the computation series (with results summarized in Table 6-20):

P(1) = (0.4493 * 0.8000)/1 = 0.3594 (or a 36% probability of striking one whale)
P(2) = (0.3594 * 0.8000)/2 = 0.1438 (or a 14% probability of striking two whales)
P(3) = (0.1438 * 0.8000)/3 = 0.0383 (or a 4% probability of striking three whales)
P(4)= (0.0383 * 0.8000)/4 = 0.0077 (or a 0.8% probability of striking four whales)

For the HRC, to estimate the Poisson probability of a Navy vessel strike to a large whale, the same formulas described above can be used. For the 20-year period from 1991-2010, if μ is based on five strikes over 20 years (5/20=0.2500) then μ = 0.2500. Plugging 0.2500 into the $P(0)=e^{-\mu}$ yields a values of P(0)=0.7788, hence the statement "there is slightly less than a 78 percent probability of a large whale of any species not being struck in a given 1-year period by a Navy vessel in the HRC portion of the HSTT." (with results summarized in Table 6-20):

P(1) = (0.7788 * 0.2500)/1 = 0.1947 (or a 19% probability of striking one whale)
P(2) = (0.1947 * 0.2500)/2 = 0.0243 (or a 2% probability of striking two whales)
P(3) = (0.0243 * 0.2500)/3 = 0.0020 (or a 0.2% probability of striking three whales)
P(4)= (0.0020 * 0.2500)/4 = 0.0001 (or a 0.01% probability of striking four whales)

Table 6-21: Poisson Probability of Striking "X" Number of Whales Per Year in the Study Area

Number of Large Whales Per Year	Probability of Strike in SOCAL Range Complex	Probability of Strike in Hawaii Range Complex
No strikes	45%	78%
1 strike	36%	19%
2 strikes	14%	2%
3 strikes	4%	0.2%
4 strikes	0.8%	0.01%

6.4 Summary of All Estimated Impulsive and Non-Impulsive Source Effects

Table 5-2 and Table 5-4 represent the Navy's final estimated impulsive and non-impulsive source effects to marine mammals by MMPA criteria for the HSTT.

Table 5-2 shows the estimated impulsive and non-impulsive source effects with mitigation analysis for training activities within the HSTT and includes training activities using non-impulsive sources (e.g., sonar), impulsive sources (e.g., underwater explosives), ELCAS pile driving and removal, and a Hawaii Range Complex specific major training event (Rim of the Pacific [RIMPAC] biennial exercise).

Table 5-4 shows estimated impulsive and non-impulsive source effects with mitigation analysis for all testing activities within the HSTT.

7 IMPACTS ON MARINE MAMMAL SPECIES OR STOCKS

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

Overall, the conclusions in this analysis find that impacts on marine mammal species and stocks would be negligible for the following reasons:

The predicted annual exposures from impact analysis conducted for this Letter of Authorization (LOA) application include:

- Most acoustic harassments are within the non-injurious temporary threshold shift (TTS) or behavioral effects zones (Level B harassment).
- Although the numbers presented in Tables 6-17 and 6-18 represent estimated modeled harassment under the Marine Mammal Protection Act (MMPA), they are conservative (i.e., over predictive) estimates of harassment, primarily by behavioral disturbance. The model calculates harassment without taking into consideration standard mitigation measures, and is not indicative of the limited likelihood of either injury or harm.
- Marine mammal densities inputted into the model are also overly conservative, particularly when considering species where data is limited in portions of the HSTT Study Area and the seasonal migrations that extend throughout the Study Area.
- Additionally, the mitigation measures described in Chapter 11 are designed to reduce sound exposure and explosive effects on marine mammals to levels below those that may cause "behavioral disruptions" and to achieve the least practicable adverse effect on marine mammal species or stocks.
- Range complexes where intensive training and testing have been occurring for decades have populations of multiple species with strong site fidelity(including resident beaked whales at some locations) and increases in the number of some species.
- Years of monitoring of United States (U.S.) Department of the Navy (Navy) activities (since 2006) have documented hundreds of thousands of marine mammal on the range complexes and there are only two instances of overt behavioral change that have been observed.
- Years of monitoring of Navy activities have documented no instances of injury to marine mammals as a result of non-impulsive acoustic sources.
- In at least three decades of identical activities, only one instance of injury to marine mammals (25 March 2011; three long-beaked common dolphin) has occurred as a result of training or testing using an impulsive source (underwater explosion).

This LOA application assumes that short-term non-injurious sound exposure levels predicted to cause onset-temporary threshold shift (TTS) or temporary behavioral disruptions (non-TTS) qualify as Level B harassment. This overestimates reactions qualifying as harassment under MMPA because there is no established scientific correlation between short term sonar use, underwater detonations, and pile driving\removal, and long term abandonment or significant alteration of behavioral patterns in marine mammals.

Consideration of negligible impact is required for NMFS to authorize incidental take of marine mammals. By definition, an activity has a "negligible impact" on a species or stock when it is determined that the

total taking is not likely to reduce annual rates of adult survival or recruitment (i.e., offspring survival, birth rates).

Behavioral reactions of marine mammals to sound are known to occur but are difficult to predict. Recent behavioral studies indicate that reactions to sounds, if any, are highly contextual and vary between species and individuals within a species (Moretti et al. 2010; Southall et al. 2011; Thompson et al 2010; Tyack 2009a; Tyack et al. 2011). Depending on the context, marine mammals often change their activity when exposed to disruptive levels of sound. When sound becomes potentially disruptive, cetaceans at rest become active, feeding or socializing cetaceans or pinnipeds often interrupt these events by diving or swimming away. If the sound disturbance occurs around a haul out site, pinnipeds may move back and forth between water and land or eventually abandon the haul out. When attempting to understand behavioral disruption by anthropogenic sound, a key question to ask is whether the exposures have biologically significant consequences for the individual or population (National Research Council of the National Academies 2005).

If a marine mammal does react to an underwater sound by changing its behavior or moving a small distance, the impacts of the change may not be important to the individual. For example, researchers have found during a study focusing on dolphins response to whale watching vessels in New Zealand, that when animals can cope with constraint and easily feed or move elsewhere, there's little effect on survival (Lusseau and Bejder 2007). On the other hand, if a sound source displaces marine mammals from an important feeding or breeding area for a prolonged period and they do not have an alternate equally desirable area, impacts on the marine mammal could be negative because the disruption has biological consequences. Biological parameters or key elements having greatest importance to a marine mammal relate to its ability to mature, reproduce, and survive. These key elements could be defined as follows:

- Growth: adverse effects on ability to feed;
- Reproduction: the range at which reproductive displays can be heard and the quality of mating/calving grounds (e.g., gray whales); and
- Survival: sound exposure may directly affect survival.

The importance of the disruption and degree of consequence for individual marine mammals often has much to do with the frequency, intensity, and duration of the disturbance. Isolated acoustic disturbances such as sonar use, underwater detonation, and pile driving\removal events within the HSTT usually have minimal consequences or no lasting effects for marine mammals. Marine mammals regularly cope with occasional disruption of their activities by predators, adverse weather, and other natural phenomena. It is reasonable to assume that they can tolerate occasional or brief disturbances by anthropogenic sound without significant consequences. However, prolonged disturbance, as might occur if a stationary and noisy activity were established near a concentrated area, is a more important concern. The long-term implications would depend on the degree of habituation within the population. If the marine mammals fail to habituate or become sensitized to disturbance and, as a consequence, are excluded from an important area or are subject to stress while at the important area, long-term effects could occur to individuals or the population.

The Context of Behavioral Disruption and TTS - Biological Significance To Populations

The exposure estimates calculated by predictive models currently available reliably predict propagation of sound and received levels and measure a short-term, immediate response of an individual using applicable criteria. Consequences to populations are much more difficult to predict and empirical

measurement of population effects from anthropogenic stressors is limited (National Research Council of the National Academies 2005). To predict indirect, long-term, and cumulative effects, the processes must be well understood and the underlying data available for models. In response to the National Research Council of the National Academies (2005) review, the Office of Naval Research (ONR) founded a working group to formalize the Population Consequences of Acoustic Disturbance (PCAD) framework. The long term goal is to improve the understanding of how effects of marine sound on marine mammals transfer between behavior and life functions and between life functions and vital rates. This understanding will facilitate assessment of the population level effects of anthropogenic sound on marine mammals. This field and development of a state-space model is ongoing.

Based on each species' life history information, expected behavioral patterns in HSTT training locations, the majority of modeled exposures resulting in temporary behavioral disturbance, few expected injury or mortality, and the application of robust mitigation procedures proposed in Chapter 11, HSTT training and testing is anticipated to have a negligible impact on marine mammal stocks within the Hawaii, Southern California, and the transit corridor portions of the Study Area.

Conclusion- The Navy concludes that training and testing activities proposed in the HSTT Study Area would result in Level B, Level A, and mortality takes, as summarized in Table 6-17 and Table 6-18. Based on best available science the Navy concludes that exposures to marine mammal species and stocks due to HSTT activities would result in only short-term effects to most individuals exposed and would likely not affect annual rates of recruitment or survival for the following reasons:

- Most acoustic exposures are within the non-injurious temporary threshold shift or behavioral effects zones (Level B harassment).
- Although the numbers presented in Tables 6-17 and 6-18 represent estimated harassment under the Marine Mammal Protection Act, as described above, they are conservative estimates of harassment, primarily by behavioral disturbance, and made without taking into consideration likely reductions as a result of standard operating procedures and mitigation measures.
- The protective measures described in Chapter 11 are designed to reduce vessel strike potential and sound exposure to levels below those that may cause injurious impacts and to achieve the least practicable adverse effect on marine mammal species or stocks

Consideration of negligible impact is required for the National Marine Fisheries Service to authorize incidental takes of marine mammals. By definition, an activity has a "negligible impact" on a species or stock when it is determined that the total taking is not likely to reduce annual rates of adult survival or recruitment (i.e., offspring survival, birth rates). Based on each species' life history information, the expected behavioral disturbance levels in the Study Area, and an analysis of behavioral disturbance levels in comparison to the overall population, an analysis of the potential impacts of the proposed activities on species recruitment or survival is presented in Chapter 6 for each species or species group. The species-specific analyses, in combination with the mitigation measures provided in Chapter 11, support the conclusion that proposed HSTT activities would have a negligible impact on marine mammals.

8 IMPACTS ON SUBSISTENCE USE

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

Potential marine mammal impacts resulting from the Proposed Action in the Hawaii-Southern California Training and Testing Study Area will be limited to individuals located in the Study Area and that have no subsistence requirements exist. Therefore, no impacts on the availability of species or stocks for subsistence use are considered.

9 IMPACTS ON THE MARINE MAMMAL HABITAT AND THE LIKELIHOOD OF RESTORATION

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

The primary source of potential marine mammal habitat impact is acoustic exposures resulting from anti-submarine warfare (ASW) activities. However, the exposures do not constitute a long-term physical alteration of the water column or bottom topography, as the occurrences are of limited duration and are intermittent in time. Surface vessels associated with the activities are present in limited duration and are intermittent as they are continuously and relatively rapidly moving through any given area. Underwater detonations activities such as bombing exercises, gunnery exercises, missile exercises, and sinking exercises do not constitute a long-term physical alteration of the water column or bottom topography, as the occurrences are of limited duration and are intermittent in time.

Underwater detonations for mine or obstruction clearance and amphibious landings occur in sandy shallow areas and will not affect known marine mammal foraging or haul-out habitats. Temporary impacts and disturbance to marine mammal prey (i.e., krill, squid, fish, etc.) are not expected to be significant in terms of impacts on forage species with a wide distribution throughout coastal California, Hawaii, and the North Pacific, and with known high recruitment and biomass (Allen 2006).

Other sources that may affect marine mammal habitat were considered and potentially include the introduction of fuel, debris, ordnance, and chemical residues into the water column. The effects of each of these components were considered in the Hawaii-Southern California Training and Testing (HSTT) Environmental Impact Statement (EIS)/Overseas Environmental Impact Statement (OEIS).

Based on the detailed review within the HSTT EIS/OEIS, there would be no effects to marine mammals resulting from loss or modification of marine mammal habitat including water and sediment quality, food resources, vessel movement, and expendable material.

10 IMPACTS ON MARINE MAMMALS FROM LOSS OR MODIFICATION OF HABITAT

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

The proposed training and testing events for the Hawaii-Southern California Training and Testing Study Area are not expected to have any habitat-related effects that could cause significant or long-term consequences for individual marine mammals or their populations. Based on the discussions in Chapter 9, there will be no impacts on marine mammals resulting from loss or modification of marine mammal habitat.

Prey distribution and Abundance- Physical effects from pressure waves generated by underwater sounds (e.g. underwater explosions) could potentially affect fish within proximity of training or testing activities. In particular, the rapid oscillation between high and low-pressure peaks has the potential to burst the swim bladders and other gas-containing organs of fish (Keevin and Hemen 1997). Sublethal effects, such as changes in behavior of fish, have been observed in several occasions as a result of noise produced by explosives (National Research Council of the National Academies 2003; Wright 1982). The abundances of various fish and invertebrates near the detonation point could be altered for a few hours before animals from surrounding areas repopulate the area; however these populations would be replenished as waters near the detonation point are mixed with adjacent waters. Military expended materials resulting from training and testing activities could potentially result in minor long-term changes to benthic habitat. Similar to an artificial reef structure, the structure would be colonized overtime by benthic organisms that prefer hard substrate and would provide structure that could attract some species of fish.

11 MEANS OF EFFECTING THE LEAST PRACTICABLE ADVERSE IMPACTS – MITIGATION MEASURES

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

The Navy recognizes that the proposed activities have the potential to impact the environment. Unlike standard operating procedures, which are established for reasons other than environmental benefit, mitigation measures are modifications to the proposed activities that are implemented for the sole purpose of reducing a specific potential environmental impact on a particular resource. Most of the procedures discussed in this chapter are currently or were previously implemented as a result of past environmental compliance documents, Endangered Species Act (ESA) biological opinions, Marine Mammal Protection Act (MMPA) letters of authorization, or other formal or informal consultations with regulatory agencies.

The Navy's overall approach to assessing potential mitigation measures is based on two principles: (1) mitigations will be effective at reducing potential impacts on the resource, and (2) from the fleet stakeholder's perspective, mitigation is consistent with existing training and testing objectives, range procedures, and safety measures.

11.1 LOOKOUT PROCEDURAL MEASURES

The Navy will have two types of lookouts for the purposes of conducting visual observations: (1) those positioned on surface ships, and (2) those positioned in aircraft or on boats. Lookouts positioned on surface ships will be dedicated solely to diligent observation of the air and surface of the water. They will have multiple observation objectives, which include but are not limited to detecting the presence of biological resources and recreational or fishing boats, observing buffer zones, and monitoring for vessel and personnel safety concerns. Lookouts positioned on surface ships will typically be personnel already standing watch or existing members of the bridge watch team who become temporarily relieved of job responsibilities that would divert their attention from observing the air or surface of the water (such as navigation of a vessel).

Due to aircraft and boat manning and space restrictions, lookouts positioned in aircraft or on boats will consist of the aircraft crew, pilot, or boat crew. Lookouts positioned in aircraft and boats may necessarily be responsible for tasks in addition to observing the air or surface of the water (for example, navigation of a helicopter or rigid hull inflatable boat). However, aircraft and boat lookouts will, to the maximum extent practicable and consistent with aircraft and boat safety and training and testing requirements, comply with the observation objectives described above for lookouts positioned on surface ships.

The procedural measures described below primarily consist of having lookouts during specific training and testing activities.

All personnel standing watch on the bridge, Commanding Officers, Executive Officers, maritime patrol aircraft aircrews, anti-submarine warfare helicopter crews, civilian equivalents, and lookouts will

successfully complete the United States Navy Marine Species Awareness Training prior to standing watch or serving as a lookout. Additional details on the Navy's Marine Species Awareness Training can be found in the Hawaii-Southern California Training and Testing (HSTT) Draft EIS/OEIS (U.S. Department of the Navy 2012b).

11.1.1 LOOKOUTS

The Navy proposes to use one or more lookouts during the following training and testing activities, which are organized by stressor category:

11.1.1.1 Acoustic Stressors – Non-Impulsive Sound

11.1.1.1.1 Low-frequency and Hull Mounted Mid-frequency Active Sonar

Mitigation measures do not currently exist for low-frequency active sonar sources associated with new platforms or systems, such as the Littoral Combat Ship. The Navy is proposing to add mitigation measures for low-frequency active sonar and the Littoral Combat Ship, as well as maintain the number of lookouts currently implemented for ships using hull mounted mid-frequency active sonar.

With the exception of vessels less than 65 ft. (20 m) in length, the Littoral Combat Ship (and similar vessels which are minimally manned), ships using low-frequency or hull mounted mid-frequency active sonar sources associated with anti-submarine warfare and mine warfare activities at sea will have two lookouts at the forward position of the vessel. For the purposes of this document, low-frequency active sonar does not include surface towed array surveillance system low frequency active sonar.

While using low-frequency or hull mounted mid-frequency active sonar sources associated with anti-submarine warfare and mine warfare activities at sea, the Littoral Combat Ship (and similar vessels which are minimally manned) and vessels less than 65 feet in length will have one lookout at the forward position of the vessel due to space and manning restrictions.

Ships conducting active sonar activities while moored or at anchor (including pierside testing or maintenance) will maintain one lookout.

11.1.1.1.2 High-frequency and Non-Hull Mounted Mid-frequency Active Sonar

Mitigation measures do not currently exist for high-frequency active sonar activities associated with anti-submarine warfare and mine warfare, or for new platforms, such as the Littoral Combat Ship; therefore, the Navy is proposing to add a new measure for these activities or platforms. The Navy is proposing to continue using the number of lookouts currently implemented for ships or aircraft conducting non-hull mounted mid-frequency active sonar, such as helicopter dipping sonar systems. Surface ships or aircraft conducting high-frequency or non-hull mounted mid-frequency active sonar activities associated with anti-submarine warfare and mine warfare activities at sea will have one lookout.

11.1.1.2 Acoustic Stressors – Explosives and Impulsive Sound

11.1.1.2.1 Improved Extended Echo Ranging Sonobuoys

Aircraft conducting improved extended echo ranging sonobuoy activities will have one lookout.

11.1.1.2.2 Anti-swimmer Grenades

Surface vessels conducting anti-swimmer grenade activities will have one lookout.

11.1.1.2.3 Mine Countermeasure and Neutralization Activities Using Positive Control Firing Devices

Mine countermeasure and neutralization activities can be divided into two main categories: (1) general activities that can be conducted from a variety of platforms and locations, and (2) activities involving the use of diver placed charges that typically occur close to shore. When either of these activities are conducted using a positive control firing device, the detonation is controlled by the personnel conducting the activity and is not authorized until the area is clear at the time of detonation.

The Navy is modifying the number of lookouts currently implemented for general mine countermeasure and neutralization activities to account for additional categories of net explosive weights. The Navy is proposing the following number of lookouts to be used during general mine countermeasure and neutralization activities:

- During activities using up to a 500 lb. net explosive weight detonation(bin E10 and below), vessels greater than 200 ft. will have two lookouts, while vessels less than 200 ft. will have one lookout.
- During activities using a 501-650 lb. net explosive weight (bin E11) detonation, the Navy will use two lookouts (one positioned in an aircraft and one in a support vessel).

The Navy is proposing to continue using the number of lookouts currently implemented for mine neutralization activities involving diver placed charges using up to a 20 lb. net explosive weight detonation. Mitigation measures for activities involving diver placed charges do not currently exist for the 21-100 lb. net explosive weight detonations. The Navy is proposing that activities using up to a 100 lb. net explosive weight (bin E8) detonation will have a total of two lookouts (one lookout positioned in each of the two support vessels). In addition, when aircraft are used, the pilot or member of the aircrew will serve as an additional lookout. All divers placing the charges on mines will support the lookouts while performing their regular duties. The divers will report all marine mammal sightings to their dive support vessel.

11.1.1.2.4 Mine Countermeasure and Neutralization Activities Using Time Delay Firing Devices

When mine neutralization activities using diver placed charges (up to a 20 lb. net explosive weight) are conducted with a time-delay firing device, the detonation is fused with a specified time-delay by the personnel conducting the activity and is not authorized until the area is clear at the time the fuse is initiated. During these activities, the detonation cannot be terminated once the fuse is initiated due to human safety concerns.

The Navy is proposing to modify the number of lookouts currently used for mine neutralization activities using diver-placed time-delay firing devices. As a reference, the current mitigation involves the use of six lookouts and three small rigid hull inflatable boats (two lookouts positioned in each of the three boats) for mitigation zones equal to or larger than 1,400 yd. (1,280 m), or four lookouts and two boats for mitigation zones smaller than 1,400 yd. (1,280 m). Using six lookouts and three boats in the long-term is impracticable to implement from an operational standpoint due to the unacceptable impact that it is causing on resource requirements (i.e., limited personnel resources and boat availability).

During activities using up to a 20 lb. net explosive weight (bin E6) detonation, the Navy will have four lookouts and two small rigid hull inflatable boats (two lookouts positioned in each of the two boats). In addition, when aircraft are used, the pilot or member of the aircrew will serve as an additional lookout.

Additionally, all divers placing the charges on mines will support the lookouts while performing their regular duties. The divers will report all marine mammal sightings to their dive support vessel.

11.1.1.2.5 Ordnance Testing (Line Charge Testing)

Surface vessels conducting line charge testing will have one lookout.

11.1.1.2.6 Gunnery Exercises-Small and Medium Caliber (Surface Target)

Surface vessels or aircraft conducting small and medium caliber gunnery exercises will have one lookout.

11.1.1.2.7 Gunnery Exercises-Large Caliber (Surface Target)

Surface vessels or aircraft conducting large caliber gunnery exercises will have one lookout.

11.1.1.2.8 Missile Exercises (Surface Target)

Surface vessels or aircraft conducting missile exercises against surface targets will have one lookout.

11.1.1.2.9 Bombing Exercises

Aircraft conducting bombing exercises will have one lookout.

11.1.1.2.10 Torpedo (Explosive) Testing

During explosive torpedo testing, the Navy will have one lookout positioned in an aircraft.

11.1.1.2.11 Sinking Exercises

During sinking exercises, the Navy will have two lookouts (one positioned in an aircraft, and one on a surface vessel).

11.1.1.2.12 At-Sea Explosives Testing

Each surface vessel supporting at-sea explosive testing will have a minimum of one lookout.

11.1.1.2.13 Elevated Causeway System – Pile Driving

Lookout measures do not currently exist for elevated causeway system – pile driving activities. The Navy is proposing to add this measure. During pile driving, the Navy will have one lookout positioned on the platform (which could include the shore, an elevated causeway, or on a ship) that will maximize the potential for sightings.

11.1.1.2.14 Weapons Firing Noise

11.1.1.2.14.1 Gunnery Exercises – Large Caliber

The Navy will have one Lookout on the surface vessel conducting explosive and non-explosive large-caliber gunnery exercises. This may be the same Lookout described in Section 11.1.1.2.7 (Gunnery Exercises – Large-Caliber using a Surface Target) when that activity is conducted from a surface vessel against a surface target.

11.1.1.3 Physical Strike and Disturbance

11.1.1.3.1 Vessels and In-Water Devices

11.1.1.3.1.1 Vessels

The Navy is proposing to continue using the mitigation measures currently implemented for this activity (including full power propulsion testing). While underway, surface ships will have a minimum of one lookout.

11.1.1.3.1.2 Towed In-Water Devices

The Navy is proposing to continue using the number of Lookouts currently implemented for activities using towed in-water devices (e.g., towed mine neutralization). The Navy will have one Lookout during activities using towed in-water devices.

11.1.1.3.2 Non-Explosive Practice Munitions

11.1.1.3.2.1 Small-, Medium-, and Large-Caliber Gunnery Exercises Using a Surface Target

The Navy is proposing to continue using the number of Lookouts currently implemented for these activities. Activities involving non-explosive practice munitions (e.g., small-, medium-, and large-caliber gunnery exercises) using a surface target will have one Lookout.

11.1.1.3.2.2 Bombing Exercises

The Navy is proposing to continue using the number of Lookouts currently implemented for these activities. The Navy will have one Lookout during activities involving non-explosive bombing exercises.

11.1.1.4 Effectiveness Assessment for Lookouts

Due to the various detection probabilities, levels of experience, and dependence on sighting conditions, lookouts will not always be entirely effective at avoiding impacts on all species. However, lookouts are expected to increase the overall likelihood that certain marine mammal species will be detected at the surface of the water, when compared to the likelihood that these same species would be detected if lookouts are not used. The Navy believes the continued use of lookouts contributes to helping minimize potential impacts on these marine mammal species from training and testing activities. A thorough analysis of the effectiveness of Navy lookouts is provided in the HSTT Draft EIS/OEIS (U.S. Department of the Navy 2012b).

11.2 Mitigation Zone Procedural Measures

Safety zones are zones designed for human safety, whereas this section will introduce mitigation zones. A mitigation zone is designed solely for the purpose of reducing potential impacts to marine mammals from training and testing activities. Mitigation zones are measured as the radius from a source. Unique to each activity category, each radius represents a distance that the Navy will visually observe to help reduce injury to marine species. Visual detections of applicable marine species will be communicated immediately to the appropriate watch station for information dissemination and appropriate action. If the presence of marine mammals is detected acoustically, lookouts posted in aircraft and on surface vessels will increase the vigilance of their visual surveillance. As a reference, aerial surveys are typically made by flying at 1,500 ft. (457 m) altitude or lower at the slowest safe speed when practicable.

Many of the proposed activities have mitigation measures that are currently being implemented, as required by previous environmental documents or consultations. Most of the current mitigation zones

for activities that involve the use of impulsive and non-impulsive sources were originally designed to reduce the potential for onset of temporary threshold shift (TTS). The Navy updated the acoustic propagation modeling to incorporate updated hearing threshold metrics (i.e., upper and lower frequency limits), updated density data for marine mammals, and factors such as an animal's likely presence at various depths. An explanation of the acoustic propagation modeling process can be found in the Marine Species Modeling Team (U.S. Department of the Navy 2012a) Technical Report.

As a result of the updates described above to the acoustic propagation modeling, in some cases the ranges to effects are much larger than those output by previous models. Due to the ineffectiveness and unacceptable operational impacts associated with mitigating such large areas, the Navy is unable to mitigate for onset of TTS for every activity. However, in some cases the ranges to effects are smaller than previous models estimated, and the mitigation zones were adjusted accordingly to provide consistency across the measures. Navy developed each proposed mitigation zone to avoid or reduce the potential for onset of the lowest level of injury, permanent threshold shift (PTS), out to the predicted maximum range. Mitigating to the predicted maximum range to PTS consequently also mitigates to the predicted maximum range to onset mortality (1% mortality), onset slight lung injury, and onset slight gastrointestinal tract injury, since the maximum range to effects for these criteria are shorter than for PTS. Furthermore, in most cases, the predicted maximum range to PTS also consequently covers the predicted average range to TTS. Table 11-1 summarizes the predicted average range to TTS, average range to PTS, maximum range to PTS, and recommended mitigation zone for each activity category, based on the Navy's acoustic propagation modeling results. It is important for the Navy to have standardized mitigation zones wherever training and testing may be conducted. Table 11-1 was developed in consideration of both Atlantic and Pacific Ocean conditions, marine mammal species, and environmental factors. Therefore, the ranges to effects in Table 11-1 provide effective values that ensure appropriate mitigation ranges for both Atlantic Fleet and Pacific Fleet activities, and may not align with range to effects values found in previous tables in this request.

The mitigation zones were based on the longest range for all the functional hearing groups. In the majority of the times, the mitigation zones were driven by either the high frequency cetaceans or the sea turtles functional hearing groups. Therefore, the mitigation zones are even more protective for the remaining functional hearing groups (low frequency cetaceans, mid-frequency cetaceans, and pinnipeds), and likely cover a larger portion of the potential range to onset of TTS.

In some instances, the Navy recommends mitigation zones that are larger or smaller than the predicted maximum range to PTS based on the effectiveness and operational assessments. The Navy will only recommend implementing mitigation that results in avoidance or reduction of an impact to a resource and that has acceptable operational impacts to a particular proposed activity.

Table 11-1: Predicted Maximum Ranges to Permanent Threshold Shift and Recommended Buffer Zones

Activity Category	Representative Source (Bin)*	Predicted Average Range to TTS	Predicted Average Range to PTS	Predicted Maximum Range to PTS	Recommended Mitigation Zone
Non-Impulsive Sound					
Low-Frequency and Hull-Mounted Mid-Frequency Active Sonar	SQS-53 ASW hull-mounted sonar (MF1)	4,251 yd. (3,887 m)	281 yd. (257 m)	<292 yd. (<267 m)	6 dB power down at 1,000 yd. (914 m); 4 dB power down at 500 yd. (457 m); and shutdown at 200 yd. (183 m)
High-Frequency and Non-Hull Mounted Mid-Frequency Active Sonar	AQS-22 ASW dipping sonar (MF4)	226 yd. (207 m)	<55 yd. (<50 m)	<55 yd. (<50 m)	200 yd. (183 m)
Explosive and Impulsive Sound					
Improved Extended Echo Ranging Sonobuoys	Explosive sonobuoy (E4)	434 yd. (397 m)	156 yd. (143 m)	563 yd. (515 m)	600 yd. (549 m)
Explosive Sonobuoys using 0.6–2.5 lb. NEW	Explosive sonobuoy (E3)	290 yd. (265 m)	113 yd. (103 m)	309 yd. (283 m)	350 yd. (320 m)
Anti-Swimmer Grenades	Up to 0.5 lb. NEW (E2)	190 yd. (174 m)	83 yd. (76 m)	182 yd. (167 m)	200 yd. (183 m)
Mine Countermeasure and Neutralization Activities Using Positive Control Firing Devices	NEW dependent (see Table 5.3-3)				
Mine Neutralization Diver Placed Mines Using Time-Delay Firing Devices	Up to 20 lb. NEW (E6)	647 yd. (592 m)	232 yd. (212 m)	469 yd. (429 m)	1,000 yd. (915 m)
Ordnance Testing (Line Charge Testing)	Numerous 5 lb. charges (E4)	434 yd. (397 m)	156 yd. (143 m)	563 yd. (515 m)	900 yd. (823 m)**
Gunnery Exercises – Small- and Medium-Caliber (Surface Target)	40 mm projectile (E2)	190 yd. (174 m)	83 yd. (76 m)	182 yd. (167 m)	200 yd. (183 m)
Gunnery Exercises – Large-Caliber (Surface Target)	5 in. projectiles (E5 at the surface***)	453 yd. (414 m)	186 yd. (170 m)	526 yd. (481 m)	600 yd. (549 m)
Missile Exercises up to 250 lb. NEW (Surface Target)	Maverick missile (E9)	949 yd. (868 m)	398 yd. (364 m)	699 yd. (639 m)	900 yd. (823 m)
Missile Exercises up to 500 lb. NEW (Surface Target)	Harpoon missile (E10)	1,832 yd. (1,675 m)	731 yd. (668 m)	1,883 yd. (1,721 m)	2,000 yd. (1.8 km)
Bombing Exercises	MK-84 2,000 lb. bomb (E12)	2,513 yd. (2.3 km)	991 yd. (906 m)	2,474 yd. (2.3 km)	2,500 yd. (2.3 km)**
Torpedo (Explosive) Testing	MK-48 torpedo (E11)	1,632 yd. (1.5 km)	697 yd. (637 m)	2,021 yd. (1.8 km)	2,100 yd. (1.9 km)

Table 11-1: Predicted Range to Effects and Recommended Mitigation Zones (continued)

Activity Category	Representative Source (Bin)*	Predicted Average Range to TTS	Predicted Average Range to PTS	Predicted Maximum Range to PTS	Recommended Mitigation Zone
Sinking Exercises	Various sources up to the MK-84 2,000 lb. bomb (E12)	2,513 yd. (2.3 km)	991 yd. (906 m)	2,474 yd. (2.3 km)	2.5 nm
At-Sea Explosive Testing	Various sources less than 10 lb. NEW (E5 at various depths***)	525 yd. (480 m)	204 yd. (187 m)	649 yd. (593 m)	1,600 yd. (1.4 km)**
Elevated Causeway System – Pile Driving	24 in. steel impact hammer	1,094 yd. (1,000 m)	51 yd. (46 m)	51 yd. (46 m)	60 yd. (55 m)

ASW: anti-submarine warfare; JAX: Jacksonville; NEW: net explosive weight; PTS: permanent threshold shift; TTS: temporary threshold shift;
* This table does not provide an inclusive list of source bins; bins presented here represent the source bin with the largest range to effects within the given activity category.
** Recommended mitigation zones are larger than the modeled injury zones to account for multiple types of sources or charges being used.
*** The representative source bin E5 has different range to effects depending on the depth of activity occurrence (at the surface or at various depths).

11.2.1 ACOUSTIC STRESSORS

11.2.1.1 Non-Impulsive Sound

11.2.1.1.1 Low-frequency and Hull Mounted Mid-frequency Active Sonar

For a summary of the estimated range to effects for a representative source in this category, see Table 11-1. In addition, Section 11.2 (Mitigation Zone Procedural Measures) provides a general discussion of mitigation zones, how they are implemented, and the potential effects they are designed to reduce.

Training and testing activities that involve the use of low-frequency and hull-mounted mid-frequency active sonar will use Lookouts for visual observation from a surface vessel immediately before and during the exercise. Mitigation zones for these activities involve powering down the sonar by 6 dB when a marine mammal is sighted within 1,000 yd. (914 m), and by an additional 4 dB when sighted within 500 yd. (457 m) from the source, for a total reduction of 10 dB. Active transmissions will cease if a marine mammal is visually detected within 200 yd. (183 m). Active transmission will re-commence if any one of the following conditions are met: (1) the animal is observed exiting the mitigation zone, (2) the animal is thought to have exited the mitigation zone based on its course and speed, (3) the mitigation zone has been clear from any additional sightings for a period of 30 min., (4) the vessel has transited more than 2,000 yd. (1.8 km) beyond the location of the last sighting, or (5) if the ship concludes that dolphins are deliberately closing in on the ship to ride the vessel's bow wave (and there are no other marine mammal sightings within the mitigation zone). Active transmission may resume when dolphins are bowriding because they are out of the main transmission axis of the active sonar while in the shallow-wave area of the vessel bow.

11.2.1.1.2 High-frequency and Non-hull Mounted Mid-frequency Active Sonar

For a summary of the estimated range to effects for a representative source in this category, see Table 11-1. In addition, Section 11.2 (Mitigation Zone Procedural Measures) provides a general discussion of mitigation zones, how they are implemented, and the potential effects they are designed to reduce.

Mitigation will include visual observation from a surface vessel or aircraft (with the exception of platforms operating at high altitudes) immediately before and during active transmission within a mitigation zone of 200 yd. (183 m) from the active sonar source. For activities involving helicopter deployed dipping sonar, visual observation will commence 10 min. before the first deployment of active dipping sonar. Helicopter dipping and sonobuoy deployment will not begin if concentrations of floating vegetation (*Sargassum* or kelp patties) are observed in the mitigation zone. If the source can be turned off during the activity, active transmission will cease if a marine mammal is visually detected within the mitigation zone. Active transmission will re-commence if any one of the following conditions are met: (1) the animal is observed exiting the mitigation zone, (2) the animal is thought to have exited the mitigation zone based on its course and speed, (3) the mitigation zone has been clear from any additional sightings for a period of 10 min. for an aircraft-deployed source, (4) the mitigation zone has been clear from any additional sightings for a period of 30 min. for a vessel-deployed source, (5) the vessel or aircraft has repositioned itself more than 400 yd. (366 m) away from the location of the last sighting, or (6) if the ship concludes that dolphins are deliberately closing in on the ship to ride the vessel's bow wave (and there are no other marine mammal sightings within the mitigation zone).

11.2.1.2 Explosives and Impulsive Sound

11.2.1.2.1 Improved Extended Echo Ranging Sonobuoys

For a summary of the estimated range to effects for a representative source in this category, see Table 11-1. In addition, Section 11.2 (Mitigation Zone Procedural Measures) provides a general discussion of mitigation zones, how they are implemented, and the potential effects they are designed to reduce.

Mitigation will include pre-exercise aerial observation and passive acoustic monitoring, which will begin 30 min. before the first source/receiver pair detonation and continue throughout the duration of the exercise within a mitigation zone of 600 yd. (549 m) around an Improved Extended Echo Ranging sonobuoy. The pre-exercise aerial observation will include the time it takes to deploy the sonobuoy pattern (deployment is conducted by aircraft dropping sonobuoys in the water). Improved Extended Echo Ranging sonobuoys will not be deployed if concentrations of floating vegetation (*Sargassum* or kelp patties) are observed in the mitigation zone (around the intended deployment location). Explosive detonations will cease if a marine mammal is visually detected within the mitigation zone. Detonations will re-commence if any one of the following conditions are met: (1) the animal is observed exiting the mitigation zone, (2) the animal is thought to have exited the mitigation zone based on its course and speed, or (3) the mitigation zone has been clear from any additional sightings for a period of 30 min.

Passive acoustic monitoring would be conducted with Navy assets, such as sonobuoys, already participating in the activity. These assets would only detect vocalizing marine mammals within the frequency bands monitored by Navy personnel. Passive acoustic detections would not provide range or bearing to detected animals, and therefore cannot provide locations of these animals. Passive acoustic detections would be reported to Lookouts posted in aircraft and on surface vessels in order to increase vigilance of their visual surveillance.

11.2.1.2.2 Explosive Sonobuoys Using 0.6–2.5 Pound Net Explosive Weight

For a summary of the estimated range to effects for a representative source in this category, see Table 11-1. In addition, Section 11.2 (Mitigation Zone Procedural Measures) provides a general discussion of mitigation zones, how they are implemented, and the potential effects they are designed to reduce.

Mitigation will include pre-exercise aerial monitoring during deployment of the field of sonobuoy pairs (typically up to 20 minutes) and continuing throughout the duration of the exercise within a mitigation zone of 350 yd. (320 m) around an explosive sonobuoy. Explosive sonobuoys will not be deployed if concentrations of floating vegetation (*Sargassum* or kelp patties) are observed in the mitigation zone (around the intended deployment location). Explosive detonations will cease if a marine mammal is visually detected within the mitigation zone. Detonations will re-commence if any one of the following conditions are met: (1) the animal is observed exiting the mitigation zone, (2) the animal is thought to have exited the mitigation zone based on its course and speed, or (3) the mitigation zone has been clear from any additional sightings for a period of 30 min.

Passive acoustic monitoring will also be conducted with Navy assets, such as sonobuoys, already participating in the activity. These assets would only detect vocalizing marine mammals within the frequency bands monitored by Navy personnel. Passive acoustic detections would not provide range or bearing to detected animals, and therefore cannot provide locations of these animals. Passive acoustic

detections would be reported to Lookouts posted in aircraft in order to increase vigilance of their visual surveillance.

11.2.1.2.3 Anti-swimmer Grenades

For a summary of the estimated range to effects for a representative source in this category, see Table 11-1. In addition, Section 11.2 (Mitigation Zone Procedural Measures) provides a general discussion of mitigation zones, how they are implemented, and the potential effects they are designed to reduce.

Mitigation will include visual observation from a small boat immediately before and during the exercise within a mitigation zone of 200 yd. (183 m) around an anti-swimmer grenade. The exercise will not commence if concentrations of floating vegetation (*Sargassum* or kelp patties) are observed in the mitigation zone. Explosive detonations will cease if a marine mammal is visually detected within the mitigation zone. Detonations will re-commence if any one of the following conditions are met: (1) the animal is observed exiting the mitigation zone, (2) the animal is thought to have exited the mitigation zone based on its course and speed, (3) the mitigation zone has been clear from any additional sightings for a period of 30 min., or (4) the activity has been repositioned more than 400 yd. (366 m) away from the location of the last sighting.

11.2.1.2.4 Mine Countermeasure and Neutralization Activities Using Positive Control Firing Devices

For a summary of the estimated range to effects for each of the charge sizes in this category, see Table 11-2. In addition, Section 11.2 (Mitigation Zone Procedural Measures) provides a general discussion of mitigation zones, how they are implemented, and the potential effects they are designed to reduce.

General mine countermeasure and neutralization activity mitigation will include visual surveillance from surface vessels or aircraft beginning 30 min. before, during, and 30 min. after the completion of the exercise within the mitigation zones around the detonation site as identified in Table 11-2. For activities involving explosives in bin E11 (501–650 lb. net explosive weight), aerial observation of the mitigation zone will be conducted. The exercise will not commence if concentrations of floating vegetation (*Sargassum* or kelp patties) are observed in the mitigation zone. Explosive detonations will cease if a marine mammal is visually detected within the mitigation zone. Detonations will re-commence if any one of the following conditions are met: (1) the animal is observed exiting the mitigation zone, (2) the animal is thought to have exited the mitigation zone based on its course and speed, or (3) the mitigation zone has been clear from any additional sightings for a period of 30 min.

In addition to the above, for mine neutralization activities involving diver placed charges, visual observation will be conducted by either two boats (rigid hull inflatable boats), or one boat and one helicopter. Survey boats will position themselves near the mid-point of the mitigation zone radius (but always outside the detonation plume radius and human safety zone) and travel in a circular pattern around the detonation location. When using two boats, each boat will be positioned on opposite sides of the detonation location, separated by 180 degrees. Helicopters will travel in a circular pattern around the detonation location when used. For activities within the Navy Cherry Point Range Complex, no detonations will take place within 3.2 nm (6 km) of an estuarine inlet and within 1.6 nm (3 km) of the shoreline.

Table 11-2: Predicted Range to Effects and Mitigation Zone Radius for Mine Countermeasure and Neutralization Activities Using Positive Control Firing Devices

Charge Size Net Explosive Weight (Bins)	General Mine Countermeasure and Neutralization Activities Using Positive Control Firing Devices*				Mine Countermeasure and Neutralization Activities Using Diver Placed Charges under Positive Control**			
	Predicted Average Range to TTS	Predicted Average Range to PTS	Predicted Maximum Range to PTS	Recommended Mitigation Zone	Predicted Average Range to TTS	Predicted Average Range to PTS	Predicted Maximum Range to PTS	Recommended Mitigation Zone
2.6–5 lb. (E4)	434 yd. (474 m)	197 yd. (180 m)	563 yd. (515 m)	600 yd. (549 m)	545 yd. (498 m)	169 yd. (155 m)	301 yd. (275 m)	350 yd. (320 m)
6–10 lb. (E5)	525 yd. (480 m)	204 yd. (187 m)	649 yd. (593 m)	800 yd. (732 m)	587 yd. (537 m)	203 yd. (185 m)	464 yd. (424 m)	500 yd. (457 m)
11–20 lb. (E6)	766 yd. (700 m)	288 yd. (263 m)	648 yd. (593 m)	800 yd. (732 m)	647 yd. (592 m)	232 yd. (212 m)	469 yd. (429 m)	500 yd. (457 m)
21–60 lb. (E7)***	1,670 yd. (1,527 m)	581 yd. (531 m)	964 yd. (882 m)	1,200 yd. (1.1 km)	1,532 yd. (1,401 m)	473 yd. (432 m)	789 yd. (721 m)	800 yd. (732 m)
61–100 lb. (E8)****	878 yd. (802 m)	383 yd. (351 m)	996 yd. (911 m)	1,600 yd. (1.4 m)	969 yd. (886 m)	438 yd. (400 m)	850 yd. (777 m)	850 yd. (777 m)
250–500 lb. (E10)	1,832 yd. (1,675 m)	731 yd. (668 m)	1,883 yd. (1,721 m)	2,000 yd. (1.8 km)				Not Applicable
501–650 lb. (E11)	1,632 yd. (1,492 m)	697 yd. (637 m)	2,021 yd. (1,848 m)	2,100 yd. (1.9 km)				Not Applicable

PTS: permanent threshold shift; TTS: temporary threshold shift

* These mitigation zones are applicable to all mine countermeasure and neutralization activities conducted in all locations that Tables 2.8-1 through 2.8-5 specifies.

** These mitigation zones are only applicable to mine countermeasure and neutralization activities involving the use of diver placed charges. These activities are conducted in shallow-water and the mitigation zones are based only on the functional hearing groups with species that occur in these areas (mid-frequency cetaceans and sea turtles).

*** The E7 bin was only modeled in shallow-water locations so there is no difference for the diver placed charges category.

**** The E8 bin was only modeled for surface explosions, so some of the ranges are shorter than for sources modeled in the E7 bin which occur at depth.

The Navy is establishing different mitigation zones depending on the depth of the water in which the detonation takes place. The Navy used the Reflection and Refraction in a Multilayered Ocean/Ocean Bottoms with Shear Wave Effects model to predict the pressure-wave propagation for underwater detonations in deep and shallow water. Due to the complicated nature of propagation in very shallow water (less than 24 ft. [7.3 m]), as well as substantial differences between very shallow water sites, this model cannot accurately predict pressure propagation from underwater detonations occurring in very shallow water environments. In very shallow water, surface- and bottom-boundary effects, thermal layering and mixing of layers, bottom substrate composition, vegetation in the water column, and surface blowout, along with charge size, configuration, and distance from the bottom, provide significant contributions to propagation characteristics. The Navy's model assumes a uniform, flat bottom throughout the energy field, does not take into account variations in bathymetry, and assumes all charges are elevated off the bottom. Because of this, the deepest point within a scenario modeling box was used to preclude diving animals from being "hidden" beneath the modeled bottom depth and, therefore, not exposed to any energy or sound. Due to modeling limitations for very shallow water, discontinuities in the modeling output over estimated propagated pressure and energies at specific distances from the charge. Models of pressure propagation from underwater detonations predict the distances at which marine mammals may be harmed and thus, are important in anticipating and mitigating potential harmful effects of underwater explosion training and testing. However, in order to establish accurate mitigation zones for determining physiological effects on marine mammals, measured waveform propagation data was collected at the actual very shallow water locations at San Clemente Island and the Silver Strand Training Complex, and were used to determine the zone of influence and mitigation zone for very shallow water detonations training and testing at these sites.

General mine countermeasure and neutralization activities will include visual surveillance from surface vessels or aircraft beginning 30 minutes before, during, and 30 minutes after the completion of the exercise. During activities using positively controlled firing devices, visual observation for marine mammals will take place within the mitigation zones around the detonation site as identified in Table 11-2. If a marine mammal is visually detected within the mitigation zone, then the exercise will cease until the mitigation zone has been clear from any additional sightings for 30 minutes. For activities involving explosives in bin E11 (501-650 lb. net explosive weight), aerial observation of the mitigation zone will be conducted.

Mitigation measures currently do not exist for mine neutralization activities involving diver placed charges using 21-100 lb. net explosive weight charges. The Navy is proposing to modify the currently implemented mitigation measures for activities involving diver placed charges using less than or equal to 20 lb. net explosive weight charges to account for additional categories of net explosive weights, in order to align with the explosive bins that were modeled. The Navy is proposing the mitigation zones to be used during activities involving diver placed charges as outlined in Table 11-2. For comparison, the currently implemented mitigation zone for less than or equal to 20 lb. net explosive weight charges is 700 yd. (640 m).

For mine neutralization activities involving diver placed charges, visual observation will be conducted by either two boats (rigid hull inflatable boats), or one boat and one helicopter. Survey boats will position themselves near the mid-point of the mitigation zone radius (but always outside the detonation plume radius and human safety zone) and travel in a circular pattern around the detonation location. When using two boats, each boat will be positioned on opposite sides of the detonation location, separated by 180 degrees.

11.2.1.2.5 Mine Neutralization Explosive Ordnance Disposal Using Time-delay Firing Device

For a summary of the estimated range to effects for a representative source in this category, see Table 11-1. In addition, Section 11.2 (Mitigation Zone Procedural Measures) provides a general discussion of mitigation zones, how they are implemented, and the potential effects they are designed to reduce.

Mine neutralization activities involving diver placed charges will not include time-delay longer than 10 min. Mitigation will include visual surveillance from small boats (rigid hull inflatable boats) or aircraft commencing 30 min. before, during, and until 30 min. after the completion of the exercise within a mitigation zone of 1,000 yd. (915 m) around the detonation site. During activities using time-delay firing devices involving up to a 20 lb. net explosive weight charge, visual observation will take place using two boats. The exercise will not commence if concentrations of floating vegetation (*Sargassum* or kelp patties) are observed in the mitigation zone. The fuse initiation will cease if a marine mammal is visually detected within the mitigation zone. Fuse initiation will re-commence if any one of the following conditions are met: (1) the animal is observed exiting the mitigation zone, (2) the animal is thought to have exited the mitigation zone based on its course and speed, or (3) the mitigation zone has been clear from any additional sightings for a period of 30 min.

Survey boats will position themselves near the mid-point of the mitigation zone radius (but always outside the detonation plume radius/human safety zone) and travel in a circular pattern around the detonation location. One Lookout from each boat will look inward toward the detonation site and the other Lookout will look outward away from the detonation site. When using two boats, each boat will be positioned on opposite sides of the detonation location, separated by 180 degrees. If available for use, helicopters will travel in a circular pattern around the detonation location.

11.2.1.2.6 Gunnery Exercises-Small and Medium Caliber – Surface Target

For a summary of the estimated range to effects for a representative source in this category, see Table 11-1. In addition, Section 11.2 (Mitigation Zone Procedural Measures) provides a general discussion of mitigation zones, how they are implemented, and the potential effects they are designed to reduce.

Mitigation will include visual observation from a surface vessel or aircraft immediately before and during the exercise within a mitigation zone of 200 yd. (183 m) around the intended impact location. Surface vessels will observe the mitigation zone from the firing position. When aircraft are firing, the crew/pilot will maintain visual watch of the mitigation zone during the activity. The exercise will not commence if concentrations of floating vegetation (*Sargassum* or kelp patties) are observed in the mitigation zone. Firing will cease if a marine mammal is visually detected within the mitigation zone. Firing will re-commence if any one of the following conditions are met: (1) the animal is observed exiting the mitigation zone, (2) the animal is thought to have exited the mitigation zone based on its course and speed, (3) the mitigation zone has been clear from any additional sightings for a period of 30 min., or (4) the intended target location has been repositioned more than 400 yd. (366 m) away from the location of the last sighting.

11.2.1.2.7 Gunnery Exercises-Large Caliber – Surface Target

For a summary of the estimated range to effects for a representative source in this category, see Table 11-1. In addition, Section 11.2 (Mitigation Zone Procedural Measures) provides a general

discussion of mitigation zones, how they are implemented, and the potential effects they are designed to reduce.

Mitigation will include visual observation from a surface vessel or aircraft immediately before and during the exercise within a mitigation zone of 600 yd. (549 m) around the intended impact location. Surface vessels will observe the mitigation zone from the firing position. When aircraft are firing, the crew/pilot will maintain visual watch of the mitigation zone during the activity. The exercise will not commence if concentrations of floating vegetation (*Sargassum* or kelp patties) are observed in the mitigation zone. Firing will cease if a marine mammal is visually detected within the mitigation zone. Firing will re-commence if any one of the following conditions are met: (1) the animal is observed exiting the mitigation zone, (2) the animal is thought to have exited the mitigation zone based on its course and speed, or (3) the mitigation zone has been clear from any additional sightings for a period of 30 min.

11.2.1.2.8 Missile Exercises up to 250 Pound Net Explosive Weight (Surface Target)

For a summary of the estimated range to effects for a representative source in this category, see Table 11-1. In addition, Section 11.2 (Mitigation Zone Procedural Measures) provides a general discussion of mitigation zones, how they are implemented, and the potential effects they are designed to reduce.

When aircraft are firing, mitigation will include visual observation by the crew or pilot prior to commencement of the activity within a mitigation zone of 900 yd. (823 m) around the intended impact location (when practicable). The exercise will not commence if concentrations of floating vegetation (*Sargassum* or kelp patties) are observed in the mitigation zone. Firing will cease if a marine mammal is visually detected within the mitigation zone. Firing will re-commence if any one of the following conditions are met: (1) the animal is observed exiting the mitigation zone, (2) the animal is thought to have exited the mitigation zone based on its course and speed, or (3) the mitigation zone has been clear from any additional sightings for a period of 30 min.

11.2.1.2.9 Missile Exercises up to 500 Pound Net Explosive Weight (Surface Target)

For a summary of the estimated range to effects for a representative source in this category, see Table 11-1. In addition, Section 11.2 (Mitigation Zone Procedural Measures) provides a general discussion of mitigation zones, how they are implemented, and the potential effects they are designed to reduce.

When aircraft are firing, mitigation will include visual observation by the crew or pilot prior to commencement of the activity within a mitigation zone of 2,000 yd. (1.8 km) around the intended impact location (when practicable). The exercise will not commence if concentrations of floating vegetation (*Sargassum* or kelp patties) are observed in the mitigation zone. Firing will cease if a marine mammal is visually detected within the mitigation zone. Firing will re-commence if any one of the following conditions are met: (1) the animal is observed exiting the mitigation zone, (2) the animal is thought to have exited the mitigation zone based on its course and speed, or (3) the mitigation zone has been clear from any additional sightings for a period of 30 min.

11.2.1.2.10 Bombing Exercises

For a summary of the estimated range to effects for a representative source in this category, see Table 11-1. In addition, Section 11.2 (Mitigation Zone Procedural Measures) provides a general

discussion of mitigation zones, how they are implemented, and the potential effects they are designed to reduce.

Mitigation will include visual observation from the aircraft immediately before the exercise and during target approach within a mitigation zone of 2,500 yd. (2.3 km) around the intended impact location. The exercise will not commence if concentrations of floating vegetation (*Sargassum* or kelp patties) are observed in the mitigation zone. Bombing will cease if a marine mammal is visually detected within the mitigation zone. Bombing will re-commence if any one of the following conditions are met: (1) the animal is observed exiting the mitigation zone, (2) the animal is thought to have exited the mitigation zone based on its course and speed, or (3) the mitigation zone has been clear from any additional sightings for a period of 30 min.

11.2.1.2.11 Torpedo Testing

For a summary of the estimated range to effects for a representative source in this category, see Table 11-1. In addition, Section 11.2 (Mitigation Zone Procedural Measures) provides a general discussion of mitigation zones, how they are implemented, and the potential effects they are designed to reduce.

Mitigation will include visual observation by aircraft (with the exception of platforms operating at high altitudes) immediately before, during, and after the exercise within a mitigation zone of 2,100 yd. (1.9 km) around the intended impact location. The exercise will not commence if concentrations of floating vegetation (*Sargassum* or kelp patties), or jellyfish aggregations are observed in the mitigation zone. Firing will cease if a marine mammal is visually detected within the mitigation zone. Firing will re-commence if any one of the following conditions are met: (1) the animal is observed exiting the mitigation zone, (2) the animal is thought to have exited the mitigation zone based on its course and speed, or (3) the mitigation zone has been clear from any additional sightings for a period of 30 min.

In addition to visual observation, passive acoustic monitoring would be conducted with Navy assets, such as passive ships sonar systems or sonobuoys, already participating in the activity. Passive acoustic observation would be accomplished through the use of remote acoustic sensors or expendable sonobuoys, or via passive acoustic sensors on submarines when they participate in the Proposed Action. These assets would only detect vocalizing marine mammals within the frequency bands monitored by Navy personnel. Passive acoustic detections would not provide range or bearing to detected animals, and therefore cannot provide locations of these animals. Passive acoustic detections would be reported to the lookout posted in the aircraft in order to increase vigilance of the visual surveillance; and to the person in control of the activity for their consideration in determining when the mitigation zone is determined free of visible marine mammals.

11.2.1.2.12 Sinking Exercises

For a summary of the estimated range to effects for a representative source in this category, see Table 11-1. In addition, Section 11.2 (Mitigation Zone Procedural Measures) provides a general discussion of mitigation zones, how they are implemented, and the potential effects they are designed to reduce.

Mitigation will include visual observation within a mitigation zone of 2.5 nm (4.6 km) around the target ship hulk. Sinking exercises will include aerial observation beginning 90 min. before the first firing, visual observations from surface vessels throughout the duration of the exercise, and both aerial and surface vessel observation immediately after any planned or unplanned breaks in weapons firing of longer than

2 hr. Prior to conducting the exercise, the Navy will review remotely sensed sea surface temperature and sea surface height maps to aid in deciding where to release the target ship hulk.

The Navy will also monitor using passive acoustics during the exercise. Passive acoustic monitoring would be conducted with Navy assets, such as passive ships sonar systems or sonobuoys, already participating in the activity. These assets would only detect vocalizing marine mammals within the frequency bands monitored by Navy personnel. Passive acoustic detections would not provide range or bearing to detected animals, and therefore cannot provide locations of these animals. Passive acoustic detections would be reported to Lookouts posted in aircraft and on surface vessels in order to increase vigilance of their visual surveillance. Lookouts will also increase observation vigilance before the use of torpedoes or unguided ordnance with a net explosive weight of 500 lb. or greater, or if the Beaufort sea state is a 4 or above.

The exercise will not commence if concentrations of floating vegetation (*Sargassum* or kelp patties), or jellyfish aggregations are observed in the mitigation zone. The exercise will cease if a marine mammal is visually detected within the mitigation zone. The exercise will re-commence if any one of the following conditions are met: (1) the animal is observed exiting the mitigation zone, (2) the animal is thought to have exited the mitigation zone based on its course and speed, or (3) the mitigation zone has been clear from any additional sightings for a period of 30 min. Upon sinking of the vessel, the Navy will conduct post-exercise visual surveillance of the mitigation zone for 2 hr. (or until sunset, whichever comes first).

11.2.1.2.13 At-Sea Explosives Testing

For a summary of the estimated range to effects for a representative source in this category, see Table 11-1. In addition, Section 11.2 (Mitigation Zone Procedural Measures) provides a general discussion of mitigation zones, how they are implemented, and the potential effects they are designed to reduce.

Mitigation during at-sea explosive testing, such as the sinking of a vessel by a sequential firing of multiple small charges (e.g., explosives in bin E5) for use as an artificial reef, will include visual observation from supporting surface vessels immediately before and during the activity within a mitigation zone of 1,600 yd. (1.4 km) around the intended impact location. The exercise will not commence if concentrations of floating vegetation (*Sargassum* or kelp patties) are observed in the mitigation zone. Detonations will cease if a marine mammal is visually detected within the mitigation zone. Detonations will re-commence if any one of the following conditions are met: (1) the animal is observed exiting the mitigation zone, (2) the animal is thought to have exited the mitigation zone based on its course and speed, or (3) the mitigation zone has been clear from any additional sightings for a period of 30 min.

11.2.1.2.14 Elevated Causeway System - Pile Driving

For a summary of the estimated range to effects for a representative source in this category, see Table 11-1. In addition, Section 11.2 (Mitigation Zone Procedural Measures) provides a general discussion of mitigation zones, how they are implemented, and the potential effects they are designed to reduce.

Mitigation will include visual observation from a support vessel or from shore starting 30 min. prior to and during the exercise within a mitigation zone of 60 yd. (55 m) around the pile driver. The exercise will not commence if concentrations of floating vegetation (*Sargassum* or kelp patties) are observed in the mitigation zone. Pile driving will cease if a marine mammal is visually detected within the mitigation

zone. Pile driving will re-commence if any one of the following conditions are met: (1) the animal is observed exiting the mitigation zone, (2) the animal is thought to have exited the mitigation zone based on its course and speed, or (3) the mitigation zone has been clear from any additional sightings for a period of 30 min.

11.2.1.3 Weapons Firing Noise

11.2.1.3.1 Gunnery Exercises – Large-Caliber

For all explosive and non-explosive large-caliber gunnery exercises conducted from a surface vessel, mitigation will include visual observation immediately before and during the exercise within a mitigation zone of 70 yd. (46 m) within 30 degrees on either side of the gun target line on the firing side of the vessel. The exercise will not commence if concentrations of floating vegetation (*Sargassum* or kelp patties) are observed in the mitigation zone. Firing will cease if a marine mammal is visually detected within the mitigation zone. Firing will re-commence if any one of the following conditions are met: (1) the animal is observed exiting the mitigation zone, (2) the animal is thought to have exited the mitigation zone based on its course and speed, (3) the mitigation zone has been clear from any additional sightings for a period of 30 min., or (4) the vessel has repositioned itself more than 140 yd. (128 m) away from the location of the last sighting.

11.2.2 Physical Strike and Disturbance

11.2.2.1 Vessels and In-Water Devices

11.2.2.2 Vessel Movement

Ships will avoid approaching marine mammals head on and will maneuver to maintain a mitigation zone of 500 yd. (457 m) around observed whales, and 200 yd. (183 m) around all other marine mammals (except bow riding dolphins), providing it is safe to do so. For additional information on species-specific mitigations pertaining to vessel strikes within mitigation areas, see Section 11.3, Mitigation Areas.

11.2.2.3 Towed In-Water Devices

The Navy will ensure that towed in-water devices avoid coming within a mitigation zone of 250 yd. (229 m) around any observed marine mammal, providing it is safe to do so.

11.2.2.4 Non-Explosive Practice Munitions

11.2.2.5 Gunnery Exercises-Small, Medium, and Large Caliber using a Surface Target

Mitigation will include visual observation immediately before and during the exercise within a mitigation zone of 200 yd. (183 m) around the intended impact location. The exercise will not commence if concentrations of floating vegetation (*Sargassum* or kelp patties) are observed in the mitigation zone. Firing will cease if a marine mammal is visually detected within the mitigation zone. Firing will re-commence if any one of the following conditions are met: (1) the animal is observed exiting the mitigation zone, (2) the animal is thought to have exited the mitigation zone based on its course and speed, (3) the mitigation zone has been clear from any additional sightings for a period of 30 min., or (4) the intended target location has been repositioned more than 400 yd. (366 m) away from the location of the last sighting.

11.2.2.6 Bombing Exercises

Mitigation will include visual observation from the aircraft immediately before the exercise and during target approach within a mitigation zone of 1,000 yd. (914 m) around the intended impact location. The

exercise will not commence if concentrations of floating vegetation (*Sargassum* or kelp patties) are observed in the mitigation zone. Bombing will cease if a marine mammal is visually detected within the mitigation zone. Bombing will re-commence if any one of the following conditions are met: (1) the animal is observed exiting the mitigation zone, (2) the animal is thought to have exited the mitigation zone based on its course and speed, or (3) the mitigation zone has been clear from any additional sightings for a period of 30 min.

11.2.3 OTHER

The Navy Marine Mammal Program will do the following to further mitigate the low risk of disease transmission from Navy sea lions to Hawaiian monk seal during deployments of the MK5 system used in MIW training events:

1. Sea lion waste will be collected and disposed of in an approved sewer system.

2. During MK5 operations, all onsite personnel will be made aware of the potential for disease transfer, and asked to report any sightings of monk seals immediately so the MK5 personnel can be alerted to the presence of the animal.

3. Sea lion handlers will visually scan for indigenous marine animals, especially monk seals, for at least five minutes before a sea lion enters the water and will maintain a vigilant watch while the sea lion is in the water. If a monk seal is seen approaching or within 100 m, the animal handler will hold the sea lion in the boat or recall the animal immediately if the animal has already been sent on the mission.

4. The Navy will obtained an Import Permit from the State of Hawaii Department of Agriculture and will adhere to the conditions of that permit.

11.3 HUMPBACK WHALE CAUTIONARY AREA

The Navy is proposing to implement mitigation measures within the Humpback Whale National Marine Sanctuary. Humpback whales migrate to the Hawaiian Islands each winter to rear their calves and mate. Data indicate that, historically, humpback whales have clearly concentrated in high densities in certain areas around the Hawaiian Islands. NMFS has reviewed the Navy's data on Mid-Frequency Active (MFA) sonar training in these dense humpback whale areas since June 2006 and found it to be rare and infrequent. While past data is no guarantee of future activity, it documents a history of low level MFA sonar activity in dense humpback areas. In order to be successful at operational missions and against the threat of quiet, diesel-electric submarines, the Navy has, for more than 40 years, routinely conducted Anti-Submarine Warfare (ASW) training in Major Exercises in the waters off the Hawaiian Islands, including the Humpback Whale National Marine Sanctuary. During this period, no reported cases of harmful effects to humpback whales attributed to MFA sonar use have occurred. Coincident with this use of MFA sonar, abundance estimates reflect an annual increase in the humpback whale stock (Mobley 2001a, 2004).

NMFS and the Navy explored ways of affecting the least practicable impact (which includes a consideration of practicality of implementation and impacts to training fidelity) to humpback whales from exposure to MFA sonar. Proficiency in ASW requires that Sailors gain and maintain expert skills and experience in operating MFA sonar in myriad marine environments. Exclusion zones or restricted areas are impracticable and adversely impact MFA sonar training fidelity. The Hawaiian Islands, including areas in which humpback whales concentrate, contain unique bathymetric features the Navy needs to ensure Sailors gain critical skills and experience by training in littoral waters. Sound propagates differently in shallow water. No two shallow water areas are the same. Each shallow water area provides a unique

training experience that could be critical to address specific future training requirements. Given the finite littoral areas in the Hawaii Islands area, maintaining the possibility of using all shallow water training areas is required to ensure Sailors receive the necessary training to develop and maintain critical MFA sonar skills. In real world events, crew members will be working in these types of areas and these are the types of areas where the adversary's quiet diesel-electric submarines will be operating. Without the critical ASW training in a variety of different near-shore environments, crews will not have the skills and varied experience needed to successfully operate MFA sonar in these types of waters, negatively affecting vital military readiness.

The Navy recognizes the significance of the Hawaiian Islands for humpback whales. The Navy has designated a humpback whale cautionary area (described below), which consists of a 5 km (3.1 miles [mi.]) buffer zone that has been identified as having one of the highest concentrations of humpback whales during the critical winter months. The Navy has agreed that training exercises in the humpback whale cautionary area will require a much higher level of clearance than is normal practice in planning and conducting MFA sonar training. Should national security needs require MFA sonar training and testing in the cautionary area between 15 December and 15 April, it shall be personally authorized by the Commander, U.S. Pacific Fleet (CPF). The CPF shall base such authorization on the unique characteristics of the area from a military readiness perspective, taking into account the importance of the area for humpback whales and the need to minimize adverse impacts on humpback whales from MFA sonar whenever practicable. Approval at this level for this type of activity is extraordinary. CPF is a four-star Admiral and the highest ranking officer in the U.S. Pacific Fleet. This case-by-case authorization cannot be delegated and represents the Navy's commitment to fully consider and balance mission requirements with environmental stewardship. Further, CPF will provide specific direction on required mitigation prior to operational units transiting to and training in the cautionary area. This process will ensure the decisions to train in this area are made at the highest level in the Pacific Fleet, heighten awareness of humpback whale activities in the cautionary area, and serve to reemphasize that mitigation measures are to be scrupulously followed. The Navy will provide NMFS with advance notification of any such activities.

12 SUBSISTENCE EFFECTS AND PLAN OF COOPERATION

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

Subsistence use is the traditional exploitation of marine mammals by native peoples (i.e., for their own consumption). In terms of the Hawaii-Southern California Training and Testing (HSTT) Letter of Authorization application, none of the proposed training or testing activities in the HSTT Study Area occur in or near the Arctic. Based on the Navy discussions and conclusions in Chapters 7 and 8, there are no anticipated impacts on any species or stocks migrating through the Study Area that might be available for subsistence use.

13 MONITORING AND REPORTING MEASURES

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

13.1 OVERVIEW

The current Navy fleet monitoring program is composed of a collection of "range-specific" monitoring plans, each developed individually as part of the Marine Mammal Protection Act (MMPA)/Endangered Species Act (ESA) process as environmental compliance documentation was previously completed. These individual plans establish specific monitoring requirements for each range complex based on a set of initial field metrics. The Navy's related, but separate marine mammal research and development program is described in Chapter 14.

Concurrent with development of the range complex specific monitoring plans, from 2009 to 2010 the Navy designed and working with the National Marine Fisheries Service (NMFS) updated a more overarching program plan in which range complex specific monitoring would occur. This plan is called the Integrated Comprehensive Monitoring Program (ICMP) (U.S. Department of the Navy 2011). The ICMP has been developed in direct response to Navy permitting requirements established in various MMPA Final Rules, ESA consultations, Biological Opinions, and applicable regulations. As a framework document, the ICMP applies by regulation to those activities on ranges and operating areas for which the Navy is seeking or has sought incidental take authorizations. The ICMP is intended to co-ordinate monitoring efforts across all regions and to allocate the most appropriate level and type of effort for each range complex based on set of standardized research goals, and in acknowledgement of regional scientific value and resource availability.

The ICMP is designed to be a flexible, scalable, and adjustable plan. The ICMP is evaluated annually through the adaptive management process to assess progress, provide a matrix of goals for the following year, and make recommendations for refinement.

An October 2010 Navy Monitoring meeting in Arlington, VA initiated a process to critically evaluate current Navy monitoring plans and begin development of revisions to existing region-specific monitoring plans and associated updates to the ICMP. Discussions at that meeting as well as through the Navy/NMFS adaptive management process established a way ahead for continued refinement of the Navy's monitoring program. This process included establishing a Scientific Advisory Group (SAG) composed of technical experts to provide objective scientific guidance for Navy consideration. The Navy established the SAG in early 2011 with the initial task of evaluating current Navy monitoring approaches under the ICMP and existing Letters of Authorization (LOA) and developing objective scientific recommendations that will serve as the basis for a future Strategic Implementation Plan for Navy monitoring. The SAG was convened for an initial workshop in San Diego, CA in March 2011. The SAG was

composed of leading academic and civilian scientists with significant expertise in marine species monitoring, acoustics, ecology, and modeling.

13.2 Monitoring Plans and Methods

Annual monitoring under MMPA permits and ESA consultations has been conducted in the Southern California Range Complex (SOCAL) and Hawaii Range Complex (HRC) since 2009. Monitoring plans committed to conducting specific levels of visual (aerial and vessel) surveys, marine mammal observers aboard Navy assets, satellite tagging, and passive acoustic monitoring. The results from the Navy's monitoring efforts to date have been posted on the NMFS' Office of Protected resources website.

In the SOCAL and HRC portions of HSTT, Navy funded marine mammal monitoring from 2009 to 2011 has accomplished the following:

- conducted over 4,000 hours of visual survey effort
- covered over 64,800 nautical miles of ocean
- sighted over 256,000 individual marine mammals
- taken over 45,500 digital photos and 32 hours of digital video
- attached 70 satellite tracking tags to individual marine mammals
- collected over 25,000 hours of passive acoustic recordings
- data collection within HSTT is ongoing and continued analysis of past and current data pending

In addition to the Navy directed monitoring described above, the Navy also co-funded additional visual surveys conducted by the NMFS' Pacific Island Fisheries Science Center and Southwest Fisheries Science Center. The U.S. Pacific Fleet funding share as part of the overall Navy-wide funding in marine mammal research and monitoring in SOCAL and HRC was over $5.5M from 2009 to 2011.The Navy R&D funding (see Chapter 14) for concurrent studies in the HSTT was approximately $7M.

Finally, there were an additional 1,262 sightings for an estimated 12,875 marine mammals made and reported by Navy lookouts aboard Navy ships within the HSTT from 2009 to 2011. During these observations, mainly from major at-sea training events, there were no reported observations of adverse reactions by marine mammals.

13.3 Monitoring Adaptation and Improvement

Discussions at the SAG March 2011 meeting along with continued Navy and NMFS dialog in June 2011 and an October 2011 annual adaptive management meeting established a way ahead for continued refinement of the Navy's monitoring program. Consensus was that the ICMP and associated implementation components would continue the evolution of Navy marine species monitoring towards a single integrated program, incorporate SAG recommendations where warranted and logistically feasible, and establish a more transparent framework for soliciting, evaluating, and implementing future monitoring across the all Navy range complexes and ocean basins. Although the ICMP does not specify actual monitoring field work or projects, it does establish top-level goals that have been developed in coordination with the NMFS. As the ICMP is implemented at the range complex level, detailed and specific studies will be developed which support the Navy's top-level goals. The following excerpt from the 2010 Update of the Navy ICMP states the current top-level goals as developed through coordination with the NMFS. In essence, the ICMP directs that monitoring measures prescribed in a range or project-specific monitoring plan and Navy-funded research relating to the effects of Navy training and testing activities on marine species should be designed to accomplish one or more of the following top-level go:

1) An increase in our understanding of the likely occurrence of marine mammals and/or ESA-listed marine species in the vicinity of the action (i.e., presence, abundance, distribution, and/or density of species);

2) An increase in our understanding of the nature, scope, or context of the likely exposure of marine mammals and/or ESA-listed species to any of the potential stressor(s) associated with the action (e.g., tonal and impulsive sound), through better understanding of one or more of the following: 1) the action and the environment in which it occurs (e.g., sound source characterization, propagation, and ambient noise levels); 2) the affected species (e.g., life history or dive patterns); 3) the likely co-occurrence of marine mammals and/or ESA-listed marine species with the action (in whole or part) associated with specific adverse effects, and/or; 4) the likely biological or behavioral context of exposure to the stressor for the marine mammal and/or ESA-listed marine species (e.g., age class of exposed animals or known pupping, calving or feeding areas);

3) An increase in our understanding of how individual marine mammals or ESA-listed marine species respond (behaviorally or physiologically) to the specific stressors associated with the action (in specific contexts, where possible, e.g., at what distance or received level)

4) An increase in our understanding of how anticipated individual responses, to individual stressors or anticipated combinations of stressors, may impact either: 1) the long-term fitness and survival of an individual; or 2) the population, species, or stock (e.g., through effects on annual rates of recruitment or survival);

5) An increase in our understanding of the effectiveness of mitigation and monitoring measures;

6) A better understanding and record of the manner in which the authorized entity complies with the Incidental Take Authorization and Incidental Take Statement;

7) An increase in the probability of detecting marine mammals (through improved technology or methods), both specifically within the safety zone (thus allowing for more effective implementation of the mitigation) and in general, to better achieve the above goals; and

8) A reduction in the adverse impact of activities to the least practicable level, as defined in the MMPA.

13.4 HSTT MONITORING IMPLEMENTATION

Based on June and October 2011 NMFS-Navy meetings, future monitoring will address the ICMP top-level goals through a series of regional and ocean basin study questions with a priority study and funding focus on species of interest as indentified for each range complex. The ICMP will also address relative investments to different range complexes based on goals across all range complexes, and monitoring will leverage multiple techniques for data acquisition and analysis whenever possible.

Within the HSTT two main range complexes, the Hawaii Range Complex (HRC) and Southern California Range Complex (SOCAL), these initial species of interest agreed to by a group of academic scientists at a September 2011 monitoring meeting include beaked whales (all species HRC and SOCAL), blue whales (SOCAL), fin whales (SOCAL), humpback whales (HRC and SOCAL), Sperm whale (HRC and SOCAL), False killer whale (HRC), Risso's dolphins (SOCAL), Rough-toothed dolphins (HRC), Hawaiian monk seals, and possibly common dolphins (as resources permit) (SOCAL). In support of this LOA application and in line with the NMFS-Navy recommendations for continuing monitoring improvements, Navy monitoring within the HSTT (and concurrently in other areas of the Pacific Ocean) will be structured to address the region-specific study questions as outlined in the HSTT Marine Species Monitoring Plan (U.S. Department of the Navy 2012b). Specific allocation of monitoring (effort, studies, and species) within the HSTT starting in 2014 is contained in the HSTT Monitoring Plan (U.S. Department of the Navy 2012b).

14 RESEARCH

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

14.1 OVERVIEW

The United States (U.S.) Department of the Navy (Navy) is one of the world's leading organizations in assessing the effects of human activities the marine environment including marine mammals. Navy scientists work cooperatively with other government researchers and scientists, universities, industry, and non-governmental conservation organizations in collecting, evaluating, and modeling information on marine resources. They also develop approaches to ensure that these resources are minimally impacted by existing and future Navy operations. It is imperative that the Navy's research and development (R&D) efforts related to marine mammals are conducted in an open, transparent manner with validated study needs and requirements. The goal of the Navy's R&D program is to enable collection and publication of scientifically valid research as well as development of techniques and tools for Navy, academic, and commercial use. Historically, R&D programs are funded and developed by the Navy's Chief of Naval Operations Energy and Environmental Readiness (OPNAV N45) and Office of Naval Research (ONR), Code 322 Marine Mammals and Biological Oceanography Program. Primary focus of these programs since the 1990s is on understanding the effects of sound on marine mammals, including physiological, behavioral and ecological effects.

ONR's current Marine Mammals and Biology Program thrusts include, but are not limited to: 1) monitoring and detection research; 2) integrated ecosystem research including sensor and tag development; 3) effects of sound on marine life [such as hearing, behavioral response studies, physiology (diving and stress), Population Consequences of Acoustic Disturbance (PCAD)]; and 4) models and databases for environmental compliance. To manage some of the Navy's marine mammal research programmatic elements, OPNAV N45 developed in 2011 a new Living Marine Resources Research and Development (LMR R&D) Program. The goal of the LMR R&D Program is to identify and fill knowledge gaps and to demonstrate, validate, and integrate new processes and technologies to minimize potential effects to marine mammals and other marine resources. Key elements of the LMR program include:

- Develop an open and transparent process with a dedicated web site for both project management and public review;
- Provide program management and execution including inputs from various Navy commands involved in monitoring and research;
- Ensure funding of research and development projects that include internationally respected and authoritative researchers and institutions;
- Establish and validate critical needs and requirements with input from a Navy Regional Advisory Committee (RAC);
- Interact with key stakeholders outside of the Navy via the RAC;
- Identify key enabling capabilities and investment areas with advice and assistance from a Navy Technical Review Committee;
- Maintain close interaction and coordination with the ONR basic and early stage applied research program;
- Develop effective information for Navy environmental planners and operators;
- Provide effective management of project funding.

14.2 NAVY RESEARCH AND DEVELOPMENT

Navy Funded Research - Both the OPNAV N45 and ONR R&D programs have projects ongoing within HSTT (Southern California and Hawaii). Some data and results from these R&D projects are typically summarized in the Navy's annual range complex Monitoring Reports currently submitted to NMFS each year. In addition, the Navy's FLEET monitoring is coordinated with the R&D monitoring in a given region to leverage research objectives, assets, and studies where possible under the ICMP (see Chapter 13).

Below are some Navy R&D funded projects or joint Navy-NMFS\academic funded projects currently ongoing within the HSTT during 2012.

Southern California:

- Behavioral Response Study (multiple academic, NMFS, contract scientists, Navy science organizations, and other collaborators; $1.8M funded by OPNAV N45 and ONR)
- Small Boat Based Marine Mammal Surveys in Southern California (Scripps Institute of Oceanography, University of California San Diego; $400KM funded by OPNAV N45)
- Distribution and Demographics of Marine Mammals In SOCAL Through Photo-Identification, Genetics, and Satellite Telemetry (Cascadia Research Collective; $260K funded by OPNAV N45)
- Blue and Humpback Acoustic Survey Methods (Southwest Fisheries Science Center, National Marine Fisheries Service Fisheries Science Center, $160K funded by OPNAV N45)
- Tracking Marine Mammals on Southern California Offshore ASW Range (SOAR) using Marine Mammal Monitoring on Navy Ranges (M3R) (Naval Undersea Warfare Center Newport; $500K funded by OPNAV N45)

Hawaii:

- Passive Acoustic Methods for Tracking marine Mammals Using Widely-Spaced Bottom Mounted Hydrophones (University of Hawaii; funded by ONR)
- Satellite Tagging Odontocetes in the Navy's Pacific Missile Range Facility (PMRF) and Kauai (Cascadia Research Collective; $150K funded by OPNAV N45)
- Tracking Marine Mammals on PMRF using Marine Mammal Monitoring on Navy Ranges (M3R) System (Naval Undersea Warfare Center Newport; $290K funded by OPNAV N45)
- Remote Monitoring of Dolphins and Whales in the High Naval Activity Areas in Hawaiian Waters (Hawaii Institute of Marine Biology, funded by ONR)

The integration between the Navy's new LMR R&D program and related fleet and SYSCOM HSTT monitoring will continue and improve during this Letter of Authorization application period with applicable R&D results presented in HSTT annual monitoring reports.

Other National Department of Defense Funded Initiative - Strategic Environmental Research and Development Program (SERDP) and Environmental Security Technology Certification Program (ESTCP) are the Department of Defense's environmental research programs, harnessing the latest science and technology to improve environmental performance, reduce costs, and enhance and sustain mission capabilities. The Programs respond to environmental technology requirements that are common to all of the military Services, complementing the Services' research programs. SERDP and ESTCP promote partnerships and collaboration among academia, industry, the military Services, and other Federal agencies. They are independent programs managed from a joint office to coordinate the full spectrum of efforts, from basic and applied research to field demonstration and validation. Beginning in March 2012, an ESTCP project that might eventually be applicable to future Navy training and testing includes:

Biodegradable Sonobuoy Decelerators (WP-201222)

http://www.serdp.org/Program-Areas/Weapons-Systems-and-Platforms/Waste-Reduction-and-Treatment-in-DoD-Operations/WP-201222/WP-201222/(language)/eng-US

The objective of this project is to develop a dissolving and biodegradable material for use in Navy sonobuoy parachutes which will address concerns associated with shelf life management, storage, reutilization, and environmental impact. The scope of this effort includes parachute and packaging design, selection and evaluation of materials, and drop tests.

- Optimize biodegradable parachute material to produce a parachute that meets Navy performance requirements.
- Develop packaging to optimize shelf life and storage, maximize biodegradability of all components, and perform environmental evaluation of technology versus traditional nylon parachute.
- Conduct system verification and operational validation testing.

Eventual goal of this project is to seek a replacement for existing sonobuoy parachutes using new biodegradable materials. Traditional nylon parachute fabric is being replaced with a polyvinyl alcohol (PVOH) based film. Because the material properties for the PVOH film are not identical to the woven nylon fabric, the sonobuoy parachute design had to be modified. This modified design has been field tested from a helicopter and meets Navy design and performance criteria thus far. PVOH is a non-toxic, water soluble synthetic polymer. When PVOH film is submersed in water, it dissolves in less than one minute and will biodegrade in a matter of weeks. Laboratory testing to determine rate of dissolution and biodegradation is being conducted at the Natick Soldier Research, Development Center, Marine Biodegradation Laboratory.

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